CRAQ

EX IMAGINE MUNDOS

iREx
INSTITUT DE RECHERCHE SUR LES EXOPLANÈTES
INSTITUTE FOR RESEARCH ON EXOPLANETS

IN THE SPIRIT OF LYOT

Direct Detection of Exoplanets and Circumstellar Disks

Université de Montréal

MONTRÉAL

June 22-26 2015

OBSERVATOIRE DU MONT-MÉGANTIC

Monday, 22

09:00 Welcome

Chair : James Graham

Instrumentation, tools and techniques

09:15 **Dimitri Mawet** High contrast imaging technologies

09:55 Laird Close

10:10 Poster popups

10:30 Coffee + Poster viewing

11:15 Olivier Guyon

11:30 David Mouillet

11:45 Arthur Vigan

12:00 Jean-François Sauvage

12:15 Gautam Vasisht

12:30 Lunch

Chair : Olivier Guyon

14:00 Elsa Huby

14:15 Gilles Otten

14:30 Jacques-Robert Delorme

14:45 Poster popups

15:05 Coffee + Poster viewing

15:50 **Laurent Pueyo** High-contrast imaging algorithms

16:30 Carlos Alberto Gomez Gonzalez

16:45 Adjourn

18:00 Cocktail

Tuesday, 23

09:00 Daily announcements

Chair : Matthew Kenworthy

Status of ongoing exoplanet imaging searches

09:05 **Bruce MacIntosh** Direct imaging of extrasolar planets: past, present, and future

09:45 Motohide Tamura

10:00 Jarron Leisenring

10:15 Katherine Follette

10:30 Poster popups

10:45 Coffee + Poster viewing

11:30 Marshall Perrin

11:45 Robert J. De Rosa

12:00 Jean-Luc Beuzit

12:15 Nemanja Jovanovic

12:30 Lunch

Chair : Jacqueline Faherty

Properties of exoplanet/substellar objects and relations to models

14:00 **Jonathan Fortney** Exoplanet Atmospheres: Where We Are and Where We Need to Go

14:40 Mark Marley

14:55 Thayne Currie

15:10 Tobias O. B. Schmidt

15:25 Poster popups

15:40 Coffee + Poster viewing

16:25 Alice Zurlo

16:40 Travis Barman

16:55 Abhijith Rajan

17:10 Katie Morzinski

17:25 Jeffrey Chilcote

17:40 Anne-Marie Lagrange

17:55 Poster popups

18:15 Beer and poster session

Wednesday, 24

09:00 Daily announcements

Chair : Beth Biller

09:05 Julien Rameau

09:20 Sasha Hinkley

09:35 Anne-Lise Maire

09:50 Jacqueline Faherty

10:05 Stanimir Metchev

10:20 Poster popups

10:35 Coffee + Poster viewing

11:20 **Tristan Guillot** Internal structure and compositions of exoplanets

12:00 Timothy Brandt

12:15 Eric Nielsen

12:30 Michael Line

12:45 Emily L. Rice

13:00 Lunch

15:00 Social activities

Thursday, 25

09:00 Daily announcements

Chair : Étienne Artigau

Formation, architecture, and dynamics of planetary systems

09:05 **Christoph Mordasini** The formation of giant planets and their luminosity at young ages

09:45 **Ruth Murray-Clay** Giant Planets: Probes of Planet Formation

10:25 Poster popups

10:45 Coffee + Poster viewing

11:30 Paul Kalas

11:45 Max Millar-Blanchaer

12:00 Erika Nesvold

12:15 Poster popups

12:30 Lunch

Chair : Christine Chen

Properties of debris/protoplanetary disks and relation to models

14:00 **Brenda Matthews** The birth of debris disks: insights into planetary systems

14:40 Jun Hashimoto

14:55 Carsten Dominik

15:10 Henning Avenhaus

15:25 Christian Thalmann

15:40 Coffee + Poster viewing

16:10 Glenn Schneider

16:25 Timothy Rodigas

16:40 **Giovanna Tinetti** Spectroscopy of exoplanetary atmospheres

17:20 Adjourn

18:30 Rodin+cocktail

19:30 Banquet

Friday, 26

09:00 Daily announcements

Chair : Stanimir Metchev

09:05 Michael Fitzgerald

09:20 Julien Milli

09:35 Jozua de Boer

09:50 Jason Wang

10:05 Jamie Lomax

10:20 Anthony Boccaletti

10:35 Elodie Choquet

10:50 Coffee + Poster viewing

11:20 **Anne-Marie Lagrange** Radial velocities of early-type young stars

11:50 Matthew Kenworthy

Future facilities and opportunities

12:05 Jérémy Lebreton

12:20 Alexandra Greenbaum

12:35 Lunch

Chair : David Mouillet

13:45 Wesley A. Traub

14:00 John Trauger

14:15 Mamadou N'Diaye

14:30 N. Jeremy Kasdin

14:45 Karl Stapelfeldt

15:00 Christopher Mendillo

15:15 Alexis Carlotti

15:25 Christian Marois

15:35 **Michael Liu** Highly Biased and Skewed Conference Summary

16:00 Cloture

- Registration starts at 16:00 on Sunday, June 21.
- Five and 10 km runs leaving from hotel at 7:00 on June 23, 24, 25 and 26.

Instrumentation, tools and techniques

P1-1	Mon, 10:10	**Thierry Fusco**	On-sky improvement, optimisation and final performance of SAXO, the SPHERE extreme AO system
P1-2	Mon, 10:11	**Eric Pantin**	Performances of the Speckle Interferometry applied to Mid-IR VISIR data
P1-3	Mon, 10:12	**Eric Pantin**	The New High Angular Resolution modes of the VLT/VISIR instrument
P1-4	Mon, 10:13	**Markus Kasper**	On-sky compensation of quasi-static speckles with SPHERE
P1-5	Mon, 10:14	**Christian Delacroix**	The Subwavelength Grating Vortex (SGV): optimized design, manufacturing and next generation devices
P1-6	Mon, 10:15	**Pierre Bourget**	High Dynamic Range Synchronous Detection: APM2 Coronagraph
P1-7	Mon, 10:16	**Daniel Rouan**	A new family of phase mask coronagraph
P1-8	Mon, 10:17	**Jun Nishikawa**	Imperfect pre-coronagraph for contrast enhancement with speckle area nulling control
P1-9	Mon, 10:18	**Jonas Kuhn**	A Vector Vortex Coronagraph for the Subaru SCExAO instrument: expected performances and current status
P1-10	Mon, 10:19	**Julien Lozi**	SCExAO: On-sky validation of the correction of low-order non-common path aberrations with a Lyot-based low-order wavefront sensor for high-contrast phase mask coronagraphs
P1-11	Mon, 10:20	**Yunjong Kim**	Optical verification of external occulter with a precisely manufactured mask
P1-12	Mon, 10:21	**Garreth Ruane**	Improving the contrast performance of a vortex coronagraph with a Lyot plane phase mask
P1-13	Mon, 10:22	**Kevin Newman**	Development of focal plane phase masks for PIAACMC
P1-14	Mon, 10:23	**James Breckinridge**	Internal polarization and image quality in coronagraphs
P1-15	Mon, 10:24	**Aïssa Jolivet**	Latest developments of VODCA (Vortex Optical Demonstrator for Coronagraphic Applications)
P1-16	Mon, 10:25	**Naoshi Murakami**	Achromatic coronagraph system based on photonic-crystal technology and its application to polarimetric observations
P1-17	Mon, 10:26	**Brunella Carlomagno**	End-to-end performance simulations of infrared vortex coronagraphs on centrally obscured segmented pupils
P1-18	Mon, 10:27	**Dan Sirbu**	Broadband wavefront control for Phase Induced Amplitude Apodization Complex Mask Coronagraphy (PIAA-CMC)
P1-19	Mon, 10:28	**Jean-François Sauvage**	Analytical and numerical expression of a coronagraphic long-exposure optical transfer function in view of ground-based exo-planet detection
P1-20	Mon, 10:29	**Pierre Baudoz**	Optimization and limitations of two-mirror design for correction of phase and amplitude
P1-21	Mon, 14:45	**Michael Wilby**	The Holographic Modal Focal-Plane Wavefront Sensor: A New Technique for High-Contrast Imaging

Back to schedule ...

Poster pop-ups schedule

P1-22	Mon, 14:46	**Hari Subedi**	Sparse Aperture Mask for Low Order Wavefront Sensing
P1-23	Mon, 14:47	**Elizabeth J. Young**	Detecting exoplanets in speckle-limited images
P1-24	Mon, 14:48	**Christian Ginski**	SPHERE/ZIMPOL astrometric calibration strategies
P1-25	Mon, 14:49	**Li-Wei Hung**	Characterization of the Instrumental polarization of GPI
P1-26	Mon, 14:50	**Johan Mazoyer**	Propagation Simulations for Two-Mirror Wavefront Correction and Active Compensation of Aperture Discontinuities.
P1-27	Mon, 14:51	**Katherine Follette**	Chasing Butterflies: Using AO Telemetry to Reconstruct Common Low Spatial Frequency PSF Artifacts in GPI Data
P1-28	Mon, 14:52	**Rebecca Jensen-Clem**	High contrast imaging at high frame rates: detecting faint companions using speckle statistics
P1-29	Mon, 14:53	**Nemanja Jovanovic**	Adaptive grid of artificial speckles for photometric and astrometric calibration
P1-30	Mon, 14:54	**Jeffrey Chilcote**	Ongoing Calibration activities for the Gemini Planet Imager Integral Field Spectrograph
P1-31	Mon, 14:55	**Sebastian Bruzzone**	Photometric characterization and contrast performance of GPI polarimetry
P1-32	Mon, 14:56	**Elsa Huby**	Resolving the surface of supergiants with FIRST at Subaru
P1-33	Mon, 14:57	**A J Eldorado Riggs**	Recursive Estimation of Both Starlight and Incoherent Sources for High-Contrast Imaging
P1-34	Mon, 14:58	**Clement Perrot**	Reference Differential Imaging with SPHERE commissioning data
P1-35	Mon, 14:59	**Faustine Cantalloube**	Evolution, performance and results of the ANDROMEDA image processing method to detect and characterize exoplanet.
P1-36	Mon, 15:00	**Faustine Cantalloube**	MEDUSAE, a Bayesian inverse problem approach to detect and characterize exoplanets in multispectral images.
P1-37	Mon, 15:01	**Julien Rameau**	Detection limits with spectral differential imaging data
P1-38	Mon, 15:02	**Mara Johnson-Groh**	TLOCI, the Speckle's Worst Nightmare
P1-39	Mon, 15:03	**Thayne Currie**	An Adaptive, Locally-Optimized Method for Imaging and Characterizing Exoplanets and Disks
P1-40	Mon, 15:04	**Raphael Galicher**	Blind tests of ADI and SDI pipelines on SPHERE data
P1-41	Tue, 10:30	**Jason Wang**	The GPIES Data Cruncher: an Automated Data Processing System for the Gemini Planet Imager Exoplanet Survey
P1-42	Tue, 10:31	**Angelle Tanner**	The Starchive: An open access, open source archive of nearby and young stars
P1-43		**Jacques-Robert Delorme**	High contrast imaging in wide spectral band witha self-coherent camera and achromatic coronagraph

Future facilities and opportunities

Back to schedule ...

Poster pop-ups schedule

P6-1	Tue, 10:32	**Tyler Groff**	CHARIS: The Low Resolution, Low Inner Working Angle IFS for Subaru
P6-2	Tue, 10:33	**John Krist**	WFIRST-AFTA Coronagraph Performance Predictions from End-to-End Modeling
P6-3	Tue, 10:34	**Bijan Nemati**	Integrated Modeling of the WFIRST AFTA Coronagraph Instrument
P6-4	Tue, 10:35	**Neil T. Zimmerman**	Shaped Pupil Lyot Coronagraphs: High-contrast solutions for restricted focal planes
P6-5	Tue, 10:36	**Eric Cady**	Performance of the shaped pupil coronagraphic architecture for the WFIRST/AFTA coronagraph
P6-6	Tue, 10:37	**Fang Zhao**	WFIRST-AFTA Coronagraph Instrument Overview and Technology Development Status
P6-7	Tue, 10:38	**Richard Demers**	Design for the WFIRST-AFTA Coronagraph Instrument
P6-8	Tue, 10:39	**Marie Ygouf**	PSF subtraction for the WFIRST-AFTA coronagraph
P6-9	Tue, 10:40	**Mark Marley**	How Well Can the WFIRST Coronagraph Characterize Cool Giants in Reflected Light?
P6-10	Tue, 10:41	**Rhonda Morgan**	The Technology Gap for Exo-Earth Direct Imaging
P6-11	Tue, 10:42	**Keigo Enya**	Heritage of the SPICA Coronagraph Instrument: high-dynamic range technologies for exoplanet science with a space infrared telescopes
P6-12	Tue, 10:43	**Brian Hicks**	Capabilities toward starlight suppression in multiple simultaneous broad bands
P6-13	Tue, 10:44	**Clement Perrot**	Performance simulation of the E-ELT/MICADO high contrast imaging mode
P6-14	Tue, 15:25	**Stephan Birkmann**	Exo-planet transit spectroscopy with JWST/NIRSpec
P6-15	Tue, 15:26	**Loïc Albert**	Exoplanet Transit Spectrocopy with NIRISS on the James Webb Space Telescope
P6-16	Tue, 15:27	**Michael McElwain**	High Contrast Integral Field Spectroscopy with PISCES
P6-17	Tue, 15:28	**Victor Garcia**	The Visible Imaging System for Interfermetric Observations at NPOI
P6-18	Tue, 15:29	**Lucien Gauchet**	FIRST-IR instrument: Latest development and results of nulling capabilities
P6-20	Tue, 15:30	**Angelos Tsiaras**	Blind source separation methods for characterizing extra-solar atmospheres
P6-21	Tue, 15:31	**Giuseppe Morello**	A blind method to detrend exoplanetary observations
P6-22	Tue, 15:32	**Ingo Waldmann**	Emission spectroscopy of transiting and imaged planets
P6-23	Tue, 15:33	**Aoi Takahashi**	Development of a Cryogenic Deformable Mirror for Direct Detecting of Exoplanets with Space Infrared Telescopes
P6-24	Tue, 15:34	**Eduardo A. Bendek**	ACESAT: The first small telescope space mission to directly image the Habitable Zone of Alpha Centauri

Poster pop-ups schedule

P6-25	Tue, 15:35	**Charles-Philippe Lajoie**	Improving JWSTs Coronagraphs Performance with Small-Grid Dithers

Status of ongoing exoplanet imaging searches

P2-1	Tue, 15:36	**Valeri Orlov**	Speckle Interferometry of exoplanet host stars.
P2-2	Tue, 15:37	**Anne-Marie Lagrange**	SPOT: a scheduler for Adaptive Optics, High Contrast Imaging Surveys
P2-3	Tue, 15:38	**Janis Hagelberg**	The brown dwarf desert between 5 and 50 AU probed by combined direct imaging and radial velocity.
P2-4	Tue, 15:39	**Tiffany Meshkat**	Searching for planets in Holey Debris Disks
P2-5	Tue, 15:40	**Justine Lannier**	M-dwArfs Statistical Survey for direct Imaging massiVe Exoplanets with NACO: probing the frequency of planets around low-mass stars.
P2-7	Tue, 17:55	**Dmitry Savransky**	GPIES Planet Yield Simulation Update
P2-8	Tue, 17:56	**Étienne Artigau**	Occurence of Giant Planets on Ultra-Wide Orbits (500-5000 AU)
P2-9	Tue, 17:57	**Marco Rocchetto**	On the detection of planetary remnants around evolved stars
P2-10	Tue, 17:58	**Brendan Bowler**	An Efficient Search for Giant Planets Orbiting New Young M Dwarfs
P2-11	Tue, 17:59	**Andreas Quirrenbach**	Giant planets around nearby young stars - a large L' band imaging survey
P2-12	Tue, 18:00	**Kimberly Ward-Duong**	Stellar and Substellar Companions to Field M-dwarfs and Nearby Young Stars from the GPI Exoplanet Survey Campaign
P2-13	Tue, 18:01	**Frédérique Baron**	Wide Imaging Search for Benchmark Planets
P2-14	Tue, 18:02	**Ryan Varley**	Exoplanets, Catalogues and Big Data
P2-15	Tue, 18:03	**Elena Sissa**	High contrast sensitivity of the ZIMPOL Halpha mode
P2-16	Tue, 18:04	**Abhijith Rajan**	A study of the contrast and planet detection sensitivity for the GPI Exoplanet Survey

Properties of exoplanet/substellar objects and relations to models

P3-1	Tue, 18:05	**France Allard**	Modelling the transition between cool stars to brown dwarfs and planetary mass objects
P3-2	Tue, 18:06	**Yasuhiro Hasegawa**	Planet Traps and Super-Earths: Implications for the Mass-Radius Diagram
P3-3	Tue, 18:07	**Michael Liu**	Young Brown Dwarfs as Gas-Giant Exoplanet Analogs
P3-4	Tue, 18:08	**Jonathan Gagné**	The search for brown dwarfs and very low mass stars in young moving groups
P3-5	Tue, 18:09	**Sasha Hinkley**	New Extreme Mass Ratio Companions in Sco-Cen

Back to schedule ...

Poster pop-ups schedule

P3-6	Tue, 18:10	**Trent Dupuy**	Testing Models of Substellar Evolution with Dynamical Masses
P3-7	Tue, 18:11	**Philippe Delorme**	Free floating planet or high metallicity atypical brown dwarf ?
P3-8	Tue, 18:12	**Jacqueline Radigan**	Discovery of a visual T-dwarf triple system and binarity at the L/T transition
P3-9	Tue, 18:13	**Sandie Bouchard**	Photometric Variability of the L/T Transition Brown Dwarf SIMP0136+0933
P3-10	Wed, 10:20	**Esther Buenzli**	Characterization of patchy clouds in substellar atmospheres with HST
P3-11	Wed, 10:21	**Beth Biller**	Cloud-Driven Variability on Young Brown Dwarfs and Giant Exoplanets
P3-12	Wed, 10:22	**Dino Mesa**	New constraints on the mass of HD142A c from SPHERE high contrast imaging data
P3-13	Wed, 10:23	**Eleanor Bacchus**	Observing HD 114174 B as a demonstration of high contrast imaging spectroscopy with Project 1640
P3-14	Wed, 10:24	**Blake M. Pantoja**	A SPHERE Discovery of an M-dwarf Companion to a Sun-Like Star
P3-15	Wed, 10:25	**Claudio Caceres**	On the nature of the planetary mass companion candidate in the FW Tau system.
P3-16	Wed, 10:26	**Julien H. Girard**	Probing for planetary-mass companions around Luhman 16 AB, our closest brown dwarf neighbours
P3-17	Wed, 10:27	**Jean-Loup Baudino**	What precision on physical parameters can we expect from modeling the atmosphere of directly imaged planets?
P3-18	Wed, 10:28	**Maxime Cudel**	Monitoring of planet variability based on SPHERE science verification time data
P3-19	Wed, 10:29	**Klaus Hodapp**	Keck OSIRIS spectroscopy of all components of the 2MJ044144/2MJ044145 quadruple system
P3-20	Wed, 10:30	**Mickaël Bonnefoy**	Characterization of the binary brown-dwarf companion to the intermediate-mass star HR6037
P3-21	Wed, 10:31	**Mickaël Bonnefoy**	The SINFONI spectral library of young M, L, and T dwarfs objects
P3-22	Wed, 10:32	**François-René Lachapelle**	Characterization of Low-mass, Wide-separation Substellar Companions to Stars in Upper Scorpius: Near-infrared Photometry and Spectroscopy
P3-23	Wed, 10:33	**Jonathan Aguilar**	Brown dwarf science at Project 1640: near-IR spectrum and RV mass constraints for the T dwarf HD 19467 B
		Formation, architecture, and dynamics of planetary systems	
P4-1	Thu, 10:25	**Lison Malo**	Fundamental properties of planet-candidate host stars
P4-2	Thu, 10:26	**Alan Boss**	Formation of Multiple Protostar and Brown Dwarf Systems with Wide Separations
P4-3	Thu, 10:27	**David Tsang**	Gap Heating and The Eccentricity Evolution of Giant Planets: Shedding Light on the Eccentricity Valley
P4-4	Thu, 10:28	**Olivier Wertz**	On the use of MCMC for orbit fitting: a new open source Python package

Back to schedule ...

Poster pop-ups schedule

P4-5	Thu, 10:29	**Tim Pearce**	Constraining the orbits of sub-stellar companions imaged over short orbital arcs
P4-6	Thu, 10:30	**Jean-Philippe Beaulieu**	Measuring masses of planetary systems discovered by microlensing thanks to high angular adaptive optics observations
P4-7	Thu, 10:31	**Quinn Konopacky**	Updated Astrometry for the HR 8799 Planets: Orbital Architecture Constraints
		Properties of debris/protoplanetary disks and relation to models	
P5-1	Thu, 10:32	**Michihiro Takami**	Subaru-HiCIAO Studies of Possible Star-Disk Interaction and Wind-Disk Interaction Toward Active Young Stellar Objects
P5-2	Thu, 10:33	**Antonio Garufi**	Forming planets and their interaction with disks imaged by SPHERE and NACO
P5-3	Thu, 10:34	**Francisco Rendón**	Geometry of Internal Walls and Gaps in Transitional and Pre-transitional Disks.
P5-4	Thu, 10:35	**Carol Grady**	The Transitional Disks of Herbig Ae/Be Stars
P5-5	Thu, 10:36	**David Kasper**	HL Tau Disk Models
P5-6	Thu, 10:37	**Hannah Jang-Condell**	Gaps in the Disk of TW Hya
P5-7	Thu, 10:38	**Tomoyuki Kudo**	Direct Imaging of Dual Differential Structures of Transition Disk around RXJ1852.3-3700.
P5-8	Thu, 10:39	**Esther Buenzli**	Deep L′-band imaging search for protoplanets and structures in pre-transitional disks with the LBT
P5-9	Thu, 10:40	**Schuyler Wolff**	Gemini Planet Imager Observations of the Protoplanetary Disk around the Young Star PDS 66
P5-10	Thu, 10:41	**Robert Stencel**	Structure revelead of the transiting disk in the extreme binary ϵ aurigae
P5-11	Thu, 10:42	**Johan Mazoyer**	Deep Inside Circumstellar Disks Investigating the Near-Infrared Coronagraphic Imager Archive
P5-12	Thu, 10:43	**Min-Kai Lin**	Vertical shear instability in the outer parts of protoplanetary disks
P5-13	Thu, 12:15	**Marc Kuchner**	AO Imaging of Debris Disks found via DiskDetective.org
P5-14	Thu, 12:16	**William Danchi**	The LBTI HOSTS Project: Determining the amount of warm zodiacal dust in the habitable zones of nearby solar type stars
P5-15	Thu, 12:17	**John Krist**	Roll Subtraction for Debris Disk Imaging on HST
P5-16	Thu, 12:18	**Farisa Morales**	Herschel-Resolved Two-Belt Spitzer Debris Disks Around A-type and Solar-type Stars and Candidate Exoplanets
P5-17	Thu, 12:19	**Jean-François Lestrade**	Debris disks around M-type stars in the Herschel survey DEBRIS.
P5-18	Thu, 12:20	**Li-Wei Hung**	Discovery of Resolved Debris Disk Around HD 131835
P5-19	Thu, 12:21	**Benjamin Gerard**	Imaging the HR 8799 Dust Halo with HST/STIS

Back to schedule ...

Poster pop-ups schedule

P5-20	Thu, 12:22	**Anne Boucher**	New debris disk candidates around young low mass stars and brown dwarfs.
P5-21	Thu, 12:23	**Tom Esposito**	Sculpting The Moth with an Inclined, Eccentric Perturber
P5-22	Thu, 12:24	**Christine Chen**	Does the HR 4796 Debris Disk Contain Icy Grains?
P5-23	Thu, 12:25	**Marshall Perrin**	HST STIS Coronagraphy of Four Debris Disks around Young Solar Analogs

Instrumentation, tools and techniques

Laird Close
University of Arizona

Status of Imaging Exoplanets in Visible Light with MagAO
• Mon, 09:55

P1-01 • The 6.5 m Magellan Adaptive Optics System has been in science operation, producing diffraction-limited visible light resolution (20-30 mas), since December 2012. Here I will overview the high contrast visible (0.6-1.0 μm) wavelength capabilities of MagAO's VisAO camera. In particular, the Simultaneous Differential Imaging (SDI) mode that allows high-contrast direct images at Halpha (0.6563 μm) of accreting objects like HD142527B. Broad-band direct imaging of Beta Pic b, CT Cha B and other planetary mass objects will also be presented. The unique scientific gains enabled by characterization of exoplanets from imaging in the visible (H_α, r', i', z', Ys) will be discussed. An upgraded coronagraph concept (MagAO-X) will be briefly presented as well.

Olivier Guyon
Subaru Telescope and Univ. of Arizona

SCExAO: combining high speed, high sensitivity wavefront control and low inner working angle coronagraphy
• Mon, 11:15

P1-02 • We show that combining (1) high speed, high sensitivity wavefront control in visible light with (2) a fast near-IR focal plane speckle control and (3) a high-throughput coronagraph is a powerful approach to high contrast imaging. The new generation of wavefront sensors operating at the diffraction limit of the telescope (pyramid, nlCWFS) are a few orders of magnitude more sensitive than conventional seeing-limited sensors, and can therefore operate at multiple kHz to achieve very low residual wavefront error at the sensor wavelength. Residual near-IR focal plane speckles, due to a combination of atmospheric wavefront chromaticity, non-common path errors, and servo lag in the visible loop, are faint ($\sim 10^{-5}$ raw contrast at 2-10 λ/D) and relatively slow, so they can be pushed down to $\sim 10^{-7}$ raw contrast with a near-IR speckle control loop operating at $\sim$kHz speed in photon-counting regime. This approach is being pursued by the Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) instrument on the 8.2 m Subaru Telescope. Its visible-light extreme-AO loop, now available to SCExAO observers, controls 1700 illuminated actuators at 3.5 kHz, using pyramid WFS feeding a deep-depletion EMCCD. The fast near-IR focal plane speckle control loop, currently under development using a SAPHIRA near-IR eAPD array, will be implemented in 2016 with a photon-counting, wavelength-resolving near-IR microwave kinetic inductance detector (MKID) array. SCExAO also offers to observers low-IWA coronagraphy (PIAACMC and Vortex) integrated with near-IR low-order wavefront sensing. The SCExAO architecture reaches deeper contrast at small separation than possible with first-generation extreme-AO systems, allowing imaging of giant planets in reflected light on Subaru Telescope and direct imaging/spectroscopy of rocky planets in the habitable zones of nearby M-type stars on ELTs.

David Mouillet
IPAG

From current to future high contrast imagers: lessons learnt from SPHERE design choices and on-sky data
• Mon, 11:30

P1-03 • We have now the first instruments, such as SPHERE and GPI, fully designed for high contrast imaging operating on sky and offered to a wide community. More than ten years ago, at the time of their early definition, the foreseen step forward in performance required to revisit the system analysis in a different way from the previous generation imagers, including new metrics, new concepts and novel technological components, and taking into account the impact of some limitations never considered before. Many trade-offs were involved in close relation with the detailed science analysis in particular for exoplanet exploration and disk observations. We will briefly remind the most important drivers and choices made in the SPHERE instrument design phase, together with the supporting technological assumptions and science goals. This includes a broad range of domains from the optical quality at various scales, the specifications on chromatism and stability, the overall or instantaneous spectral bandpass, the coronagraphs intrinsic performance, wavefront sensing and up to the post-processing. In the light of actual laboratory and on-sky tests, we will then rediscuss the validity of these early (and often risky) assumptions and trade-offs, and we will revisit the key specifications, identify some already known potential items for performance improvement in the perspective of such instruments or later on for the next generation.

Arthur Vigan
European Southern Observatory (ESO)

On-sky performance of the dual-band imaging and long-slit spectroscopy modes of SPHERE/IRDIS
• Mon, 11:45

P1-04 • The exoplanet imager for the Very Large Telescope, SPHERE, has been commissioned at the VLT in 2014 and is now in operation since April 2015. It offers three scientific instruments dedicated to the detection and characterization of young giant planets. One of them is IRDIS, a near-infrared imager and spectrograph, which offers a wide range of observational modes including dual-band imaging (DBI) and long slit spectroscopy (LSS). We present an overview of the on-sky performance of the DBI and LSS modes. The DBI mode offers exquisite performance in spectral differential imaging (SDI) compared to previous generation instrumentation thanks to the very low level of differential aberrations. Coupling SDI with angular differential imaging (ADI), we demonstrate the ultimate performance of SPHERE/IRDIS for the detection of giant exoplanets. The LSS mode couples a classical Lyot coronagraph with a long-slit to form a long-slit coronagraph (LSC), which offers low ($R \sim 50$) and medium ($R \sim$300) resolution over YJHKs and YJH respectively, for objects up to 5$''$ away from their star. This mode is unique in the world of high-contrast instruments in terms of field-of-view and resolution. We demonstrate its performance using SPHERE data on HR8799d and Beta Pic b. Finally, we present an improvement of this unique mode using the stop-less Lyot coronagraph (SLLC), which is designed to improve the performance at very small inner-working angles ($0.2 - 0.4''$). We show the first internal data obtained with the SLLC prototype, which was installed in SPHERE during its last commissioning.

Contributed talks

Jean-François Sauvage ONERA-DOTA	**Beyond SPHERE ultimate performance, current limitations, upcoming upgrades and new observation strategies** • Mon, 12:00	**P1-05** • The aim of the Spectro-Polarimetric High-contrast Exoplanet Research (SPHERE) instrument is to detect extremely faint astronomical sources (i.e., giant extra-solar planets) in the vicinity of bright stars. The detection capabilities of an exoplanet hunter are largely controlled by its adaptive optics (AO) system. Better AO correction provides improved coronagraph extinction and fewer residual defects. The challenging SPHERE science goals require a very high-order performance AO system to feed a quasi-perfect flat wave front, corrected for atmospheric turbulence and internal defects, to the scientific instruments. In May 2014 SPHERE was installed on the third unit telescope (Melipal) of the Very Large Telescope (VLT) in Chile. SPHERE is nowaday delivering unprecedented images to the exoplanet astronomers community, allowing the most accurate observation in the coming months. The integration and first light period allowed the author to identify the main limitations of SPHERE instrument. This paper presents a performance assessment performed during AIT and SVT period, and presents firsts results of key components and concepts for a stabilised ultimate performance system. This system is based on the coupling of absolute precision of focal-plane post-coronagraphic wave-front sensing, the fine time-stabilisation given by the Zernike mask, and the deep contrast level obtained by dark hole technique.
Gautam Vasisht JPL	**Updates on Concurrent Wavefront Control in Project 1640** • Mon, 12:15	**P1-06** • Project 1640 is the only AO coronagraph to use concurrent wavefront control. This control's sole task is to lower and and then maintain the system's quasi-static speckle floor, enhancing imaging contrast and sensitivity to faint companions to stars. We will describe the performance achieved using both phase and E-field conjugation, and describe upcoming plans to improve the performance, and the potential of concurrent wavefront control for future ELT coronagraphs.
Elsa Huby Université de Liège	**The vortex coronagraph: from laboratory characterization to on-sky operation** • Mon, 14:00	**P1-07** • Vortex coronagraphs (VC) offer unprecedented potential for the direct detection and characterization of extrasolar planets and are therefore being considered for next generation high contrast imaging instruments on future 30 m telescopes (e.g. METIS and MICADO). The VORTEX project, led by the University of Liège and the Uppsala University, aims to develop the following aspects of the vector vortex phase masks based on sub-wavelength gratings, also known as AGPM (Annular Groove Phase Masks): (i) mask design and manufacturing ; (ii) in-lab and on-sky performance testings and optimization ; and (iii) observation data reduction optimization and analysis. In this talk, we will report on the latest results obtained in the laboratory with the most recent generation of components, optimized for the L and M bands. The newest AGPMs have shown remarkable in-lab performance, with a raw peak attenuation of 500:1 in L-band and up to 100:1 in M-band. The best components have been integrated with the Keck/NIRC2 instrument in March 2015 and will see first light in early June 2015, offering enhanced contrast capabilities in both the L and M bands. We will thus likely present first on-sky results obtained with Keck/NIRC2 (L+M bands) and with VLT/VISIR (N band commissioned in March 2015). In addition, we have developed a technique of tip-tilt retrieval to reduce the inevitable slow decentering of the beam with respect to the center of the mask caused by mechanical drifts. This is currently one of the main limitations of small inner working angle coronagraphs such as the VC and must be addressed in order to enhance on-sky performance. The QACITS technique (Quadrant Analysis of Coronagraphic Images for Tip-tilt Sensing) was initially introduced for the four-quadrant phase mask. We will present the theoretical basis for the particular case of vortex phase masks and results obtained with Keck/NIRC2. The basic principle is that asymmetry in the coronagraphic image of a star is directly linked to the amount of tip-tilt affecting the beam incident on the mask, which allows for the correction of residual pointing errors that are not sensed by the adaptive optics system.
Gilles Otten Leiden Observatory	**First on-sky demonstration of the achromatic vector Apodizing Phase Plate at 2-5 μm on the LBT and Magellan** • Mon, 14:15	**P1-08** • We present recent results for the on-sky demonstration of the vector Apodizing Phase Plate (vAPP) coronagraph in the near-infrared at the Large Binocular Telescope/LMIRCam and Magellan/Clio2.The vAPP is an achromatic pupil-plane phase-only coronagraph that simultaneously suppresses both sides of a star by producing two PSFs with complementary dark holes. A patterned multi-layered liquid crystal retarder produces a phase delay as a function of pupil position. By adding a phase ramp to the normal APP phase pattern, separation of the two PSFs is achieved in one optic, and manufacturing and installation is simplified. Furthermore the phase ramp deflects the coronagraphic PSFs away from any leakage term that is created if the optic is not perfectly half-wave which otherwise degrades the contrast. The performance of the pupil-only device is insensitive to tip-tilt motion such as chopping and nodding for background subtraction, dithering motions and telescope vibrations. A narrow-band version of the vAPP (optimized for 4.05 μm) was installed in September 2014 in LBT/LMIRCam and tested on-sky early November. At the end of April 2015 a broad-band (2-5 μm) version is installed in Clio2 and the first measurements are scheduled for May. We will present our findings of the initial performance of the coronagraphs on both telescopes.

Contributed talks

Jacques-Robert Delorme Paris Observatory - LESIA	**Description and last results obtained with the THD bench.** • Mon, 14:30	**P1-09** • The THD bench has been developed at Paris observatory since 2007 for the conception and the experimental validation of high contrast imaging components and techniques in the context of space missions and ground-based extremely large telescopes. One of the main components of the bench is the self-coherent camera (SCC) which is a focal plane wavefront sensor that enables the control of the deformable mirror directly from the science image. We demonstrated the performance of the SCC when associated to several coronagraphs: the four-quadrant phase mask (FQPM) the Multi-stage FQPM and the dual zone phase mask. We are able to create dark Holes with contrast levels of 2.1×10^{-8} between 5 and 12 λ/D in monochromatic light (640 nm). We also proved that the spectral limitation of the bench is low enough to reach contrast lower than 6×10^{-8} for bandwidths up to 200 nm in visible. Recently, we proposed the multi-reference SCC to reduce the chromaticism of the SCC and we demonstrated in laboratory that this solution reaches, for a bandwidth of 12%, the same performance than the SCC does in monochromatic light. During my presentation, I will describe the THD bench and I will give an overview of the different high contrast imaging techniques that we tested or that we plan to test. Then, I will present the latest results and the future developments that are scheduled.
Carlos Alberto Gomez Gonzalez PhD student, Université de Liège	**Beyond PCA and Low-rank plus Sparse decomposition of high-contrast ADI/SDI image sequences for exoplanet detection** • Mon, 16:30	**P1-10** • Data processing constitutes one of the pillars of high contrast imaging and is almost as important as the choice of a coronagraph, the wavefront control system or the observing strategy. The role of post-processing algorithms for boosting the detectability of real faint companions in a noisy background is critical. Among these data processing techniques, the most recent is the family of Principal Component Analysis (PCA) based algorithms. PCA, also known as the Karhunen-Love transform, is a widely used statistical tool developed during the first half of the past century. With PCA we look for a lower-dimensional subspace that explains most of the variation in our high-dimensional data, revealing underlying hidden structures. PCA has been applied in diverse fields as in, for instance, computer vision for the problem of background subtraction and detection of moving objects. Only recently PCA based algorithms have been proposed for point spread function (PSF) subtraction in high-contrast imaging (KLIP and Pynpoint implementations). Indeed, the problem of detecting a moving planet from Angular Differential Imaging (ADI) or Spectral Differential Imaging (SDI) data has a lot in common with the task of video sequences background subtraction; therefore, projecting the images onto the orthogonal basis created by the first principal components gives a convenient approximation of the stellar PSF (and its associated speckle field) and of the background for a video sequence in the latter case. In this talk, I will start with a short review of recent subspace projection techniques and robust subspace models proposed in the machine learning/computer vision communities that can also be applied to ADI/SDI high-contrast datasets. This kind of robust subspace models, via decomposition in low-rank plus sparse (L+S) matrices, alleviates the weakness of classical PCA in presence of non independent and identically distributed Gaussian noise and outliers. In particular, I will report on the application of an L+S decomposition whose model enhances speckle suppression, reduces background noise and improves detectability of point-like sources in the final combined image. I will conclude my talk with a comparison "in terms of SNR, likelihood ratio of positive detections (TPR/FPR), computing time and other metrics" of this new algorithm and PCA performed on data taken with the L-band AGPM vortex coronagraph on VLT/NACO and LBT/LMIRCam, as well as on commissioning VLT/SPHERE data.

Status of ongoing exoplanet imaging searches

Motohide Tamura UTokyo / NAOJ / ABC	**Five Year Summary of Subaru SEEDS Survey** • Tue, 09:45	**P2-01** • The SEEDS survey of exoplanets and disks is the first Subaru Strategic Program, whose aim is to conduct a direct imaging survey for giant planets as well as protoplanetary/debris disks at a few to a few tens of AU region around 500 nearby solar-type or more massive young stars. 120 Subaru nights for 5 years starting from 2009 have been devoted. The targets are composed of five categories spanning the ages of $\sim$1 Myr to $\sim$1 Gyr (YSOs, Moving Groups, Open Clusters, Nearby stars. Debris Disks). Some RV-planet targets with older ages are also observed. The main survey has been completed in January 2015 without major troubles during the survey period. We present the survey outline and summarize its main results from each category on both planets/companions and disks.
Jarron Leisenring University of Arizona	**The LEECH Exoplanet Imaging Survey** • Tue, 10:00	**P2-02** • The ongoing LEECH (LBTI Exozodi Exoplanet Common Hunt) survey consists of a $\sim$100-night campaign using LBT/LMIRcam to search for and characterize directly imaged planets orbiting nearby stars. This survey benefits from the many technological achievements of the LBT, including two 8.4-meter mirrors on a single fixed mount, dual adaptive secondary mirrors for high Strehl performance, and a cold beam combiner to dramatically reducing the telescope's overall background emissivity. LEECH operates primarily at L' (3.8 μms) in order to maximize mass sensitivities for planets orbiting nearby adolescent ($\sim$0.1-1 Gyr) stars. This wavelength regime complements other high-contrast imaging efforts observing in the near-infrared (1-2.4 μm) while providing contrasts similar to those from extreme AO systems such as GPI and SPHERE. These observations at 3-5 μms are critical for advancing our theoretical understanding of self-luminous exoplanets in advance of JWST.
Katherine Follette Stanford University	**Isolating the Accretion Luminosity of Forming Protoplanets: Results from the Magellan Adaptive Optics Giant Accreting Protoplanet Survey (GAPplanetS)** • Tue, 10:15	**P2-03** • I will present recent results from the Magellan Adaptive Optics (MagAO) Giant Accreting Protoplanet Survey (GAPplanetS), a visible light simultaneous differential imaging campaign designed to isolate the accretion luminosity of forming protoplanets inside of transitional disk gaps. Early results included a directly imaged accreting M dwarf companion at just 86 milliarcsecond separation (12 AU) inside of the HD142527 gap. I will focus here on several more recent results, including our first planetary companion candidates, and will describe prospects for characterization of detected objects at other wavelengths with GPI and ALMA.
Marshall Perrin STScI	**The Gemini Planet Imager** • Tue, 11:30	**P2-04** • The Gemini Planet Imager is a dedicated instrument for directly imaging and spectroscopically characterizing extrasolar planets. It combines a very high-order adaptive optics system, a diffraction-suppressing coronagraph, and an integral field spectrograph with low spectral resolution but high spatial resolution, along with sophisticated instrument control software and an open-source data analysis pipeline supporting both spectral and polarimetric modes. Every aspect of GPI has been tuned for maximum sensitivity to faint planets near bright stars. After nearly a decade of development, GPI was commissioned at Gemini South starting in 2013 November, and moved into full science operations a year later. This talk will present an overview of GPI's key enabling technologies, summarize its performance and achieved contrast, and discuss lessons learned and prospects for ongoing performance tuning. GPI is now being used to carry out a wide variety of high contrast investigations, including a multi-year Exoplanet Survey.
Robert J. De Rosa UC Berkeley	**The Gemini Planet Imager Exoplanet Survey** • Tue, 11:45	**P2-05** • We will present an update on the ongoing Gemini Planet Imager Exoplanet Survey (GPIES), an 890-hour campaign designed to measure the frequency and properties of giant extrasolar planets in wide orbits ($4-40$ AU) around a sample of 600 young, nearby stars. Using a high-order adaptive optics system, an apodized pupil coronagraph, and an integral field spectrograph, the Gemini Planet imager (GPI) is designed to detect faint planetary-mass companions between 0.2 and 1.0$''$ around bright ($I < 9$) stars. In addition to its spectral capabilities, GPI can also be operated in a dual channel polarimetry mode capable of measuring polarized light scattered from small dust grains within circumstellar debris disks. During the initial GPIES campaign runs, we have achieved a median 5-sigma sensitivity of 1.6×10^{-5} (2.0×10^{-6}) at 0.3$''$ (0.75$''$) at H band in spectral mode after PSF subtraction, reaching a contrast of 6.3×10^{-6} (9.2×10^{-7}) at 0.3$''$ (0.75$''$) for our most sensitive observation. For the average star within our sample, a 125 Myr F6 star at 47 pc, the median sensitivity corresponds to a detectable planet mass of 10 M_{Jup} (6 M_{Jup}) at a projected separation of 14 AU (35 AU) using the COND model grid. We will summarize the progress of the campaign, and highlight several science results based on the initial campaign observations in both the spectral and polarimetric modes which we have obtained since late 2014.

Contributed talks

Jean-Luc Beuzit CNRS/IPAG	**SPHERE, a planet finder instrument for the VLT** • Tue, 12:00	**P2-06** • SPHERE (Spectro-Polarimetric High-contrast Exoplanet Research in Europe) is a second-generation instrument for the ESO Very Large Telescope (VLT) dedicated to the direct detection and spectral characterization of giant extra-solar planets, which is one of the most exciting but also one of the most challenging areas in modern astronomy due to the very large contrast between the host star and the planet at very small angular separations. SPHERE combines an extreme adaptive optics system, various coronagraphic devices and a suite of focal instruments providing imaging, integral field spectroscopy and polarimetry capabilities in the visible and near-infrared spectral ranges. After almost 10 years of development, SPHERE obtained its first light in May 2014, has been successfully commissioned at the VLT during the past year and is now offered to the community since April 2015. We give an overview of the science objectives and main instrument features, review the performance achieved during the commissioning period and present some highlights of the very first results.
Nemanja Jovanovic Subaru Telescope	**The Subaru Coronagraphic Extreme Adaptive Optics instrument: commissioning status** • Tue, 12:15	**P2-07** • The Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) instrument is an adaptive test bed for prototyping cutting edge high contrast imaging technologies for ELTs. It is currently nearing the completion of commissioning and beginning regular science operations. The instrument exploits the latest that technology has to offer. High order wavefront control is provided by a visible light pyramid wavefront sensor, a deep depletion EMCCD and a 2000 element deformable mirror. Non-common path and chromatic wavefront errors are monitored at he Coronagraphic focal plane with a Lyot based low order wavefront sensor. To suppress the glare from the star, SCExAO offers a choice of 6 coronagraphs, with the most aggressive offering inner working angles as low as 1 lambdFAD. To enhance contrast SCExAO utilizes an active speckle nulling algorithm which digs a dark hole in a region of the focal plane. Artificial speckles can also be deployed for astrometric and photometric calibration purposes. Visible light science is provided by one of three interferometric imagers: VAMPIRES, FIRST or lucky Fourier imaging. Besides offering a spatial resolution approaching 10 mas, VAMPIRES also allows for precision polarimetry while FIRST enables spectra to be collected. Finally, with a stable high Strehl PSF, SCExAO is the ideal platform for injecting light into photonic technologies for enhanced spectroscopy. In this work we detail the SCExAO architecture and the commissioning status of each module. We present initial science results to come from several modules including preliminary detections of never before seen dust shells around post-AGB stars.

Properties of exoplanet/substellar objects and relations to models

Mark Marley
NASA - Ames Research Center

Characterizing Young Giant Planets with the Gemini Planet Imager: An Iterative Approach to Planet Characterization
• Tue, 14:40

P3-01 • After discovery, the first task of exoplanet science is characterization. However experience has shown that the limited spectral range and resolution of most directly imaged exoplanet data requires an iterative approach to spectral modeling. Simple, brown dwarf-like models, must first be tested to ascertain if they are both adequate to reproduce the available data and consistent with additional constraints, including the age of the system and available limits on the planet's mass and luminosity, if any. When agreement is lacking, progressively more complex solutions must be considered, including non-solar composition, partial cloudiness, and disequilibrium chemistry. Such additional complexity must be balanced against an understanding of the limitations of the atmospheric models themselves. For example while great strides have been made in improving the opacities of important molecules, particularly NH_3 and CH_4, at high temperatures, much more work is needed to understand the opacity of atomic Na and K. The highly broadened resonance lines of Na and K in the optical stretch into the near-infrared, strongly influencing the spectral shape of Y and J spectral bands. Another example is partial cloudiness; models with multiple columns of varying cloud opacity allow more degrees of freedom to fit data, but the net effect of such columns on the atmospheric thermal profile and chemistry must also be considered. In short, discerning gravity and atmospheric composition is difficult, if not impossible, without both good atomic opacities as well as an excellent understanding of the relevant atmospheric chemistry and physics. I will present examples of the iterative process of directly imaged exoplanet characterization as applied to both known and potentially newly discovered exoplanets with a focus on constraints provided by GPI spectra. As a case study I will discuss HR 8799 c and d will explain why some solutions, such as spatially inhomogeneous cloudiness, introduce their own additional layers of complexity. Alternatively if a spectrum of a newly discovered planet is available I will explain the modeling process in the context of understanding such a new world.

Thayne Currie
NAOJ

New High-Contrast Imaging Results with SCExAO and GPI: The First Planetary Systems Discovered with Extreme AO and New Science Capabilities
• Tue, 14:55

P3-02 • We report the first science results from cutting-edge extreme-AO systems SCExAO on Subaru and GPI on Gemini-South from data obtained in the past year. The GPI data provide the first spectral characterization of a protoplanet and reveal the first new planetary system discovered with extreme adaptive optics. The new SCExAO observations follow recent lab tests showing up to 94% Strehl in H band. SCExAO now achieves true extreme AO capability on sky, with prospects to fully close the gap between on-sky and lab performance soon. New, high-contrast images of debris disk systems with SCExAO clarifies the disks' structures and provides new insights into planets perturbing these disks. Finally, we close by describing the unique science focus of SCExAO and upcoming observations to characterize young planetary systems with both SCExAO and GPI.

Tobias O. B. Schmidt
Hamburg Observatory, Germany

Direct Imaging Discovery of a new very young L-T transition planet
• Tue, 15:10

P3-03 • In the course of a direct imaging survey with NACO at ESO/VLT we found a new sub-stellar companion candidate. The object is consistent with a 4-5 Jupiter mass planet and has unusually blue colors for its temperature, estimated using SINFONI integral field spectroscopy follow-up data in comparison to Drift-Phoenix atmospheric model spectra. We will present how photometry and spectroscopy fit an L-T transition object at only few Myr age when compared to BT-Settl evolutionary models and other comparison objects.

Alice Zurlo
LAM/OAPD

New SPHERE results on the planetary system around HR8799
• Tue, 16:25

P3-04 • The planetary system around HR8799 was observed with VLT/SPHERE from July to December 2014 (during commissioning and science verification runs of the instrument). We obtained new spectrophotometric data in J, H, and K band, for the four planets HR8799bcde with SPHERE/IRDIS (first detection of planet e in J band) plus YH-band spectra for planets d and e with SPHERE/IFS. These spectra have the highest quality ever obtained in this wavelength range. We measured astrometric points for three epochs of observation. We present the analysis of the available spectrophotometry of the planets and our measurements, and give our interpretation on the architecture of the system.

Travis Barman
University of Arizona / Lunar and Planetary Lab

Exoplanets and R$>$ 1000: it doesn't get any better than this!
• Tue, 16:40

P3-05 • The two outer-most planets in the HR8799 system have been observed at extraordinary spectral resolution and coverage, revealing numerous absorption lines produced by water, carbon monoxide, and methane (Konopacky et al. 2013; Barman et al. 2015). Comparisons between these data and atmosphere models yield estimates of molecular abundances, carbon-to-oxygen ratios, and vertical mixing in both HR8799 b and c. We will present new evidence for non-equilibrium chemistry and compare our abundance estimates to predictions tied to planet formation models. These two planets likely differ in mass by a factor of two and, interestingly, methane absorption has only been detected in the lowest mass planet. We will discuss the differences between these two planets and potential clues for understanding the temperature and gravity dependence of vertical mixing, clouds and other basic chemical properties. We will also discuss the lessons learned from this system for uniquely estimating bulk properties (e.g., effective temperature and gravity) from spectra of directly imaged planets at various spectral resolving powers.

Contributed talks

Abhijith Rajan Arizona State University	**Surveying Young Planetary Systems: Atmospheric Analysis of HR8799 with HST/WFC3 and New Substellar Companions with LBT** • Tue, 16:55	**P3-06** • We present results from our multi-wavelength Hubble Space Telescope program using Wide Field Camera 3 (WFC3) to characterize the atmospheres of the two outer planets in the HR8799 system, the only multi-planet system that has been imaged. We present the first direct detection of HR8799 b in the water band centered on 1.38 um, which is inaccessible from ground-based telescopes. This unique photometric measurement was compared with synthetic atmosphere models to understand the water abundance and cloud opacity for this companion. The new HST data were also combined with photometry at other wavelengths from the literature, and the ensemble of measurements were best matched by models including solar metallicity for planet b, but super-solar metallicity for planet c. Previous ground-based J-band detections of HR8799 c have reported considerably different values, and models involving patchy clouds were required to fit the brighter reported J-band flux. The new J-band measurement from HST is consistent with the fainter previous value, and these new results do not require patchy clouds to fit the near IR photometry. While most directly imaged planets such as HR 8799 have been discovered in the near infrared, characterization of planetary atmospheres is enhanced with observations in the mid-infrared which is the wavelength range over which the companions are brightest. To identify a population of mid-IR detected planets amenable to follow-up observation by HST for fuller atmosphere characterization, we are also pursuing an L-band search for substellar companions around low mass stars of $\sim$1-2 Myr in the Taurus star forming region, using adaptive optics on the Large Binocular Telescope. From this on-going program a number of close companions have already been identified, including new discoveries and candidate sub-stellar companions.
Katie Morzinski University of Arizona	**Completing the optical-infrared SED of beta Pic b with MagAO** • Tue, 17:10	**P3-07** • Young giant exoplanets are currently our best laboratory for understanding cool, low-gravity atmospheres. I will describe the example of beta Pic b, a 10-Jupiter-mass exoplanet embedded in the disk of young nearby A star beta Pic. We have measured this planet's empirical bolometric luminosity and characterized its atmosphere by combining Magellan Adaptive Optics (MagAO) photometry with GPI spectroscopy and NICI and NaCo photometry. GPI spectroscopy gives details of the near-IR atmospheric properties, while MagAO/VisAO+Clio photometry allows us to measure bolometric luminosity. Simultaneous fitting of VisAO in the blue and Clio in the thermal IR gives a dual constraint on temperature and radius that is unique to MagAO. Clio, VisAO, and GPI together give an empirically complete optical-infrared picture of the atmosphere.
Jeffrey Chilcote University of Toronto, Dunlap	**GPI Spectrum of the Giant Planet Beta Pictoris b** • Tue, 17:25	**P3-08** • Using the recently installed Gemini Planet Imager (GPI), we have obtained a low resolution multi-band spectrum of the planetary companion to the nearby young star beta Pictoris. GPI is designed to image and provide low-resolution spectra of Jupiter-sized, self-luminous planetary companions around young nearby stars. While H-band is the primary workhorse of GPI, the instrument is capable of observing in the Near Infrared covering Y, J, H, and K bands. These observations of beta Pic were taken covering multiple bands as part of GPI's verification and commissioning phase in 2013 and 2014. Using atmospheric models of the H-band, we find an effective temperature of 1600-1700 K and a surface gravity of log (g) = 3.5-4.5 (cgs units). These values agree well with "hot-start" predictions from planetary evolution models for a gas giant with mass between 10 and 12 M Jup and age between 10 and 20 Myr. We present the H-band spectra and updates on the results at other wavelengths from the commissioning data.
Anne-Marie Lagrange IPAG CNRS	**Close insights in the beta Pictoris system: further constraints on beta Pic b and on the disk.** • Tue, 17:40	**P3-09** • The Beta Pictoris system has focused much efforts since the last 30 years, and is regarded as a laboratory to study early stages of planet formation and evolution. This is because the system is close, and hosts a bright circumstellar debris disk, as well as, at least, one massive planet orbiting at a distance comparable to that of Saturn in the solar system. High angular resolution imaging is a key technics to further constrain both the disk and the already identified planet. The extreme AO systems SPHERE and GPI were then expected to bring precious new information on this system. The first imaging and IFS data indeed bring various new constraints on the planet orbital, physical and atmospheric properties, as well as on the innermost parts of the disk, which were not accessible before. We will present the results obtained so far with these new instruments and the implications on the global understanding of the system, once coupled with other types of data (radial velocities, ALMA data). The first results of an attempt to make a global dynamical modeling of the system will be also showed. We will finally present the lessons learnt from this well studied system in terms of observational strategy in the framework of a multi technics approach, and the limitations of the present high angular resolution, high contrast imaging data with the news imaging systems, and discuss possible ways to overcome them.
Julien Rameau iREx, UdeM	**The planetary system around HD 95086** • Wed, 09:05	**P6-08** • Only few giant planets have been directly imaged to date. Therefore, deep investigations of these few systems are of great importance to study the formation, early evolution, and atmosphere of giant planets. In 2013, we detected and confirmed a giant planet around the young, dusty, and massive HD 95086 with VLT/NaCo. HD95086 b is a 5 Jupiter mass planet at a projected separation of 55 astronomical units. This discovery has rapidly motivated follow-up investigations of the planet but also of the stellar environment. I will present our current knowledge of HD 95086 b. By combining a new low-resolution $K1$-band spectrum obtained with the Gemini Planet Imager with H, $K1$, and L' photometry, I will show the constraints we have on its physical and atmospheric parameters (mass, spectral type, effective temperature, etc.). I will place the results in the context of other directly-imaged companions to reveal how peculiar is HD 95086 b. Lastly, I will discuss the planetary system architecture and its implications in terms of additional companions and formation mechanisms.

Contributed talks

Sasha Hinkley University of Exeter	**Early Results from SPHERE: Long-Slit Spectroscopy of a Young Companion Near the Deuterium Burning Limit.** • Wed, 09:20	**P3-11** • I will present new SPHERE long-slit spectroscoy of a ∼12-27 Jupiter mass companion obtained during the Science Verification period in December 2014 at Paranal. This companion, orbiting a very faint ($R \sim 13.6$), nearby, young M-dwarf is a particularly important "bridge" object between the hotter directly imaged planets (e.g. ROXs 42Bb, beta Pic B) and the cooler, planetary mass companions with dusty atmospheres (e.g., 2M1207b, HR 8799bcde). The unique coronagraphic long-slit capability of the IRDIS instrument on SPHERE enables spectral resolution an order of magnitude higher (R ∼350) than other extreme-AO exoplanet imaging instruments (R ∼35). The higher spectral resolution of the SPHERE YJH-band data, when combined with Keck K-band OSIRIS spectroscopy on the same object, has allowed us to fit detailed BT-Settl models providing much stronger constraints on the physical properties of this object than would otherwise be possible with lower resolution spectrographs. Furthermore, this higher spectral resolution allows us to quantitatively measure the strength of the FeH, VO, and KO alkali spectral features, thereby placing strong constraints on the surface gravity. Lastly, my presentation will demonstrate how the remarkable correction achieved with SPHERE (Strehl ratios $\sim 70\%$) on faint stars such as this one (R ∼13.6), will allow extremely powerful, detailed spectroscopic studies of planetary mass companions going forward.
Anne-Lise Maire INAF - Osservatorio Astronomico di Padova	**The SPHERE science capabilities for the study of young brown dwarfs and giant exoplanets** • Wed, 09:35	**P3-12** • The VLT planet finder SPHERE saw first light in early May 2014 and was successfully commissionned during four runs spanning from May to October 2014. During the commissioning, we observed the two young systems of PZ Tel and HD1160 with several imaging and spectroscopic modes. We will discuss the spectral and physical properties of the companions PZ Tel B and HD1160 BC, the orbital parameters of PZ Tel B, and constraints on putative additional companions based on these new data. We will use these results to outline the new science capabilities offered by SPHERE for the study of young brown dwarfs and giant exoplanets, from high-contrast imaging capabilities at optical wavelengths (500-900 nm) to high signal-to-noise spectroscopy in the near-infrared domain (0.95-2.3 μms) from low resolutions (∼30-50) to medium resolutions (∼350).
Jacqueline Faherty Carnegie DTM/AMNH	**The Fundamental Properties of Giant Exoplanet Analogs** • Wed, 09:50	**P3-13** • All directly imaged exoplanets to date have effective temperatures squarely in the brown dwarf regime. Largely that is because they were discovered by targeting stars in nearby moving groups where the planets are still hot and young. Consequently, characterizing the current and future collection of directly imaged planets will greatly benefit from a thorough understanding of the fundamental properties of brown dwarfs in a similar temperature range. To address this outstanding need, our team has compiled a list of all known brown dwarfs with parallaxes and collected all photometric and spectroscopic data on them to create complete SEDs and calculate bolometric luminosities. Within our sample are recently confirmed members of the same moving groups for which the planets belong (young), subdwarfs (old) and generic disk members (middle age). In this talk I will review the diversity of this age calibrated sample in near to mid infrared colors, brightnesses, effective temperatures and luminosities. Importantly I will demonstrate how atmospheric conditions are likely linked with age and drive the largest diversity in the population.
Stanimir Metchev Western University, CPSX	**Brown dwarf variability trends with temperature, gravity, and wavelength** • Wed, 10:05	**P3-14** • In the *Weather on Other Worlds* Spitzer Exploration Science program, we surveyed 44 nearby L3-T8 dwarfs for spot-induced rotational variability. Among single L dwarfs, we found that 80% are variable at $> 0.2\%$ in the 3-5 μm wavelength range, while 36% of T dwarfs are variable at $> 0.4\%$. Taking into account viewing angle and sensitivity considerations, these findings are consistent with spots being present on ∼100% of L dwarfs and on the majority of T dwarfs. We observe an increase in the maximum amplitudes over the entire spectral type range, revealing a potential for greater temperature contrasts in T dwarfs than in L dwarfs. From ancillary 0.8-2.2 μm observations, we find evidence for greater variability at shorter wavelengths, with T dwarfs exhibiting amplitudes of 0.5-5% in the near-infrared and $> 10\%$ in the I band. We also find a tentative association between low surface gravities and high-amplitude variability among L3-L5.5 dwarfs. Although we can not confirm whether lower gravity is also correlated with a higher incidence of L dwarf variables, the result is promising for the characterization of directly imaged young extrasolar planets through variability.
Timothy Brandt Institute for Advanced Study	**A Statistical Analysis of SEEDS and Other High-contrast Exoplanet Surveys: Massive Planets or Low-mass Brown Dwarfs?** • Wed, 12:00	**P3-15** • I will present the results of a combined statistical analysis of SEEDS and other high-contrast imaging surveys. The sample includes nearly 250 stars with a wide range of ages and spectral types, and five detected substellar companions. We have conducted a uniform, Bayesian analysis of all stellar ages using both membership in a kinematic moving group and activity/rotation age indicators, and have derived a new statistical method for computing the likelihood of a substellar distribution function. By performing most of the integrals analytically, we achieve an enormous speedup over brute-force Monte Carlo. We have used this method to place upper limits on the maximum semimajor axis of the distribution function derived from radial-velocity planets, finding model-dependent values of $\sim 30 - 100$ AU. Finally, we have modeled the entire substellar sample, from massive brown dwarfs to a theoretically motivated cutoff at ∼5 M_{Jup}, with a single power-law distribution. We find that p(M, a) $\sim M^{-0.65\pm0.60}\ a^{-0.85\pm0.39}$ (1-σ errors) provides an adequate fit to the data, with 1.0%-3.1% (68% confidence) of stars hosting $5 - 70\,M_{Jup}$ companions between 10 and 100 AU. This suggests that many of the directly imaged exoplanets known, including most (if not all) of the low-mass companions in our sample, formed by fragmentation in a cloud or disk, and represent the low-mass tail of the brown dwarfs.

Contributed talks

Eric Nielsen SETI/Stanford	**Early Measurements of the Intermediate Semi-Major Axis Giant Planet Occurrence Rate from GPIES** • Wed, 12:15	**P3-16** • Giant planets at intermediate semi-major axes (∼4-40 AU) have up to now been largely inaccessible to both radial velocity and previous direct imaging surveys, and so the architecture of planetary systems in these regimes has been mostly unknown. The Gemini Planet Imager Exoplanet Survey is one of the first campaigns with the necessary instrumentation and sample size required to reliably detect and characterize giant planets at these separations. Having observed 100 of the 600-star target list GPIES is already surpassing many previous surveys in terms of sensitivity to shorter-period and lower-luminosity planets and number of stars observed. We combine previous direct imaging surveys such as the Gemini NICI Planet-Finding Campaign with early results from GPI, and describe what limits can be placed on occurrence rate of large- and intermediate-separation giant planets based on the stars observed to date.
Michael Line UC Santa Cruz	**Atmospheric Retrieval on Directly Imaged Planets** • Wed, 12:30	**P3-17** • Determining the properties of directly imaged planet atmospheres is key to understanding the chemical processes occurring in the their atmospheres, their thermal structures, and their formation environment. Atmospheric retrieval has recently proven to be a powerful tool for extracting the temperatures and compositions from both transiting extrasolar planet and brown dwarf atmospheres, free from the assumptions made in standard grid modeling approaches. I will present state of the art retrieval results on synthetic data that is of similar spectral resolution and noise properties of today's instruments in order to determine the constraints we can expect on temperatures and abundances. First I will explore to what degree and significance we can constrain molecular absorbers such as water, methane, ammonia, clouds, gravity, and thermal structure in the spectra. Furthermore I will discuss what impacts systematic uncertainties, such as photometric calibration or offsets in adjacent spectral windows, can have on the retrieved results.
Emily L. Rice CUNY College of Staten Island and AMNH	**A New Method for Characterizing Very-Low-Mass Companions with Low Resolution Near-Infrared Spectroscopy** • Wed, 12:45	**P3-18** • We present a new and computationally efficient method for characterizing very low mass companions using low resolution (R ∼30) near-infrared (YJHK) spectra from high contrast imaging campaigns with integral field spectrograph (IFS) units. We conduct a detailed quantitative comparison of the efficacy of this method through tests on simulated data comparable in spectral coverage and resolution to the currently operating direct imaging systems around the world. We present results from comparing simulated spectra of M, L, and T dwarfs with a large and finely-sampled grid of synthetic spectra from atmosphere models using Markov Chain Monte Carlo techniques. We determine the precision and accuracy of effective temperature and surface gravity inferred from fits to synthetic spectra and compare results to spectral type-effective temperature relationships from the literature and to surface gravity predictions from evolutionary models. Single-band spectra (i.e., narrower wavelength coverage) result in larger uncertainties and often discrepant results, suggesting that high contrast IFS observing campaigns can compensate for low spectral resolution by expanding the wavelength coverage for reliable characterization of detected companions.

Formation, architecture, and dynamics of planetary systems

Paul Kalas
UC Berkeley

New results on the Fomalhaut system using HST/STIS
• Thu, 11:30

P4-01 • The highly eccentric orbit discovered for Fomalhaut b leads to the hypothesis that the system is recently dynamically disturbed. However, it is not known if the dynamical upheaval originated from planet-planet perturbations interior to the system, or by interactions involving the stellar companions Fomalhaut B (TW PsA) and/or Fomalhaut C (LP 876-10) exterior to the system. Here we present the results of two experiments using HST/STIS that empirically test the upheaval hypothesis. First, for planet-planet scattering, we expect that Fomalhaut A's ice line belt at 10 AU may have a perturbed morphology. We therefore used short exposure times with HST/STIS to image this region as close as 1.3 arcseconds (10 AU) from the star. Second, if Fomalhaut C had a recent close stellar flyby with Fomalhaut A, then the Herschel-detected debris disk surrounding Fomalhaut C would have a perturbed morphology. We therefore obtained the first coronagraphic data of Fomalhaut C with HST/STIS. Our results demonstrate that a hypothetical past epoch of dynamical upheaval that is inferred to occur in the evolution of planetary systems can be directly observed at the present epoch in the Fomalhaut system.

Max Millar-Blanchaer
University of Toronto

Beta Pictoris as seen by the Gemini Planet Imager: a polarized disk detection and multi-epoch astrometry of the directly imaged planet
• Thu, 11:45

P4-02 • The study of the Beta Pictoris system provides a rare opportunity to directly study the dynamical relationship between an exoplanet and a debris disk. An ongoing debate concerns whether or not Beta Pic b and the inner mid-plane warp are causally connected. Here, we present H-band observations of Beta Pictoris as seen with the Gemini Planet Imager's polarimetry mode that reveal the debris disk in polarized light at angular separations between $0.3''$ and $1.9''$, while simultaneously recovering Beta Pic b in unpolarized light. We fit the polarized disk image with a dust density described by a radial power law and a Henyey-Greenstein scattering function and find that the image is well represented by an inclined disk (i $\sim$85.8) with a position angle of $\sim$30.4 degrees (when marginalized over the model nuisance parameters). Further, we present an updated orbital fit for the planet, Beta Pictoris b, using astrometric measurements obtained with the Gemini Planet Imager's spectroscopy mode over 9 epochs that span 1.25 years. The planet's orbit is found to have an inclination of $\sim$88.8 degrees and a line of nodes at a position angle of $\sim$31.4 degrees. By including the recent radial velocity measurement of Beta Pictoris, we are able to constrain the argument of the periapsis for the first time. The inclination and position angle of the disk relative to the planet's orbit will inform dynamical models of the evolution of the system and will put constraints on the properties and/or presence of other massive bodies in the system.

Erika Nesvold
University of Maryland, Baltimore County

A Unified Model for the Submillimeter Observations of the beta Pictoris Debris Disk
• Thu, 12:00

P4-03 • The beta Pictoris debris disk exhibits several features in infrared and submillimeter observations. We present a 3D collisional model of the disk and planet system. Secular perturbations due to the planet's measured inclination and eccentricity can explain the observed warp and planetesimal ring, while collisions between planetesimals shape the disk by eroding close-in material. The complex 3D structure of the disk due to the perturbations from the planet create an azimuthally asymmetric distribution of collisions, which could contribute to the observed azimuthal clumping in the dust and gas distributions.

Properties of debris/protoplanetary disks and relation to models

Jun Hashimoto Astrobiology Center, NINS	**Near-Infrared Polarimetric Imaging Survey of Protoplanetary/Transitional Disks in the Subaru/SEEDS project** • Thu, 14:40	**P5-01** • SEEDS is a strategic project in the Subaru telescope exploring exoplanets and circumstellar disks around 500 stars in the near-infrared wavelengths. The project has started in 2009 and been completed in 2015. Here, we review the project and summarize the major results especially in the survey of protoplanetary disks by near-infrared polarimetric imaging. In observing protoplanetary disks, we mainly focus on transitional disks known as a protoplanetary disk with a cavity in a central region of a disk. Disk-planet interaction would be one of intriguing interpretations potentially responsible for such a cavity-stracture. Thus, transitional disks would be unique samples for understanding planet formation in a disk. As results of tens of observations in transitional disks, we have resolved fine structures in disks such as spirals, gaps, and dips at a radius of tens AU possibly due to gravitational interactions with unseen planet(s). These results may support planet formation at a wide orbit, e.g., GJ 504 b at 43 AU. We also found differences in structures of a cavity observed in the near-infrared and (sub-)millimeter wavelengths, i.e., a clear cavity in (sub-)millimeter wavelengths while a smaller cavity in near-infrared wavelengths. The different behavior between small (sub-micron size) and large (millimeter size) dust grains would be consistent with disk-planet interaction plus dust filtration. Finally, we mention our results of disk demographics in tens of transitional disks based on SEEDS data.
Carsten Dominik University of Amsterdam	**First results from the SPHERE disk observation program** • Thu, 14:55	**P5-02** • SPHERE has started normal operations in April 2015 and has obtained data during commissioning runs, SVT runs, and through the first GTO and open time programs. SPHERE provides unprecedented resolution images of circumstellar disks in the optical and near-IR, using ADI, PDI and RDI techniques. I will summarize results from observations of several disks including MWC758 and SAO 206462, both of which show prominent spiral structure in addition to circular features around the star. I will also discuss the formation mechanism of these spiral structures.
Henning Avenhaus Universidad de Chile	**Unleashing SPHERE - a case study featuring HD142527** • Thu, 15:10	**P5-03** • HD142527 is one of the most intriguing Herbig Ae/Be transitional disk systems, featuring the largest known dust-depleted gap of any such system (out to $\sim$130 AU) and a massive outer disk with complex structure. The disk has been observed with a plethora of different instruments from the visible and near-infrared through the mid- and far-infrared out to the (sub-)mm and cm-wavelengths. In my talk, I will present very recent data from the new next-generation extreme-AO instrument SPHERE, showcasing some of the new capabilities that SPHERE offers for high-contrast imaging of circumstellar disks. The data presented was taken with the ZIMPOL and IRDIS sub-instruments of SPHERE during commissioning and early GTO observations. They shed new light on this complex and well-studied disk, revealing intriguing new detail thanks to the very high resolution and contrast capabilities of SPHERE. While the near-infrared probes the outer disk and shows spiral patterns in great detail, new ZIMPOL PDI data are able to probe the surroundings of the star down to $0.04''$ ($\sim$6 AU), revealing for the first time the inner disk structure in scattered polarized light. The inner disk has recently been proposed to be responsible for the two prominent in the outer disk. They also show these nulls and the rim of the outer disk at high signal-to-noise and in never-before seen detail. I will put all these new observations into the context of this transitional disk, connecting it to the work of others in the field and their results at similar and longer wavelengths. I will discuss what we can learn from these new observations and will point out open questions yet to be answered. At the same time, I will discuss what we have learnt from SPHERE and how this new instrument can help us understand the nature of circumstellar disks. Depending on the results of the SPHERE GTO campaign acquired in the meantime, I might also touch briefly on other examples of circumstellar disks.
Christian Thalmann ETH Zurich	**The true face of the LkCa 15 planet-forming disk** • Thu, 15:25	**P5-04** • Within the exciting field of protoplanetary disk studies, LkCa 15 is among the most exciting targets, featuring a young solar analog as its star, a pre-transitional disk with a gap large enough to fit all solar system planets, ongoing stellar accretion, and claims of a protoplanet caught in the act of formation. We present our newest results from high-contrast imaging, including imaging polarimetry with SPHERE ZIMPOL at unprecedented angular resolution, which shed light on long-standing open questions regarding the system.

Contributed talks

Glenn Schneider The University of Arizona	**Revealing the Outer Reaches of the HR 4796A Debris System with HST/STIS Visible-Light Coronagraphy** • Thu, 16:10	**P5-05** • Visible-light corongraphy with the Hubble Space Telescope Imaging Spectrograph (STIS; the last HST coronagraph now operational) continues to deliver new and important optical broadband images of starlight-scattering circumstellar debris systems (CDSs) that trace the spatial distribution of the small starlight-scattering particles in these systems. These high-contrast, high-resolution, and high-fidelity CDS images are in observational domains of wavelength and stellocentric angles that are both symbiotic to, and unique from, complementary capabilities provided by the latest generation of ground-based extreme adaptive optics systems. Herein we report the first results of an in-progress STIS imaging survey of five ring-like debris disks (GO program 13786) following a prior ten target survey program (GO 12228; Schneider et al 2014) utilizing similar and (since) augmented technical capabilities. We focus on new (preliminary) deep imaging results for the HR 4796A CDS that clearly unveil a large, highly asymmetric, debris structure in which the well-imaged debris ring is embedded. The presence of a population of small (posited micron size) particles beyond the ring ansa were previously only hinted at in earlier shallow depth HST and ground-based AO imaging of the ring itself, but now is firmly established. An outer truncation of this extended CDS on only one side of the star (in the direction of its $8''$ distant M-star companion), that extends to $\sim 10''$ (730 AU) is apparent in even only a preliminary (yet incomplete) data set. In light of other such structures seen in ring-like CDSs revealed with HST/STIS coronagraphy (several others which we also discuss here), these be common features in debris systems, though a challenge to discern with contemporary ground-based AO imaging.
Timothy Rodigas Carnegie Institution of Washington	**High-Contrast Imaging of Circumstellar Disks with MagAO and GPI** • Thu, 16:25	**P5-06** • Circumstellar disks offer clues to nearby, otherwise-hidden planets. In the late stages of planet formation (the *debris disk* phase), the morphology of the disk (sharpness, width, offsets) can be used to place constraints on the shepherding planet's mass and orbit. The chemical composition of the scattering dust grains can tell us about the inventory of life-essential building blocks (water, organics). In the early stages (*protoplanetary disk* phase), young forming planets can create spirals and gaps which can be readily observed. In this talk, I will present recent high-contrast imaging results on the debris disk around HR 4796A with MagAO, and the transition disk around HD 142527 with GPI (Early Science). For HR 4796A, we find that the ring is offset and narrow (14%, 11 AU), which precludes the existence of planets more massive than 4 M_{Jup}. We model our new scattered light images and test more than 8400 unique dust grain compositions, finding that the best matches are silicates and organics, with low abundances of water ice. For HD 142527, we easily detect the low-mass stellar companion (at separation $< 0.1''$) in Y band total intensity and for the first time also detect an offset source of polarized light, which is most likely infalling dust. Thus HD 142527 offers a scaled-up version of in-situ planet formation.
Michael Fitzgerald UCLA	**Debris Disk Imaging in the GPI Exoplanet Survey** • Fri, 09:05	**P5-7** • The Gemini Planet Imager is designed to be sensitive to light scattered by small dust grains orbiting bright nearby stars. Its dual-channel polarimeter provides a significant gain in contrast relative to the typically unpolarized starlight. The Gemini Planet Imager Exoplaet Survey is targeting 600 young nearby stars, aiming for direct detection of exoplanets. A subset of these stars are known or suspected to host dusty circumstellar debris disks. Structures in the distribution of circumstellar debris can inform properties of the underlying planetary system. I will describe the effort within the survey to detect the dust-scattered light in these disks in both unpolarized and linearly polarized light, I will give details on the subsample of stars we are targeting for measurement in the polarimetric mode and the achieved sensitivity. Finally, I will also highlight some initial results from this effort.
Julien Milli ESO	**The intriguing scattering properties of the HR4796 disk** • Fri, 09:20	**P5-08** • HR4796A is surrounded by a well-structured and very bright debris disc, shaped as an annulus with many interesting features: very sharp inner and outer edges, brightness asymmetries, center offset and suspected distortions in the ring. Combining data from VLT/SPHERE, VLT/NaCo and HST/NICMOS we reveal a very peculiar brightness asymmetry between polarized and unpolarized light. We retrieve the phase function of the dust over a wide range of scattering angle and interpret it in terms of dust composition. We analyse the morphology of the ring and constrain the dust radial distribution thanks to the spatial resolution provided by VLT/SPHERE.
Jozua de Boer Leiden Observatory	**SPHERE/ZIMPOL imaging of the circumstellar disk of BP Psc** • Fri, 09:35	**P5-09** • BP Psc was classified as a Classical T Tauri Star (CTTS), but recent studies suggest that it is more likely to be an evolved star. This uncertainty in our knowledge of the evolutionary stage of BP Psc has led to diversity of interpretations of its circumstellar disk structure including suggestions of ongoing or recently completed planet formation. We observed BP Psc with VLT/SPHERE/ZIMPOL during the Science Verification period. The disk is clearly detected in polarized intensity as well as in total intensity, for the first time at visible wavelengths. A comparison of radiative transfer models and the observed polarized intensity image reveals a disk at an inclination where the direct starlight grazes the disk surface. This configuration is extremely sensitive to disk irregularities transiting the star, which might explain the observed variability of BP Psc and constrain its distance and evolutionary stage.
Jason Wang UC Berkeley	**Imaging the AU Microscopii Debris Disk at Close Separations with the Gemini Planet Imager** • Fri, 09:50	**P5-10** • We present Gemini Planet Imager (GPI) observations of AU Microscopii, a young star with a previously imaged debris disk. The data were taken during the commissioning of GPI using both integral field spectroscopy and broadband imaging polarimetry. Using our integral field spectroscopy data, we present constraints on the mass of possible planets around AU Microscopii. In our broadband imaging polarimetry observations, we detect the disk only in total intensity at separations between $\sim 0.2''$ to $\sim 2''$ from the star. We discover asymmetries in the disk morphology and surface brightness between the southeast and northwest sides of the disk and discuss possible explanations such as planet-disk interactions and inclination effects.

Contributed talks

Jamie Lomax University of Oklahoma	**AU Mic's Debris Disk Chemistry Revealed Using Coronagraphic Spectroscopy** • Fri, 10:05	**P5-11** • We present the first coronagraphic spectroscopy of the AU Mic debris disk system obtained with HST/STIS as part of GO-12512. Spectra of the system were taken by placing a long slit in the disk direction while blocking out the central star with an occulting bar. A naked star of similar spectral type was likewise observed for a PSF subtraction. This procedure results in a two dimensional spectrum as a function of disk position between 5200 and 10,200 angstroms for the system. We report the results of these AU Mic spectra, which have been used to determine the cold dust grain composition by characterizing the system's color as a function of radial distance along the disk's midplane. In addition, we compare the spectra on either side of the disk in order to probe the presence of any compositional and structural asymmetries. This reveals the dynamical perturbations and chemical processing occurring within the disk and traces the potential composition and architecture of any planetary bodies in the system.
Anthony Boccaletti LESIA - Paris Observatory	**Unexpected structures in a young circumstellar disk** • Fri, 10:20	**P5-12** • During the commissioning of SPHERE in 2014, we discovered in a circumstellar disk, a chain of enigmatic large-scale structures, spanning several AUs. The very peculiar morphologies we observed were never reported previously in such systems, and raise a lot of questions regarding the possible origin and the mechanisms at play in this system. We will present the SPHERE images, and will discuss the properties of these structures in particular their locations and temporal evolution over several years owing to comparison with earlier HST images. As a result, these observations reveal unexpected behaviors of structures in a circumstellar disk. Finally, we will propose some hypotheses to account for the presence of these structures, some involving the presence of a planet orbiting the star.
Élodie Choquet STScI	**Four more detections from the NICMOS archive: Newly seen debris disks around several M dwarfs and a young Solar Twin** • Fri, 10:35	**P5-13** • We recently resolved four more debris disks seen for the first time in scattered-light by our reprocessing of HST-NICMOS archival data, as part of our project *Archival Legacy Investigations of Circumstellar Environments* (ALICE). The disks are detected around three adolescent ($4 - 100$ Myr) late-type stars (M3-K6) and one 220 Myr old solar twin. These four detections add up with the five debris disk published in Soummer et al. 2014, bringing the total number of debris disks seen in scattered light from 18 to 27 from (a 50% increase) thanks to our ALICE project. Furthermore, with only the disk around the M dwarf AU Mic imaged so far, our detections quadruple the sample of debris disks around late-type stars observed in scattered light. Several reasons have been proposed and debated so far to explained the relatively low number of detections around this type of stars: gravitational binding lesser than more massive stars, lesser radiation pressure, presence of stellar wind that can perturb the dust. In this communication we will present the detection images and the morphological analysis of the disks. We will also discuss the low number of disks detected around M-type stars in the light of these new detections.
Matthew Kenworthy Leiden Observatory	**A Transiting Extrasolar Ring System: Indirect Evidence for Exosatellite Formation?** • Fri, 11:50	**P6-01** • The young star 1SWASP J140747.93-394542.6 ("J1407") is a 16-million-year-old pre-main sequence star in Sco-Cen, the nearest OB association. In 2012, we reported that time series photometry data from the SuperWASP and ASAS programs show that the star J1407 had a series of extremely complex eclipses over a two-month span in early 2007, with $\sim$95% of the star's light blocked out near minimum. The star J1407 shows no evidence for accretion nor any circumstellar disk blueward of the WISE4 IR band. The eclipses have been modeled as due to a set of (at least 30) concentric dust rings with total mass of approximately 1 Earth mass, with radii ranging from approximately 30-90 million km. There is at least one very clean gap in the ring system at radius $\sim$0.4 AU which may be cleared by a sub-Earth-size exosatellite. While popularly described as a "super-Saturn" with "rings", given the age of the system, and the size and inferred mass of the rings, it seems plausible that we are detecting a circumplanetary (or protoexosatellite) disk. The disk would appear to fill a non-negligible fraction of its Hill radius, and the appearance of gaps would suggest that system is in the process of spawning exosatellites. I will summarize the current knowledge about the J1407 system: including archival and on-going photometric searches for additional eclipses, imaging and Doppler constraints on the companion of the ringed companion, and future prospects for discovering eclipsing disks girding young exoplanets and substellar objects.

Future facilities and opportunities

Jérémy Lebreton IPAC / Caltech	**Debris disks observations with the JWST/NIRCam coronagraph** • Fri, 12:05	**P6-02** • Main sequence stars are hosts to dusty debris belts that provide unique insight on planetary systems. Coronagraphic observations with the Near-Infrared Camera (NIRCam) on the James Webb Space Telescope (JWST) will enable great progress in debris disk science by looking at light scattered by Kuiper Belt analogues in the 2 to 5 μm region with revolutionary sensitivity. We construct models for a sample of 8 high priority debris disks targets including both detailed dust properties derived from SED fitting and spatial profiles based on existing optical imaging from HST and from the ground. We then simulate coronagraphic observations with the NIRCam coronagraph using models from the WebbPSF software and including in particular the effect of wave-front error, PSF-subtraction residual, background and photon noise. We show that NIRCam will resolve fine structures in debris disks in multiple bands, and that it has the potential to detect features such as the water band at 3 μm using medium-band filters, thus confirming indirect evidence for icy extraterrestrial bodies. We predict the mass and separation of putative disk-sculpting exoplanets and test the capability of JWST to directly image them. Finally, we also discuss the importance of coordinated observations with the MIRI instrument to characterize fully debris disks and planets via the combination of scattered and thermal emission.
Alexandra Greenbaum Johns Hopkins University	**Overview of Aperture Masking Science on NIRISS** • Fri, 12:20	**P6-03** • The Near-IR Imager and Slitless Spectrograph (NIRISS) on the the James Webb Space Telescope (JWST) will contain a 7-hole non-redundant mask in its pupil that will provide interferometric resolution with good dynamic range. NIRISS aperture masking interferometry (AMI) will provide an order of magnitude better contrast than ground-based aperture masking, enabling the detection of lower mass young jovian planets at the highest resolution available to JWST at the near-IR wavelengths. Coupled with three medium band filters from 3.8-4.8 μm, it will be able to penetrate dust providing exoplanet and disk science at small inner-working angles. Current ground-based aperture masking detections rely on measuring closure phase quantities to bypass atmospheric corruption of fringe phase and amplitudes. JWST will provide the stability to reliably measure both fringe phases and amplitudes to measure both symmetric and asymmetric structures for full image reconstruction. I will discuss NIRISS-AMI science, such as following up ground extreme-AO discoveries, precision wide-field astrometry of massive planet and brown dwarf companions detected by GAIA, and studying feedback at the few to several parsec scale in active galactic nuclei.
Wesley A. Traub JPL	**Expected Exoplanet Detections with the WFIRST-AFTA Coronagraph** • Fri, 13:45	**P6-11** • Current models of the Hybrid Lyot, Shaped Pupil, and PIAA coronagraphs are applied to the known as well as expected range of exoplanets around nearby stars to produce the currently-expected science yield for the coronagraph instrument on the WFIRST-AFTA mission.The coronagraph models are updated from those presented in the WFIRST-AFTA 2015 Report.The expectation for new planets is likewise updated, based on ongoing estimates of the population of planets from the Kepler sample.The expected science yield will be presented in terms of specific nearby stars, broken down by type of star, type of planet radius, and type of orbit.The potential for enhancing the science yield by carrying out radial velocity observations prior to the mission will be quantified.
John Trauger JPL - Caltech	**Managing the wavefront for high contrast exoplanet imaging from space** • Fri, 14:00	**P6-04** • The prospect of extreme high contrast astronomical imaging from space has inspired developments of new coronagraph methods for exoplanet imaging and spectroscopy. However, the requisite contrast, at levels of a billion to one or better for the direct imaging of cool mature exoplanets in reflected starlight, leads to challenging new requirements on the stability and control of the optical wavefront, at levels currently beyond the reach of ground based telescopes. We briefly review the designs, laboratory validations, and science prospects for direct imaging and spectroscopic characterization of exoplanet systems with an actively corrected Lyot coronagraph. We review exoplanet science performance predicted for NASA's AFTA/WFIRST coronagraph, as well as smaller dedicated space coronagraphs. Together with a pair of deformable mirrors for optical wavefront control, the Lyot coronagraph creates high contrast dark fields of view extending to within angular separations of 2.5 lambdFAD from the central star at visible wavelengths. Performance metrics are presented, including image contrast, spectral bandwidth, overall efficiency and throughput, and laboratory demonstrations.
Mamadou N'Diaye Space Telescope Science Institute	**New coronagraph designs to study habitable worlds with future large space** • Fri, 14:15	**P6-05** • The Apodized Pupil Lyot Coronagraph (APLC) was implemented on Gemini/GPI, VLT/SPHERE, and Palomar/P1640 with the primary goal to observe self-luminous gas giant planets around nearby stars. These coronagraphs design reach contrast levels of 10^7 at $0.2''$ from the host star. Future envisioned space missions with high-contrast capabilities (e.g., WFIRST-AFTA, EXO-C/S, LUVOIR) will extend the discovery space of exoplanets and eventually, observe habitable worlds around nearby stars in broadband light. One of the key issue for the observation of such companions is designing a coronagraph that achieves at least 10^{10} contrast in the presence of pupil features such as large central obstruction, support structures, and/or primary mirror segmentation. We found novel coronagraphic designs combining APLC and shaped pupils (SP) to produce PSF dark holes with 10^{10} raw contrast at 4 λ/D over 10% bandpass with a segmented, on-axis aperture. Based on existing technologies and derived from shaped-pupil type optimization, these new designs solve a critical issue for the observation of habitable worlds with future large missions. We derive an estimate of the exo-earth yield with our coronagraph for different telescope sizes. We finally identify levers on the coronagraph properties to push the limits even further and increase the number of observable exo-earths. These new APLC/SP solutions will be implemented on the new HiCAT testbed at STScI.

Contributed talks

N. Jeremy Kasdin Princeton University	**The WFIRST-AFTA Coronagraph Instrument** • Fri, 14:30	**P6-06** • The acquisition by NASA of the 2.4 m Astrophysics Focused Telescope Asset (AFTA) allowed for the addition of a coronagraph to the Wide Field Infra-Red Space Telescope Mission (WFIRST). The WFIRST mission has a robust portfolio of science including dark energy, exoplanet statistics via gravitational microlensing, exoplanet imaging, and a general observer program. In particular, the Coronagraph Instrument (CGI) in the observatory will have the capability of exoplanet imaging and spectroscopy of planets down to mini-Neptunes. After a rigorous selection process in 2013, two coronagraph types were selected for the instrument, the Shaped Pupil (SPC) and the Hybrid Lyot (HLC) with a third, Phase Induced Amplitude Apodization-Complex Mask Coronagraph (PIAA-CMC) selected as a backup. All three are now in technology development and testing at the Jet Propulsion Laboratory (JPL). This talk will describe the instrument and how the two coronagraphs are integrated into a complementary design that maximizes efficiency and planet yield and fits into the overall WFIRST architecture. It will also describe the backup approach using PIAA and how it could potentially enhance science. Progress in the laboratory and in modeling of the telescope system and its impact on the coronagraph will be described.
Karl Stapelfeldt NASA Goddard Space Flight Center	**Exo-C: A probe-scale space observatory for direct imaging and spectroscopy of extrasolar planetary systems using an internal coronagraph** • Fri, 14:45	**P6-07** • Exo-C is NASA's first community study of a modest aperture space telescope optimized for high contrast observations of exoplanetary systems. Over its 3 year mission Exo-C will take optical spectra of nearby exoplanets in reflected light, discover previously undetected planets, and image structure in a large sample of circumstellar disks. It will obtain unique science results on planets down to super-Earth sizes and serve as a technology pathfinder toward an eventual flagship-class mission to find and characterize habitable Earth-like exoplanets. We present the mission/payload design and its science yield, highlighting steps to reduce mission cost/risk relative to previous mission concepts. Key elements are an 1.4 m unobscured telescope aperture, an internal coronagraph with deformable mirrors for precise wavefront control, and an orbit and observatory design chosen for high thermal stability. Exo-C has a similar telescope aperture, orbit, lifetime, and spacecraft bus requirements to the highly successful Kepler mission (which is our cost reference). The needed technology development can be completed for a mission start in 2017, should NASA decide to proceed. This paper summarizes the study final report completed in March 2015. Key accomplishments include excellent modeled telescope stability, a telescope and instrument design that is optimal for internal coronagraphy, and fitting the mission into the prescribed cost cap.
Christopher Mendillo Lowell Center for Space Science and Technology	**Optical Design and Tolerancing for the PICTURE-C Balloon Mission** • Fri, 15:00	**P6-08** • The PICTURE-C mission will fly a 60 cm off-axis unobscured telescope and two high-contrast coronagraphs in successive flights with the goal of directly imaging and spectrally characterizing visible scattered light from exozodiacal dust in the interior 1-10 AU of nearby exoplanetary systems. The first flight in 2017 will use a 10^{-4} visible nulling coronagraph (previously flown on the PICTURE-B sounding rocket) and the second flight in 2019 will use a 10^{-7} vector vortex coronagraph. A low-order wavefront corrector will be used to remove large amplitude and time-varying aberrations from the telescope wavefront. A high-order 1024 element deformable mirror in the coronagraph will be used to create the high-contrast dark hole. This presentation will detail the design and tolerancing of the telescope and coronagraph optics. End-to-end PROPER simulations are used to address the effects of surface and reflectivity non-uniformities, beam walk, and low-order, time-varying aberrations caused by thermal and mechanical stresses in the balloon environment.
Alexis Carlotti IPAG	**Estimating the performance of the high-contrast imaging mode of E-ELT/HARMONI** • Fri, 15:15	**P6-09** • Thanks to a higher spectral resolution than those of the current direct imaging instruments like GPI and SPHERE, HARMONI's high-contrast imaging mode will be a key asset to improve our understanding of how planets form and evolve. Its achievable contrast levels will depend on several factors: the characteristics of the E-ELT aperture, the performance of the adaptive optics system, the coronagraphs used in HARMONI, and the differential imaging techniques that will be used on the data. We present the results of exhaustive simulations that we have conducted to estimate the contrast levels than can be achieved with HARMONI.
Christian Marois National Research Council of Canada Herzberg	**The 30 m Era: TMT first light performances** • Fri, 15:25	**P6-10** • All three 30 m class telescopes have one thing in common: no dedicated first light exoplanet imaging/characterization instrument. The potential for 30m class telescopes is enormous, given the smaller inner working angle and D^2 advantage, opening a vast array of new science capabilities. I will discuss the various steps we have been taking to 'bend' the first generation TMT adaptive optics/IFS NFIRAOS/IRIS instrument design to allow improve exoplanet science at first light. I will also present ideas to complement these performances with a visitor-class instrument.

Instrumentation, tools and techniques

Thierry Fusco	**On-sky improvement, optimisation and final performance of SAXO, the SPHERE extreme AO system** Mon, 10:10 • P1-1	The aim of the Spectro-Polarimetric High-contrast Exoplanet Research (SPHERE) instrument is to detect extremely faint astronomical sources (i.e., giant extra-solar planets) in the vicinity of bright stars. The detection capabilities of an exoplanet hunter are largely controlled by its adaptive optics (AO) system. Better AO correction provides improved coronagraph extinction and fewer residual defects. The challenging SPHERE science goals require a very high-order performance AO system to feed a quasi-perfect flat wave front, corrected for atmospheric turbulence and internal defects, to the scientific instruments. In May 2014 SPHERE was installed on the third unit telescope (Melipal) of the Very Large Telescope (VLT) in Chile. After four months of extensive and comprehensive tests (for robustness, performance, and ease of use) the instrument is now available to the astronomical community for observations (until April 2015). The AO system on the instrument is known as the Sphere AO for eXoplanet Observation (SAXO) and is the 'heart' of the instrument, which 'beats' 1200 times per second to provide unprecedented image quality from a large ground-based telescope operating at optical/near-IR (NIR) wavelengths. As such, SPHERE presents tremendous potential for exoplanet discoveries. We present here the various improvements and optimisations implemented on SAXO and its environment during the four SPHERE commissioning runs in order to achieve the ultimate AO performance. In a few months we went from the first 75 % SR (H band) max value, obtained in COM1, up to more than 90% routinely achieved now. Combining IRDIS scientific data and SAXO telemetry (high frame rate residual slopes and voltages, low frequency IR WFS pixels) obtained during the AIT period in Europe, the four commissioning runs as well as the Science Verification Period, a comprehensive view of SAXO performance is proposed. Ultimate performance, evolution with respect to the atmospheric conditions and to the GS flux are described and analysed. Comparisons with end-to-end simulations and predicted performance show that SAXO meets (and for some of them exceed) its initial requirements.
Eric Pantin	**Performances of the Speckle Interferometry applied to Mid-IR VISIR data** Mon, 10:11 • P1-2	VISIR is the VLT mid-infrared instrument that just underwent a major upgrade. Amongst the various modes offered, the rapid imaging (so-called 'Burst Mode') mode is able to record frames at timescales between 10 and ∼50 ms. At such a frame rate, the turbulence when observing around a wavelength of 10 um can be considered as frozen, which allows to use the speckle analysis to estimate visibilities of the target and get some spatial information down to a theoretical limit of 0.5 λ/D. In this paper, we will present the burst mode also as the analysis developed specifically to VISIR imaging data. From simulated observations of binaries and protoplanetary disks, we estimate the performances of this observing technique to detect faint companions or angularly resolve structures in protoplanetary disks. Finally, an example of resolved protoplanetary disk will be shown and compared to standard imaging analysis.
Eric Pantin	**The New High Angular Resolution modes of the VLT/VISIR instrument** Mon, 10:12 • P1-3	The New high angular resolution mode of the VLT/VISIR instrument VISIR is the VLT mid-infrared instrument that just underwent a major upgrade. Two new modes modes dedicated to high angular resolution have been implemented in the instrument. The first one is phase-masks coronagraphy based on two difference phase masks of two types; one four-quadrants phase mask (4QPM, Rouan et al., 2007), and one Annular Groove Phase mask vortex-type mask (Mawet et al., 2005; Delacroix et al., 2012). The second one is a Sparse Aperture Masking (SAM) interferometric mode which brings spatial information on frequencies down to 0.5 λ/D. We will present the concepts and the implementation of these modes and show preliminary performances results based on the commisionning of these modes, with focus on the study of protoplanetary disks.
Markus Kasper	**On-sky compensation of quasi-static speckles with SPHERE** Mon, 10:13 • P1-4	The Spectro-Polarimetric High-contrast Exoplanet REsearch (SPHERE) instrument has been installed at the VLT in spring 2014. By combining XAO and coronagraphy, SPHERE achieves imaging contrasts of the order of one part in a million at a few hundred milliarcseconds separation. One major contributor limiting this contrast are quasi-static speckles (QSS) internal to the instrument. We present an implementation of the electric field conjugation (EFC) method for SPHERE reducing the QSS by one order of magnitude, and on-sky tests confirming the end-to-end efficiency of the method for ground-based high-contrast imaging.

Posters

Christian Delacroix	**The Subwavelength Grating Vortex (SGV): optimized design, manufacturing and next generation devices** Mon, 10:14 • P1-5	The subwavelength grating vortex (SGV) is a focal-plane phase mask whose key benefit is to allow high contrast imaging at small angles. Directly etched onto a diamond substrate, it is well suited to perform in the infrared domain. The vortex provides a continuous helical phase ramp with a singularity in its center, and is characterized by its number of phase revolutions, called the topological charge. Since 2005, we have been developing an SGV2 (vortex of charge 2), referred to as the Annular Groove Phase Mask (AGPM). In the last three years, several science-grade mid-infrared AGPMs have been produced, validated on coronagraphic test benches, and installed on state-of-the-art diffraction-limited infrared cameras, namely VLT/NACO, VLT/VISIR, LBT/LMIRCam, and Keck/NIRC2. In this talk, I will give an overview of the development of current and next generation SGV coronagraphs. I will first detail how these vortices are designed and simulated with rigorous coupled-wave analysis to optimize their performance, present the microfabrication process carried out in synergy with the grating design optimization, and discuss the manufacturing and metrology results for infrared components down to the K-band. I will then explain how we can improve the performance of current SGVs for future applications. In particular, I will present an original design of an SGV4 (vortex of charge 4), which will provide a better starlight rejection and reduced sensitivity to pointing jitter on future 30-m class telescopes (E-ELT, TMT, GMT), especially at near-infrared wavelengths, at the cost of a slightly degraded inner working angle. Our new optimization method, using 3D finite-difference time-domain (FDTD), addresses the principal limitation of such space-variant polarization state manipulation, i.e., the discontinuities in the discrete grating pattern. Simulated performance and manufacturing prospects will be discussed.
Pierre Bourget	**High Dynamic Range Synchronous Detection: APM2 Coronagraph** Mon, 10:15 • P1-6	The APM2 coronagraph is a recent instrument concept aiming at accommodating both high dynamic and high angular resolution imaging of faint sources around bright objects. This concept uses an Adaptive Phase Mask (APM) coronagraph in a first stage and synchronous detection techniques at the coronagraph output to discriminate eventual companion from quasi-static speckles. The APM2 uses the coherence of speckles to discriminate them from proper companions, using the mask itself as the electric field modulator. A spatial Phase Modulation (PM) performed in the coronagraph output focal plane is used to induce an amplitude modulation. Synchronous detection in the radio frequency range is used to freeze the turbulence and enable the detection of low amplitude signals. The APM2 concept offers high dynamic range detection and provides a quick tool to quantify the probability of presence of a faint object close to the central star. We present an experimental setup done for the characterization of the sensitivity of this technique.
Daniel Rouan	**A new family of phase mask coronagraph** Mon, 10:16 • P1-7	Among the very rich family of coronagraphic devices, the 4-quadrant phase mask coronagraph (4QPMC) proposed fifteen years ago by our team is one of the few actually in operation in several instruments (VLT-NACO, JWST-MIRI, VLT-SPHERE, Palomar 200-inch, etc.) and producing results. Two of its known limitations are the sensitivity to tip-tilt and chromatism, like all phase masks made by engraving a glass plate, that is to say the loss of efficiency when the wavelength deviates from a nominal value. A theoretical study of phase masks, with other profiles than the 4QPMC, that share the same total extinction property in the ideal case (no wavefront defects, filled pupil) lead to define mathematically a family of devices that has never been explored up to now. Numerical simulations show that some members of the family have much better properties, up to a factor 10, with respect to these two limitations (sensitivity to tip-tilt and chromaticism). We started a R and D program to explore those new phase masks. Components are currently being manufactured by RIE etching technique and will be tested on a dedicated bench in april-may. The theory, results of numerical simulations and first laboratory results will be presented.
Jun Nishikawa	**Imperfect pre-coronagraph for contrast enhancement with speckle area nulling control** Mon, 10:17 • P1-8	We have studied a coronagraph system with a low-contrast (imperfect) pre-coronagraph which was originally developed as an unbalanced nulling interferometer (UNI). The system consists of an upstream deformable mirror, the pre-coronagraph, a deformable mirror, and a main coronagraph, in sequence. A pre-reduction of the star light to 1/100 at the pre-coronagraph stage would enable to enhance the final contrast by 100. It can be operated by the dark-hole control when the pre-coronagraph status can be exchanged between perfect and imperfect nulling. In the style of the nulling interferometer, it could be obtained by phase shift operations. In the case of a focal-plane mask coronagraph it could be obtained by exchanging the masks with a small difference of transmittance pattern. We are planning to construct an experimental optics with two vortex mask coronagraphs and two deformable mirrors to validate the techniques. Without the pre-coronagraph method, using a DM and a vortex mask, we obtained a contrast of 8E-8 by the dark-hole control where a 12x12 deformable mirror was used. We expect a better contrast if we can use the pre-coronagraph as well as a deformable mirror with more actuators. In the dark-hole control, here, we developed the speckle area nulling (SAN) method as a new dark-hole control algorithm which is capable of controlling speckle electric field in a wide area quickly, in spite of an extension of speckle nulling, and is robust not relying upon an optical model.

Jonas Kuhn	**A Vector Vortex Coronagraph for the Subaru SCExAO instrument: expected performances and current status** Mon, 10:18 • P1-9	We report on the Vector Vortex Coronagraph (VVC) observation mode that is part of the Subaru Coronagraphic Extreme AO (SCExAO) instrument, the second-generation near-infrared high-contrast imager of the Subaru Telescope. This focal plane coronagraph mode is now available for use on the SCExAO platform, which will deliver extreme extreme AO correction for the HiCIAO imager by the 2015B observing period. The SCExAO VVC device operates at H-band and can provide better than 100:1 raw starlight rejection at high-Strehl, combined with competitive inner-working angle performances (2 λ/D, or 80 mas at H-band) with the Subaru Telescope pupil. Pointing accuracy of better than 1 mas is provided by a dedicated Lyot-based low-order wavefront sensor. We will present an overall description of the VVC mode, describe its expected performances in extreme AO regime, and present the most recent on-sky results. The VVC coronagraphic mode is straightforward to operate with no extra optics, and is the first H-band vortex to be installed on a 8-m class telescope in the Northern hemisphere.
Julien Lozi	**SCExAO: On-sky validation of the correction of low-order non-common path aberrations with a Lyot-based low-order wavefront sensor for high-contrast phase mask coronagraphs** Mon, 10:19 • P1-10	The ability to detect exoplanets as close as possible to the inner working angle of a coronagraph is limited by the quality of the wavefront control, especially non-common path and chromatic aberrations. On the Subaru Coronagraphic Extreme Adaptive Optics (SCExAO), a versatile high performance coronagraphic instrument using various focal plane phase masks to cancel the starlight, we developed a Lyot-based low-order wavefront sensor (LLOWFS) that uses the light rejected by the Lyot mask to sense low-order aberrations. When used without the extreme Adaptive Optics (AO) loop, we demonstrated the correction of up to 35 low-order Zernike modes in laboratory conditions on 5 different coronagraphs, leaving sub-nanometer wavefront errors after correction of a simulated turbulence, and a pointing residual of 0.02 mas for data sampled at the 2-second minimum exposure time of the science camera. During an on-sky engineering campaign, we corrected up to 10 modes on post-AO wavefront errors, achieving a pointing residual of 0.15 mas at the same data sampling. Finally, we validated the LLOWFS as part of the extreme AO scheme, correcting tip/tilt non-common path and chromatic errors in H band left by the high-order visible pyramid wavefront sensor. Despite strong vibrations of the telescope, we achieve a pointing residual of 0.1 mas, on target as faint as m_H=7. To mitigate the vibrations degrading the measurements, a Linear Quadratic Gaussian control algorithm with an automatic detection of the disturbance characteristics is currently being implemented, that should improve significantly the wavefront correction in the infrared channel. Finally, a better integration of the LLOWFS with the high-order pyramid wavefront sensor is currently developed to allow the correction of more modes than just tip/tilt chromatic errors.
Yunjong Kim	**Optical verification of external occulter with a precisely manufactured mask** Mon, 10:20 • P1-11	One of the main candidates for creating high-contrast for future exoplanet detection is an external occulter. This is a spacecraft flown along the line-of-sight of a space telescope to suppress starlight and enable high-contrast direct imaging of exoplanets. Because of its large size and scale it is impossible to fully test an external occulter system on the ground before launch. Therefore, laboratory verification of occulter designs is necessary to validate the optical models used to design and predict occulter performance. At Princeton, we designed and built a testbed that maintains a constant Fresnel number to an equivalent 400 mas space mission. Here we will present experimental verification of a scaled occulter design with a precisely manufactured occulter mask using a diverging beam. We will also present progress in implementation and preliminary results.
Garreth Ruane	**Improving the contrast performance of a vortex coronagraph with a Lyot plane phase mask** Mon, 10:21 • P1-12	We present phase-only optical elements that may be placed in the Lyot plane of a vortex coronagraph to improve the contrast performance on telescopes with obstructed apertures. On such systems, the secondary mirror, spider support structures, and gaps between mirror segments limit the starlight suppression achieved by causing diffracted starlight to pass through the Lyot stop. With a Lyot plane phase mask, residual starlight is relocated away from a region of the image plane such that light from an exoplanet may be detected with reduced stellar noise. Examples are given for relevant telescopes and the imaging performance is analyzed in terms of image plane contrast and off-axis point spread function quality. The effect of realistic wavefront error is also simulated.
Kevin Newman	**Development of focal plane phase masks for PIAACMC** Mon, 10:22 • P1-13	The Phase Induced Amplitude Apodization Complex Mask Coronagraph (PIAACMC) is an architecture for directly observing extrasolar planets, and can achieve performance near the theoretical limits for any direct-detection instrument. PIAACMC can be designed for centrally-obscured and segmented apertures, which is particularly useful for next-generation telescopes. The PIAACMC architecture includes aspheric PIAA optics, and a complex phase-shifting focal plane mask that provides a pi phase shift to a portion of the on-axis starlight. The phase-shifted starlight is forced to interfere destructively with the un-shifted starlight, causing the starlight to be eliminated, and allowing a region for high-contrast imaging near the star. The PIAACMC focal plane mask is composed of zones that are optimized for broadband operation. We discuss various mask design and optimization strategies, with an emphasis on choosing designs that are more favorable for the manufacturing process. We include a discussion of mask manufacturing techniques, manufacturing limits, and their impact on potential coronagraph performance. We show laboratory results from fabricated masks, and propose the next steps for developing broadband achromatic phase masks for coronagraphy.

Posters

James Breckinridge	**Internal polarization and image quality in coronagraphs** Mon, 10:23 • P1-14	The contrast achievable in coronagraphs is limited by polarization aberrations*. Polarization aberrations in optical systems depend on optical coatings, F/#, opto-mechanical layout, and wavelength. Here we examine the polarization aberrations of a "typical" 2.4 meter Cassegrain telescope with an F/#=1.2 primary, that uses bare Al coatings at 800 nm wavelength with a 90-degree fold mirror in an F/8 converging beam. The ghost PSF, which originates from the cross-polarization term is found have an intensity of about 10E-4 which will limit the contrast in exoplanet telescope/coronagraph systems and affect speckle post processing algorithms now under development.
Aïssa Jolivet	**Latest developments of VODCA (Vortex Optical Demonstrator for Coronagraphic Applications)** Mon, 10:24 • P1-15	This poster will present the most recent developments of VODCA (Vortex Optical Demonstrator for Coronagraphic Applications), the University of Liège (Belgium) coronagraphic bench. VODCA's first priority is the performance assessment of the AGPMs (Annular Groove Phase Masks) before their installation on large ground-based telescopes. An AGPM is a charge two vortex phase mask made of circular subwavelength grating in diamond. The Uppsala University (Sweden) as part of the Vortex project is in charge of the manufacturing. The bench design allows us to operate in near- to mid-infrared wavelengths, (between 1 and 5 μm). We are especially interested in the K, L and M bands. First I will briefly present the optical layout of VODCA. Then I will detail the future implementation of different pre- or post-coronagraphic concepts, such as optimal apodisation and wavefront control by coronagraphic image analysis. Our purpose is to improve as much as possible the starlight cancellation without cancelling the potential scientific signal of nearby off-axis sources.
Naoshi Murakami	**Achromatic coronagraph system based on photonic-crystal technology and its application to polarimetric observations** Mon, 10:25 • P1-16	Photonic-crystal device is useful for coronagraph phase masks because of its extremely small manufacturing defects. Various coronagraph masks have been manufactured to date, such as an eight-octant phase mask (8OPM), 2nd-order and 4th-order vector vortex masks. Theoretically, it is possible to build fully-achromatic coronagraph system when the coronagraph mask is placed between crossed polarizers at the expense of low system throughput. To improve the system throughput, we constructed a laboratory simulator of a two-channel coronagraph system in which polarizing beam splitters are used instead of the polarizers. By using the two-channel coronagraph simulator, we carried out laboratory demonstration of a polarimetric observational mode with a novel post-process method. In addition, we also designed a three-layer photonic-crystal 8OPM. It is expected that the three-layer design would realize extremely high contrast over a broad wavelength range without the polarizing optical elements. In the presentation, we report our recent progress on the two-channel coronagraph system, the polarimetric observational mode, and the three-layer 8OPM design.
Brunella Carlomagno	**End-to-end performance simulations of infrared vortex coronagraphs on centrally obscured segmented pupils** Mon, 10:26 • P1-17	Vortex coronagraphs provide total starlight rejection for a circular pupil and a perfect incoming wavefront, by diffracting the starlight outside the geometric pupil in the Lyot plane located downstream the focal-plane vortex phase mask. Any departure from a perfectly circular pupil and a flat input wavefront results in starlight leakage and reduces the performance of the vortex coronagraph. In this work, we present end-to-end performance simulations using Fourier optical propagation to determine the attenuation produced by infrared vortex coronagraphs on centrally obscured segmented pupils, applied to the specific case of the METIS mid-infrared camera on the future E-ELT. We define the metrics required to assess the quality of the starlight rejection and study the influence of (i) the central obscuration and spiders, (ii) the pupil segmentation, and (iii) the imperfections of the vortex phase mask itself. We then perform more realistic simulations by introducing pointing jitter and random phase screen representative of the adaptive optics residuals. The need for more advanced concepts than a simple vortex coronagraph is then discussed in the context of the on-going METIS pre-phase B.
Dan Sirbu	**Broadband wavefront control for Phase Induced Amplitude Apodization Complex Mask Coronagraphy (PIAA-CMC)** Mon, 10:27 • P1-18	The Phase-Induced Amplitude Apodization (PIAA) coronagraph uses two specially shaped mirrors to remap the entrance pupil to a desired apodization. This enables the creation of regions of high-contrast starlight suppression at the telescope focal plane to allow for direct imaging of exoplanets using high throughput. The complex-amplitude focal plane mask in PIAA-CMC is designed to allow for PIAA to operate in broadband light. In the presence of chromatic aberrations, the ideal coronagraph performance is limited to a level worse than the designed thereotical. A deformable mirror can be used to recover regions of high-contrast, so-called dark-holes. Here we implement a wavefront control algorithm in conjunction with PIAA-CMC to determine the expected level of contrast that can be obtained with this configuration and assist towards the design of complex focal plane masks.

Jean-François Sauvage	**Analytical and numerical expression of a coronagraphic long-exposure optical transfer function in view of ground-based exoplanet detection** Mon, 10:28 • P1-19	Context: Ground-based high-contrast imaging systems are equipped with a coronagraph and an adaptive optics system in view of exoplanet detection. The ultimate performance of such systems is limited by the presence of speckles on the image. These speckles are induced by quasi-static aberrations, which must hence be measured and corrected for. In order to measure all optical aberrations down to the focal plane, the scientific detector is used as a wave front sensor, thanks to the coronagraphic phase diversity technique called COFFEE.Problem: The use of COFFEE currently needs a point-source without turbulence so COFFEE must therefore be used between observations only. The evolution of quasi-static aberrations during an observation limits the achievable contrast, so ideally aberrations must be corrected during an observation. In this setting, the observed coronagraphic images will necessarily be affected by residual turbulence. So, in order to analyze the wave-front during an observation, it is necessary to have a direct model of image formation with aberrations as inputs and the corresponding image as output, and this model must take into account both the coronagraph and the residual atmospheric turbulence. Method: We propose an analytical expression giving the long-exposure optical transfer function of a ground-based AO-corrected coronagraphic system, while taking into account residual turbulence described by its phase structure function. We propose a method for the implementation of this formula on a form that reduces the computing time, mainly using fast Fourier transforms. The method is then validated by comparison with a sum of short-exposure coronagraphic point spread functions. Perspective: This development will soon be integrated into the coronagraphic phase diversity method (COFFEE), in order to make it work online i.e., on the sky, with an instrument such as SPHERE.
Pierre Baudoz	**Optimization and limitations of two-mirror design for correction of phase and amplitude** Mon, 10:29 • P1-20	With the improvement of phase estimation and correction in high contrast imaging tested, the need for estimation and correction of amplitude defects has arisen. Amplitude correction requires a second active element. The implementation of a second deformable mirror located at a finite distance from the pupil has been chosen by most of the test bench so far, with more to come. While there have been a few extensive simulation studies of the implementation of two-mirror solutions, a more simple approach would be better to define the optical specifications of any test bench. First, I will describe an intuitive and almost-analytical description of solutions using several mirrors. Then, optimizations and limitations will be described for several implementations. I will conclude by describing the 3-mirror solution chosen for the upgrade of the high contrast THD bench at LESIA.
Michael Wilby	**The Holographic Modal Focal-Plane Wavefront Sensor: A New Technique for High-Contrast Imaging** Mon, 14:45 • P1-21	On-sky performance achievable with the current generation of high-contrast imaging instrumentation is predominately limited by Non-Common Path Errors (NCPEs) arising between conventional pupil-plane wavefront sensors and the science focal plane. The Holographic Modal Wavefront Sensor (HMWFS) provides a fast and highly tunable form of focal plane wavefront sensing, which is in principle ideally suited to the real-time correction of NCPEs, in addition to further error sources such as high-frequency image jitter. When combined with apodizing phase plate coronography, this technique is able to create and maintain high contrast dark regions at separations of a few λ/D within the science PSF. Such a technique would provide the means for high-resolution spectral characterization of known exoplanets, using a wavefront-sensing system based on a small number of single-pixel detectors. Here I shall outline the principle underlying operation of the HMWFS and present first results.
Hari Subedi	**Sparse Aperture Mask for Low Order Wavefront Sensing** Mon, 14:46 • P1-22	While the level of contrast required for direct imaging of exoplanets can be achieved by stellar corona graphic imaging, the resulting dark hole is highly sensitive to phase aberrations. In order to effectively suppress starlight for exoplanet imaging applications, low-order wavefront aberrations entering a coronagraph such as tip-tilt, defocus and coma must be determined and compensated for. Work has been done to show the utility of pupil-plane masks (both non-redundant/sparse-aperture and generally asymmetric aperture masks) for wavefront sensing. A sparse-aperture mask (SAM) can be integrated in the telescopic imaging system to make precise estimate of low-order wavefront aberrations. In this technique, the starlight rejected by the coronagraph's focal plane stop is collimated to a relay pupil, where the mask forms an interference fringe pattern on a detector and the phase aberrations are inferred from this fringe pattern. At Princeton's High Contrast Imaging Lab (HCIL), we have numerically proved this concept and we are currently working to creating a testbed devoted to low-order wavefront sensing experiments.
Elizabeth J. Young	**Detecting exoplanets in speckle-limited images** Mon, 14:47 • P1-23	High-contrast imaging of exoplanets is limited due to residual quasi-static speckles. Speckles look like the image of a planet, but they have a different spectral behavior and are optically coherent with the star. All speckles are formed from the same coherent source, the star, and are incoherent with the planet. Moving the DM (or other changes to the optical layout) causes interference and therefore changes in the speckle pattern as seen on the camera. Since the planet light does not interfere with the speckles, the image of the planet remains untouched (except that speckles may appear on top of the planet). This fundamental coherence property of the speckles (and incoherence with the planet light) guides us to develop methods to take advantage of a changing speckle pattern to distinguish a planet from a speckle. We present a series of models for estimating the intensity of a planet given a point spread function (PSF), and assuming an unknown and locally constant background source as well as photon noise. We use these models to develop a planet detection algorithm. This work extends the process of image analysis from one image to multiple images, presuming an independent source of aberrations between images.

Posters

Christian Ginski	**SPHERE/ZIMPOL astrometric calibration strategies** Mon, 14:48 • P1-24	SPHERE/ZIMPOL is a revolutionary optical high resolution imager and polarimeter. Due to its high spatial sampling and the supreme performance of the SPHERE extreme AO system even at short wavelengths, ZIMPOL can achieve high astrometric precision. However, its small field of view does not allow for classical calibration sources like open clusters. We present different approaches for astrometric calibration and characterize important detector properties.
Li-Wei Hung	**Characterization of the Instrumental polarization of GPI** Mon, 14:49 • P1-25	We are investigating the instrumental polarization of Gemini Planet Imager (GPI) to calibrate our science observations in polarimetry mode. We have the on-sky observations of several unpolarized standard stars as the test cases. The observations are taken in different modes and are used to test the stability of the instrumental polarization. This work builds on earlier preliminary calibrations taken during the instrument's initial commissioning. Once the instrumental polarization is well characterized, we will make the calibration easily accessible to the community by implementing it into the GPI data reduction pipeline. By setting it as a standard procedure in the pipeline, we will be able to easily correct the instrumental polarization to obtain well calibrated GPI science images in the polarimetry mode.
Johan Mazoyer	**Propagation Simulations for Two-Mirror Wavefront Correction and Active Compensation of Aperture Discontinuities.** Mon, 14:50 • P1-26	Over the past 15 years, many coronagraph designs have been proposed: very high contrast levels have been achieved and several hurdles have been overcome. As the performance of these coronagraphs improves, the achievable contrast depends more and more on the telescope aperture geometry itself, which effects were previously dominated by strong phase aberrations. The future generation of space and ground-based coronagraphic instruments will most likely involve on-axis or segmented telescopes, and this issue needs to be addressed quickly. To correct for the high amplitude aberrations introduced by secondary mirror structures and primary mirror segmentation, we explore a two deformable mirror (DM) method: Active Compensation of Aperture Discontinuities (ACAD). The major issue of two DM corrections is the non-linear relationship between actuator strokes and final point spread function in the final coronagraphic focal plane, which may bring the solution to a local minimum. To overcome this hurdle, we proceed with a two-step correction: the ACAD method first corrects the aberrations introduced by the aperture geometry itself, by solving a non-linear differential Monge-Ampere equation. Once this open-loop correction has been applied, a closed-loop stroke minimization method can be applied to correct for both phase and amplitude aberrations, and achieve the final contrast in the coronagraphic focal plane. We first describe recent developments with end-to-end propagation simulations using two DMs. We then explore the performance of the combined ACAD + stroke minimization method for various apertures on a large parameter space (including e.g. width and number of secondary support structures, size of the secondary mirror, number of missing segments). Finally, we illustrate this method using several known space telescope aperture geometries (JWST, WFIRST, ATLAST).
Katherine Follette	**Chasing Butterflies: Using AO Telemetry to Reconstruct Common Low Spatial Frequency PSF Artifacts in GPI Data** Mon, 14:51 • P1-27	I will describe recent efforts to use adaptive optics telemetry to reconstruct artifacts introduced into the Gemini Planet Imager (GPI) Point Spread Function (PSF) by servo lag and aliasing of high spatial frequencies. Left uncorrected, these create distinctive butterfly and cross-shaped artifacts in the AO PSF that have necessitated the use of high-pass filtering in GPI Exoplanet Survey (GPIES) campaign data. This is particularly problematic in isolating circumstellar disk emission, which does not easily survive high-pass filtering. GPI can detect polarized emission through differential polarimetry, but recovering the astrophysically interesting polarization fraction requires also isolating unpolarized disk emission through PSF subtraction, as does detection of low-polarization disks. I will discuss results of early experiments in this regard, as well as prospects for broadening this effort to intelligently comb a large reference PSF library for stars with potentially well-matched PSFs. Isolating a subset of stars to use as PSF references for high contrast imaging will potentially reduce computational overhead in future data processing efforts.
Rebecca Jensen-Clem	**High contrast imaging at high frame rates: detecting faint companions using speckle statistics** Mon, 14:52 • P1-28	The advent of high frame rate, low read noise detectors operating in the visible and near-infrared opens up new opportunities for high contrast imaging. By choosing exposure times shorter than the speckle correlation time, it is possible to identify a companion by observing the departure from modified Rician statistics at the companion's location, even if it is co-located with a static speckle. We extend earlier efforts to exploit such statistical differences (e.g. Labeyrie et al 1995; Boccaletti et al 1998; Gladysz and Christou 2008) by considering the added advantage of the simultaneous wavelength information provided by integral field spectrographs and microwave kinetic inductance detectors (MKIDs). We use simulated and on-sky data to compare the performance of our algorithm with existing data reduction techniques, such as principle component analysis.
Nemanja Jovanovic	**Adaptive grid of artificial speckles for photometric and astrometric calibration** Mon, 14:53 • P1-29	Calibration of the angular separation and photometry of a faint companion is as important as the initial detection itself. Precisely determining these metrics places constraints on the orbital properties, including the mass and density and could reveal information about the composition of the companion. The high contrast imager SCExAO at the Subaru Telescope enables an artificial grid of satellite speckles to be generated by simply applying a sinusoidal corrugation to the deformable mirror. The contrast, separation, position angle and the number of speckles can be tailored to each observation. Most importantly, by modulating the phase of the sinusoid applied to the deformable mirror, several times per exposure, it's possible to generate incoherent speckles which are unaffected by the speckle halo surrounding the PSF, improving precision. We demonstrate the implementation of the grid of artificial speckles tested both in a laboratory setting and on-sky. In addition we demonstrate how such speckles can be used to measure residual chromatic dispersion (post ADC), a factor which will limit extremely high contrast imaging in the near future.

Posters

Jeffrey Chilcote	**Ongoing Calibration activities for the Gemini Planet Imager Integral Field Spectrograph** Mon, 14:54 • P1-30	We present the current status of calibrations for the recently commissioned Gemini Planet Imager (GPI) Integral Field Spectrograph as part of the GPI Exoplanet Survey (GPIES). GPI is one of a new generation of instruments built to directly image extrasolar planets in the outer solar systems of young main sequence stars. As part of the GPIES survey and to support the broader user community, we have invested substantial effort in understanding and improving instrumental calibrations in order to achieve the best possible final datacubes. We present the ongoing work to better generate calibration data sets for GPI including, the known effects of inadequate calibration, and the ongoing attempts to improve the reduced data product from the GPI pipeline including work on linearization and persistence in the GPI H2RG detector.
Sebastian Bruzzone	**Photometric characterization and contrast performance of GPI polarimetry** Mon, 14:55 • P1-31	We characterize the photometric response of the Gemini Planet Imager (GPI) in polarimetry mode and estimate the attainable contrast in linearly polarized intensity. The photometric response of GPI in polarimetry mode has not been addressed yet, a prerequisite to fully characterize this new instrument. Using observations of several targets obtained during the GPI Exoplanet Survey (GPIES) campaign we have calibrated the photometry in polarimetry mode to a precision of 2%. Consequently, we are able to determine the contrast performance in polarimetry mode. We measure a 5-sigma surface brightness contrast of 3×10^{-6} at $0.5''$ in linear polarization and 8 minutes of integration time. We observe that the contrast improves roughly as the square root of the integration time, suggesting that a contrast of $\times10^{-6}$ at $0.5''$ could be expected in one hour of integration time. The tools developed to measure fluxes and contrast curves in polarimetry will be incorporated to the GPI reduction pipeline and become accessible to the community.
Elsa Huby	**Resolving the surface of supergiants with FIRST at Subaru** Mon, 14:56 • P1-32	FIRST (Fibered Imager foR a Single Telescope) is an instrument based on the pupil remapping technique. It consists of dividing the pupil into sub-pupils, each of them feeding single-mode fibers. Their outputs are recombined following a non-redundant scheme. This setup offers several advantages over the classical aperture masking technique, such as: (i) potentially better visibility accuracy thanks to the spatial filtering performed by the single-mode fibers, (ii) a better (u,v) plane coverage for the same size of sub-pupils, (iii) the capability of cross-dispersion with in-line recombination. FIRST is now a module of the SCExAO instrument at the 8-m Subaru telescope. Two sets of 9 sub-apertures are recombined independently, covering 70% of the accessible spatial frequencies. The recombination is coupled with a spectrometer, providing a spectral resolution of 300 over the 600-850nm band. In this poster presentation, we will report on our latest on-sky results obtained on evolved stars in April 2015. With an angular resolution of 15mas, our preliminary results show that stellar disks are resolved. The data reduction is in progress and should soon allow the detection of potential asymmetries in the surface brightness of the stars we have observed.
A J Eldorado Riggs	**Recursive Estimation of Both Starlight and Incoherent Sources for High-Contrast Imaging** Mon, 14:57 • P1-33	The direct imaging of exoplanets with high-contrast coronagraphs requires the correction of quasi-static aberrations. To avoid non-common path aberrations, the science camera must be used as the wavefront sensor. In focal plane wavefront correction, several probed images are used to estimate the starlight electric field. A control signal is then sent to the deformable mirror(s) to improve the contrast, and this process of estimation and control is repeated until high contrast is reached. In a photon-limited scenario such as a space mission, most of the wavefront correction time will be spent taking the estimation images. We previously showed that recursive estimation of the starlight with a Kalman filter yields a better E-field estimate and faster wavefront correction. In our new work, we demonstrate recursive, nonlinear estimation of both the starlight and incoherent light (including from exoplanets and disks) with an extended Kalman filter (EKF). The EKF utilizes all correction images to build a near-optimal incoherent light estimate, and the EKF can be easily modified to estimate uncertain parameters in the optical system. Here we present experimental results of the EKF in the presence of incoherent sources in Princeton's High Contrast Imaging Laboratory.
Clement Perrot	**Reference Differential Imaging with SPHERE commissioning data** Mon, 14:58 • P1-34	In May 2014 the new imager of exoplanets SPHERE received first light on the UT3 at the VLT. SPHERE produces high angular resolution and high-contrast images (June 2014 ESO Press release, Beuzit et al.) by means of extreme adaptive optics, broad band coronagraphy, and post-processing technique, in particular angular differential imaging (ADI). ADI-like algorithms enable self-calibration of the data and they aim at removing most of the starlight contribution to enhance the contrast for detecting faint sources as exoplanets or cirumstellar disks. However, these faint sources partly contribute to the calibration including self-subtraction of their flux in the resulting image. This effect can be problematic for point sources at short angular separations or disks at small inclinations. The SPHERE instrument is a good opportunity to test and optimize the technique of Reference Differential Imaging (RDI). The stability of the instrument allows to estimate the star contribution using images of reference stars that are well chosen: same spectral type, same declination and same parallactic angle. Assuming the aberrations in the instrument are the same when observing the reference stars and the target star, the calibration is effective. Though there are caveats with these constraints, one of the advantages to use a reference is the absence of self-subtraction of planets and disks, which could be profitable in some cases, for instance at very short angular separations. We will present the result of a test performed during SPHERE commissioning and will discuss the pros and cons of the technique with respect to ADI.

Posters

Faustine Cantalloube	**Evolution, performance and results of the ANDROMEDA image processing method to detect and characterize exoplanet.** Mon, 14:59 • P1-35	In order to exploit high contrast images for exoplanet detection and characterization, it is necessary to use advanced data processing tools that can disentangle the residual quasi-static speckles from planetary signals in the images. ANDROMEDA is an unsupervised ADI-based method whose specificity is to estimate the position and flux of any planetary signal in the field thanks to a detection-theory approach, based on the computation of the data likelihood: a model of the expected planetary signal shape inside each differential image is built and tracked in the differential image series. This method is currently operational on experimental data thanks to the addition of pre and post-processing stages to the original algorithm (Mugnier et al. 2009). Now ANDROMEDA permits to perform automatically the detection thanks to a 'SNR map' in which each pixel gives a probability of presence of a companion; this map also provides the sub-pixel position of the companion. Another 'flux map' output by ANDROMEDA yields directly the value of the flux of the probable companions, without needing fake planet injection. A third map, the map of the standard deviation of the flux, permits to compute directly the detection limit of the data set. During this talk, I will present in details the ANDROMEDA algorithm, in particular the pre and post-processing stages that have been added to make this pipeline robust to instrumental artefacts, automatic and fast. I will then show its performance obtained on VLT/NaCo and VLT/SPHERE data and present a short comparison with other successful algorithms that are widely used today.
Faustine Cantalloube	**MEDUSAE, a Bayesian inverse problem approach to detect and characterize exoplanets in multi-spectral images.** Mon, 15:00 • P1-36	A very important feature brought by direct imaging is the acquisition of exoplanet atmospheric spectra allowing astronomers to study the chemical composition of exoplanets at different stages of their evolution. The new generation of instruments dedicated to exoplanet imaging such as SPHERE and GPI, as well as one of the first light instrument chosen for the E-ELT (HARMONI), are all equipped with integral field spectographs providing multispectral images. MEDUSAE is an image processing method under development which uses a Bayesian inverse problem approach to obtain exoplanet spectra out of these data. The originality of this approach is that both the speckle field and the planetary companion image are modeled and jointly retrieved. The aberrations, being parametrized through the optical path difference (whose achromaticity reduces the number of unknowns), are estimated via phase retrieval. The object map is then found by myopic deconvolution. These estimations are made alternately and iteratively until convergence of the process. Results have been obtained on simulated data. This poster will present the current progress of this algorithm that is being made to apply MEDUSAE to experimental on-sky data.
Julien Rameau	**Detection limits with spectral differential imaging data** Mon, 15:01 • P1-37	Spectral differential imaging has been developed to optimize the detection of cool planetary companions by subtracting the speckle pattern taken simultaneously through two channels. We show in this poster how SDI can affect the signal of any off-axis companion. We then demonstrate that the self-subtraction due to SDI processing cannot be calibrated in a standard way. We therefore provide a new method to take this effect into account to derive unbiased detection limits associated to this mode. This method can be applied to future observations with SPHERE/IRDIS and extended to multi-wavelength observations with GPI and SPHERE/IFS.
Mara Johnson-Groh	**TLOCI, the Speckle's Worst Nightmare** Mon, 15:02 • P1-38	The TLOCI Gemini Planet Imager (GPI) PSF subtraction package is designed to use a priori planet spectral information to optimize the least-squares subtraction algorithm to maximize planet detection when using data acquired with the SSDI and the ADI techniques. Several important updates have been implemented, mainly in ways to self-optimize itself to maximize planet SNR, correction of subtraction biases, and extract bias-free candidate astrometry and photometry. The IDL code is also being setup to be easily run as an independent package, and tests are under way to run it on CANFAR, a Canadian-wide computer grid of 700 cores for processing large amount of data sets.
Thayne Currie	**An Adaptive, Locally-Optimized Method for Imaging and Characterizing Exoplanets and Disks** Mon, 15:03 • P1-39	We present results describing the performance of our image processing method, A-LOCI, as applied to ground-based high-contrast imaging at moderate to high Strehl ratios. Our approach largely builds upon the groundbreaking LOCI algorithm (Lafrenière et al. 2007). It uses SVD, frame selection, pixel masking, and damping to yield higher SNR detections of planets and disks and higher throughput/precision photometry using forward modeling. We compare its performance to other methods (e.g. PCA/KLIP, LOCI, sADI) and demonstrate its use for forward-modeling of IFS data like GPI.
Raphael Galicher	**Blind tests of ADI and SDI pipelines on SPHERE data** Mon, 15:04 • P1-40	The SPHERE instrument that was commissioned at the Very Large Telescope at the end of 2014 was optimized for imaging exoplanets and circumstellar disks. In the raw images, the central star flux is greatly reduced thanks to coronagraphs and adaptive optics, but because of unavoidable optical aberrations there are still stellar speckles that mimic planet images. The observing strategy was optimized to apply angular and spectral differential imaging to calibrate these speckles a posteriori but once the data is recorded, one question arises which algorithm shall we apply? The SPHERE members have several algorithms available (cADI, sADI, rADI, LOCI, PCA, TLOCI) and we ran a series of blind tests to determine which algorithm will be used to uniformly reduce all the SPHERE data. First, one of us injected random fake planets in SPHERE data taken with the IRDIS and IFS instruments during the commissioning and the early guaranteed time observations. Then, different teams of the SPHERE consortium blindly tried to find these planets, and retrieve their photometry and astrometry. We will present the results and the conclusions of these blind tests.

Status of ongoing exoplanet imaging searches

Jason Wang	**The GPIES Data Cruncher: an Automated Data Processing System for the Gemini Planet Imager Exoplanet Survey** Tue, 10:30 • P1-41	The Gemini Planet Imager Exoplanet Survey (GPIES) is observing 600 young nearby stars to search for exoplanets and debris disks to study planet formation. To efficiently and consistently reduce all the data in this multi-year survey, we developed an automated data processing system, the GPIES Data Cruncher. The Data Cruncher links together many data processing tools, including the GPI Data Reduction Pipeline and various PSF subtraction codes, to produce fully calibrated data products and contrast curves from raw data. We present the software infrastructure that allows the GPIES Data Cruncher to produce fully reduced data within one hour of raw data becoming available. The GPIES Data Cruncher also has the capability to reprocess the entire survey. We discuss how the multithreaded Python framework that we built is easily scalable and demonstrate its performance on both a single server and a supercomputing cluster. Lastly, we show how it integrates with collaborative tools and databases to ensure consistent record keeping.
Jacques-Robert Delorme	**High contrast imaging in wide spectral band witha self-coherent camera and achromatic coronagraph** • P1-43	Direct imaging ofexoplanetsis very attractive but challenging. It requireshigh angular resolutionand veryhigh contrast imaging. One solution is the use ofcoronagraphsbehind theadaptive opticsof large telescopes. Unfortunately, optics ofspace telescopeandground telescopeintroducequasi-static aberrationswhich stronglylimit the quality of the final image and adedicatedstage of adaptive optics is required. We proposed a focal plane wavefront sensor called self-coherentcamera (SCC)in 2006 and we obtained contrast levels of2×10^{-8}at a fewλ/Dat635 nmin laboratory. In this poster, we explain how to achromatize the SCC. We present laboratory performance inwide spectral band 5-10%bandpass.
Angelle Tanner	**The Starchive: An open access, open source archive of nearby and young stars** Tue, 10:31 • P1-42	At the inaugural Spirit of Lyot meeting in 2007 a group of high contrast imaging aficionados sat around a table discussing the need for a centralized repository of imaging data to help with common proper motion confirmations and non detections. Finally, there will be such an archive of valuable images in addition to stellar parameters, optical and infrared spectra and light curves. Historically, astronomers have utilized a piecemeal set of archives such as SIMBAD, the Washington Double Star Catalog, various exoplanet encyclopedias and electronic tables from the literature to cobble together stellar and planetary parameters with the absence of corresponding images and spectra. As the search for planets around young stars through direct imaging and infrared/optical radial velocity surveys blossoms, there is a void in the available set of to create comprehensive lists of the stellar parameters of nearby stars especially for important parameters like metallicity and stellar activity indicators. For direct imaging surveys, we need better resources for downloading existing high contrast images to help confirm new discoveries and find ideal target stars. As a solution to these issues, we are developing the Starchive - an open access stellar archive in the spirit of the open exoplanet catalog, the Kepler Community Follow-up Program and many others. The archive will allow users to download various datasets, upload new images, spectra and metadata and will contain multiple plotting tools to use in presentations and data interpretations. While we will highly regulate and constantly validate the data being placed into our archive the open nature of its design is intended to allow the database to be expanded efficiently and have a level of versatility which is necessary in today's fast moving, big data community. Finally, the front end scripts will be placed on github and users will be encouraged to contribute new plotting tools. Here, I will introduce the community to the content and expected capabilities of the archive and query the audience for community feedback.
Tyler Groff	**CHARIS: The Low Resolution, Low Inner Working Angle IFS for Subaru** Tue, 10:32 • P6-1	The Coronagraphic High Angular Resolution Imaging Spectrograph (CHARIS) is an integral field spectrograph (IFS) being built for the Subaru telescope. CHARIS will take spectra of brown dwarfs and hot Jovian planets in the coronagraphic image provided by the Subaru Coronagraphic Extreme Adaptive Optics (SCExAO) and AO188 adaptive optics systems. The system is designed to detect objects five orders of magnitude dimmer than their parent star down to an 80 milliarcsecond inner working angle. For characterization, CHARIS has a "high-resolution" prism providing an average spectral resolution of R82, R69, and R82 in J, H, and K bands respectively. Discovery mode uses a second 'low-resolution' prism with an average spectral resolution of R19 spanning 1.15-2.37 μm (J+H+K bands). This is unique compared to other high contrast IFS designs. It augments low inner working angle performance by reducing the separation at which we can rely on spectral differential imaging. The unprecedented low inner working angle achievable with SCExAO+CHARIS using this discovery mode augments discovery completeness in the $\sim$10 AU regime. We also discuss the science yield and show simulated spectra from those targets we choose to follow up with the 'high-resolution' mode. Extracting high quality spectra from the data cube is one of the principal challenges for a high-contrast IFS. Contamination lies in the form of quasi-static speckles, which cause undue levels of spectral crosstalk. CHARIS has addressed this through several key design aspects that should constrain crosstalk between adjacent spectral features to be below 1%. Sitting on the Nasmyth platform, the alignment between the lenslet array, prism, and detector will be highly stable, key for the performance of the data pipeline. Nearly every component has arrived and the project is entering its final build phase. Here we review the science case, the resulting design, status of final construction, and lessons learned that are directly applicable to future exoplanet instruments.

Posters

John Krist	**WFIRST-AFTA Coronagraph Performance Predictions from End-to-End Modeling** Tue, 10:33 • P6-2	The WFIRST-AFTA 2.4 m telescope will provide the opportunity to host a coronagraph for the imaging and spectroscopy of planets and disks in the next decade. The telescope, however, is not ideal given its obscured aperture. Only recently have coronagraph designs been thoroughly investigated that can efficiently work with this configuration. The Hybrid Lyot, shaped pupil, and PIAACMC coronagraphs have been selected for further development by the AFTA project. Real-world testbed demonstrations of these have just begun, so for now the most reliable means of evaluating their potential performance comes from numerical modeling incorporating diffraction propagation, realistic system models, and simulated wavefront sensing and control. The methods of performance evaluation and results for the current coronagraph designs are presented here.
Bijan Nemati	**Integrated Modeling of the WFIRST AFTA Coronagraph Instrument** Tue, 10:34 • P6-3	The WFIRST AFTA observatory, based on an already-built 2.4 meter space telescope, will be a platform that will host a wide field instrument for dark energy research. For the past year, intensive design and modeling has been underway to evaluate the addition of a powerful coronagraph instrument to this observatory for exoplanet imaging and characterization. The coronagraph will operate across 5 bands spanning the visible to the near infra-red, and will include an integral field spectrometer. The coronagraph will boast a contrast of better than 10^{-8} in broad (10-20%) bands with speckle instability of less than 1e-9. Contrast levels this low put stringent requirement on instrument design and operation. Integrated modeling of this instrument, incorporating the thermal, structural, control, and optical aspects, is essential for accurate assessment of tolerances in the design, build, alignment, and operation. Here we present our integrated modeling approach, recent results, and our plans for model validation.
Neil T. Zimmerman	**Shaped Pupil Lyot Coronagraphs: High-contrast solutions for restricted focal planes** Tue, 10:35 • P6-4	Generally, a Shaped Pupil Coronagraph (SPC) is optimized to create an arbitrarily contoured but finite region of destructive interference in the image plane. Therefore, the focal plane mask matched to the dark search region of an SPC is a hard-edged aperture. When the science beam is allowed to propagate through this restricted focal plane opening, then re-collimated to a Lyot stop, and finally re-imaged, the resulting system is a hybrid of an Apodized Pupil Lyot Coronagraph (APLC) and a SPC (Riggs et al. 2014; Carlotti et al. 2015, under review). Here, we demonstrate the compelling starlight-suppression properties of the SPLC architecture through numerical experiments relying on interior-point optimization methods. We reveal how the on-axis field cancellation mechanism relates to that of the APLC. We present specific designs that form part of the baseline configuration of the WFIRST-AFTA Coronagraph, including a set of masks customized for visible-wavelength spectroscopic characterization of giant exoplanets.
Eric Cady	**Performance of the shaped pupil coronagraphic architecture for the WFIRST/AFTA coronagraph** Tue, 10:36 • P6-5	One of the two primary architectures being tested for the WFIRST/AFTA coronagraph instrument is the shaped pupil coronagraph, which uses a binary aperture in a pupil plane to create localized regions of high contrast in a subsequent focal plane. The aperture shapes are determined by optimization, and can be designed to work in the presence of secondary obscurations and spiders—an important consideration for coronagraphy with WFIRST/AFTA. A new variant turns a field stop into a focal plane mask with a subsequent Lyot stop, and enables smaller inner working angles than a shaped pupil alone. We present the current performance of the shaped pupil testbed, including the results of AFTA Milestone 2, in which $\sim 6 \times 10^{-9}$ contrast was achieved in three independent runs starting from a neutral setting, and discuss upcoming testing plans.
Fang Zhao	**WFIRST-AFTA Coronagraph Instrument Overview and Technology Development Status** Tue, 10:37 • P6-6	The WFIRST-AFTA coronagraph will directly image exoplanets and disks around nearby stars, and obtain spectra. The coronagraph has photometric bands covering about $400 - 1000$ nm, and an integral field spectrometer with a resolution of about 70. The range of sensitivity in angular separation from a star is about 0.1 to $0.6''$. The limiting contrast is about 10^{-9}, and a goal of 10^{-10}. The technology development program is focused on low-order wavefront sensing and control, coronagraph masks, speckle detection and suppression, post-processing algorithms, and low-noise detectors. Plans and progress in these areas will be reported.
Richard Demers	**Design for the WFIRST-AFTA Coronagraph Instrument** Tue, 10:38 • P6-7	The WFIRST-AFTA coronagraph instrument is designed specifically for the AFTA 2.4-meter obscured aperture to provide novel exoplanet imaging and spectroscopy. The AFTA coronagraph also matures direct imaging technologies to high TRL for an Exo-Earth Imager in the next decade. The coronagraph Design Reference Mission (DRM) optical design is supported by the successful High Contrast Imaging Testbed (HCIT), with modifications to accommodate the AFTA telescope design, service-ability at an L2 orbit and spacecraft volume constraints. and the addition of an Integral Field Spectrograph (IFS). In order to optimally satisfy the three science objectives of planet imaging, planet spectral characterization and dust debris imaging, the coronagraph is designed to operate as either of two different coronagraphs using a single optical beamtrain. Active mechanisms change pupil masks, focal plane masks, Lyot masks, and bandpass filters to shift between a Hybrid Lyot Coronagraph or a Shaped Pupil Coronagraph. A lightweight conic-surfaced Tertiary mirror combined with a collimator mirror reduce the wave front error from the telescope from nanometers to picometers. The combination of the tertiary and collimator are designed to be highly insensitive to thermally induced displacements of the coronagraph bench relative to the telescope. This paper describes the optical, mechanical and thermal instrument design for a Design Reference Mission.

Posters

Marie Ygouf	**PSF subtraction for the WFIRST-AFTA coronagraph** Tue, 10:39 • P6-8	Direct detection and characterization of mature giant or sub-Neptunes exoplanets in the visible require space-based instruments optimized for high-contrast imaging with contrasts of 10^{-9}. In this context, the Wide-Field Infrared Survey Telescope - Astrophysics Focused Telescope Assets (WFIRST-AFTA) will reach raw contrasts of about 10^{-9} to 8×10^{-9} using state-of-the-art starlight suppression and wavefront control techniques. A ten-fold contrast improvement is therefore expected using post-processing techniques to reduce the speckle noise level to a factor of at least 10 lower in order to distinguish 1e-9 planets from speckles. Point spread function (PSF) subtractions on both ground-based and space-based instruments have not yet been demonstrated at such high-contrast levels and we explore new ways of implementing these techniques on AFTA-like simulated images in the presence of deformable mirrors, coronagraph and integral field spectrograph (IFS). We use the Karunhen-Loève Image Projection (KLIP) algorithm, which has been successfully applied to ground-based and space-based data with contrasts up to 10^{-6}, but performance has yet to be demonstrated at higher contrast levels; we assess the preliminary contrast gain from post-processing using these techniques for WFIRST-AFTA.
Mark Marley	**How Well Can the WFIRST Coronagraph Characterize Cool Giants in Reflected Light?** Tue, 10:40 • P6-9	In order to better understand the fidelity with which a space based coronagraph, such as that being studied for the WFIRST space telescope, to characterize cool giant planets we applied a powerful Markov Chain Monte Carlo (MCMC) retrieval technique to synthetic noisy spectra of cool giants. We explored how well various atmospheric parameters–particularly molecular abundances and cloud properties–could be constrained. This is the first time such techniques have been applied to this problem. Our results clearly show that even at S/N ~ 5, scientifically interesting and valuable conclusions can be drawn about the properties of giant planet atmospheres from noisy spectra. We find that atmospheric abundances are best constrained when the planet gravity is bounded. Thus direct imaging observations of known radial velocity planets are extremely valuable as limits on a target planet's gravity can be obtained from astrometric imaging and reflectivity and mass-radius relationship arguments (for mass and radius, respectively). Further retrieval studies are clearly warranted and would be valuable to help guide instrument design decisions.
Rhonda Morgan	**The Technology Gap for Exo-Earth Direct Imaging** Tue, 10:41 • P6-10	The current results of laboratory coronagraphs are approaching the contrast levels needed for direct imaging and characterization of an Earth-like planet around a Sun-like star. Direct exo-Earth imaging requires other critical technologies, such as ultra-low noise detectors, a large aperture space telescope, and sophisticated post-processing algorithms. We present the gap from the current state of the art to the performance levels required to enable a potential future space mission to directly image exo-Earths, for both filled-aperture and segmented aperture architectures.
Keigo Enya	**Heritage of the SPICA Coronagraph Instrument: high-dynamic range technologies for exoplanet science with a space infrared telescopes** Tue, 10:42 • P6-11	Based on public information, this presentation reviews heritages of technology developed for the SPICA Coronagraph Instrument (SCI). The SCI was one of previous instruments of SPICA, and was dropped in the big change of framework of SPICA. Contents of this presentation are technologies for high-dynamic observation of exoplanets, e.g., coronagraph masks, full-metal mirror optics, cryogenic tip-tilt mirror, testbeds, wavefront correction technologies, spectral dispersers for transiting exoplanets, and so on. The SCI is no more, however, these heritage technologies are useful for other various kind of space IR mission including exoplanet science.
Brian Hicks	**Capabilities toward starlight suppression in multiple simultaneous broad bands** Tue, 10:43 • P6-12	Spectroscopic measurement of an exoEarth's oxygen, water, carbon dioxide, and methane absorption features spanning the visible to near infrared will best be done simultaneously in order to address issues associated with observing dynamic atmospheres on rotating planets at different orbital epochs. Such broad spectral coverage will most likely require multiple $5 - 20\%$ bandwidth coronagraphic systems operating in parallel with each channel nominally achieving high-order starlight suppression, full off-axis discovery space, and high throughput, all with minimal sensitivity to telescope instabilities. Here we present recent efforts to further the development of high-contrast imaging technology that spans all aperture types from monolithic to formation flying sparse aperture telescopes.
Clement Perrot	**Performance simulation of the E-ELT/MICADO high contrast imaging mode** Tue, 10:44 • P6-13	MICADO is a first light instrument of the European Extremely Large Telescope (E-ELT). It is a wide field near-infrared camera dedicated to observe deep and faint objects and equipped with a single-conjugate adaptive optics (SCAO) module. The ultra-fine angular resolution offered by MICADO (8.7 mas in H-band) combined with good AO correction level places exoplanets as an obvious scientific program for MICADO. Because of the practical limitations of implementing a high contrast mode in MICADO, and building on our experience with SPHERE and NACO, we developed numerical simulations to assess the astrophysical interest of an exoplanet program with MICADO, and to predict the performance in terms of contrast while optimizing the coronagraphic design. We will present the preliminary results of these simulations, where contrasts as large as 10^{-4} and 10^{-5} are achieved at separations of 40 mas and 200 mas. This should open up a new parameter space compared to SPHERE in order to search for young giant planets at very short separations from nearby stars and in wider orbits around more distant young stellar associations unattainable compared with 8-m class telescopes.

Properties of exoplanet/substellar objects and relations to models

Stephan Birkmann	**Exo-planet transit spectroscopy with JWST/NIRSpec** Tue, 15:25 • P6-14	NIRSpec will be one of the four instruments on-board the James Webb Space Telescope (JWST), scheduled to be launched in 2018. The instrument will have a wide aperture that is dedicated to exo-planet transit spectroscopy covering the 0.6-5.3 μm range. We will present the features of NIRSpec's exo-planet characterisation mode and give an overview of the expected performances and saturation limits for bright sources.
Loïc Albert	**Exoplanet Transit Spectrocopy with NIRISS on the James Webb Space Telescope** Tue, 15:26 • P6-15	One of the four science instruments that JWST will carry when it launches in 2018 is the Near-Infrared Imager and Slitless Spectrograph (NIRISS). A canadian-built instrument, NIRISS was designed with one of its observing modes dedicated to exoplanet spectroscopy. A cross-dispersed grism produces a spectral trace at a resolving power of $R = 700$ (order 1) and $R = 1400$ (order 2) between 0.6 μm and 2.8 μm. To minimize systematic errors and improve the saturation limit, a cylindrical weak lens spreads the PSF over about 22 pixels in the spatial direction while preserving its Nyquist-limited resolution in the spectral direction. In this way, NIRISS will enable transit spectroscopy of targets as bright as $J = 7$, encompassing the blackbody emission peak of late-type stars to maximize photon harvesting. Simulations show that single-transit observations of Jupiter-mass planets will yield sufficient photons to characterize at high signal-to-noise ratio the hydrogen-dominated atmospheres, at full spectral resolution. The brightest super-earth atmospheres will require a few transits to be characterized. Simulations for phase curves and secondary eclipses with NIRISS will also be presented.
Michael McElwain	**High Contrast Integral Field Spectroscopy with PISCES** Tue, 15:27 • P6-16	We will present the Prototype Imaging Spectrograph for Coronagraphic Exoplanet Studies (PISCES) design, simulations, and initial characterization. PISCES is a prototype integral field spectrograph (IFS) that will advance the technology readiness of high contrast imaging technologies for the WFIRST-AFTA Coronagraph Instrument as well as future life-finder mission concepts such as ATLAST. PISCES is currently in development at NASA Goddard and will be integrated with the WFIRST-AFTA technology demonstrations in the High Contrast Imaging Testbed at the Jet Propulsion Laboratory.
Victor Garcia	**The Visible Imaging System for Interfermetric Observations at NPOI** Tue, 15:28 • P6-17	The Visible Imaging System for Interferometric Observations at NPOI (VISION) is a versatile visible light beam combiner for the Navy Precision Optical Interferometer (NPOI). VISION is a fiber-optics based beam combiner that can coherently combine light from up to 6 telescopes simultaneously using an image-plane combination scheme. VISION was inspired by the Michigan Infrared Combiner (MIRC) for the CHARA array - but VISION operates at optical wavelengths. VISION features a photometric camera for calibrations, spatial filtering from single mode fibers, and negligible read noise with a modern electron-multiplying CCD. These features will enable visibility amplitude and closure phase precisions of a few percent and a couple of degrees respectively. With planned spatial resolutions of < 0.2 milli-arcseconds, VISION will be used to make multi-pixel images of stellar surfaces, directly observe planet transits and characterize exoplanet host stars at optical wavelengths.
Lucien Gauchet	**FIRST-IR instrument: Latest development and results of nulling capabilities** Tue, 15:29 • P6-18	In the context of direct detection of exoplanets and disks, the use of high angular resolution and high contrast techniques is essential. The issue is to detect the light from a companion located at a small angular separation from its parent star and at the same time to deal with the high difference of their respective luminosity. FIRST-IR (Fibered Instrument foR a Single Telescope) is an interferometric instrument developed at the Observatoire de Paris-Meudon (LESIA) to fulfill the aforementioned requirements. This demonstrator is operating in the near infrared (H band: λ=1.65 μm) and leans upon pupil remapping using single mode fibers and integrated optic for recombination. Pupil remapping derives from sparse aperture masking, transforming the pupil of the telescope into a interferometric array, but push the concept further, aiming at making interfere every sub-division of main pupil, two by two. This allow to get rid of non-coherent addition of the perturbed wavefront due to redundancy in the pupil. The light from each sub-pupil is injected into its respective fiber, dispatching it into the integrated optic beam combiner. Integrated optics, originally developed for telecommunications were implanted successfully in astronomy. The PIONIER instrument at the VLTI and the soon-coming GRAVITY instrument are perfect examples of the strong potential of such devices. They offer an advantageous technical solution that is stable and compact and easy to integrate in an instrument for the recombination of light. They consist in a substrate on which waveguides are engraved and whose disposition and geometry allow multiple configurations of recombination. The output of the integrated optic display the information on the phase delay between input beams: the intensity of interference fringes are sampled on a quadruplet of pixels for each pair of recombined sub-pupils. In this study, we present the current state of the FIRST-IR instrument which combine pupil remapping with nulling to cancel the stellar light, and thus decrease the photon noise outshining the light from the companion. We will present the first results of closure phase after nulling.

Posters

Angelos Tsiaras	**Blind source separation methods for characterizing extra-solar atmospheres** Tue, 15:30 • P6-20	The number of extra-solar planets is now already very high and the future seems to be even more promising as many teams, all around the world, are dedicated to exploring the sky and finding new ones. Having made this progress, the next challenge is to investigate what are these planets made of and what are the conditions on them by studying their atmospheres. Currently, only two types of planets can be studied for their atmospheres, those detected by transits or direct imaging. For transiting planets we have the opportunity to measure their transmission and emission spectra from their transits and eclipses respectively. More specifically, observations with Hubble and Spitzer space telescopes and other ground-based instruments have started to give us information about the composition of a number of extra-solar planets. The main problem with such observations is the necessary precision of 1 over ten thousand which is usually bellow the level of the systematics. Our team has put a lot of effort in order to cope with all the kinds of systematics that are included in these data, both parametrically, in the case of known systematics, and non-parametrically, for systematics with unclear or unknown cause and behavior. Such methods include, PCA, ICA and wavelet decomposition techniques, which are being used in other fields of astronomy, and other sciences, for many years. The importance of studying the atmospheres of directly imaged planets alongside with transiting planets is clear, given the very different orbital separations (and therefore different conditions on the planet) to which both techniques are sensitive. Similarly, the data analysis expertise crossover at the boundary of low SNRs (for the most challenging observations) is significant. We believe that adopting blind source separation methods in the expanding field of direct imaging will significantly improve the odds of understanding an even wider range of new, exotic, worlds.
Giuseppe Morello	**A blind method to detrend exoplanetary observations** Tue, 15:31 • P6-21	Observations of exoplanetary transits are a powerful tool to investigate the nature of planets around other stars. Transits are revealed through periodic drops in the apparent stellar brightness, due to the interposition of a planet between the star and the observer. Multi-wavelength observations can be used to characterize the atmospheres of exoplanets, through differences in the transit depths, typically at the level of one part in 10^4 in stellar flux for giant planets. Although this method has been successfully used to detect a list of molecules on several exoplanets, some controversial results are present in the literature. Instrumental systematics are often difficult to disentangle from the signal, and the use of different parameterizations of the systematics can affect the results. We present a blind source separation method, based on Independent Component Analysis (ICA) of individual pixel time series, to decorrelate the planetary signal without any prior instrument model or astrophysical information, hence ensuring a higher degree of objectivity. This method has been applied to a few Spitzer/IRAC light-curves of HD189733b and GJ436b, obtaining for the first time coherent and repeatable results over different epochs (Morello et al. 2014, ApJ, 786, 22, Morello et al. 2015, ApJ, 802, 117). The ability of ICA to disentangle the source signals from observations is not limited to photometric time series, but also to spectroscopic data (Waldmann et al. 2012, 2013, 2014), and images (Hyvarynen and Oja 2000, Neural Networks, 13, 411). We introduce here the ICA statistical technique, present its applications in exoplanetary science, and, in particular, the data detrending algorithm mentioned above (see also Morello 2015, ArXiv). We also report the results of its application to different observations, in addition to the already published ones. Finally, we discuss the possible advantages of implementing similar methods in other contexts, and future perspectives.
Ingo Waldmann	**Emission spectroscopy of transiting and imaged planets** Tue, 15:32 • P6-22	For both transiting and directly imaged planets, emission spectroscopy of the exoplanet's atmosphere provides an important window into its dynamics, chemistry and formation history. Permanently at the edge of instrument feasibility, it is as important as it is difficult to find the most optimal and objective atmospheric retrieval methodologies to interpreting current data. This is particularly true for smaller and fainter plants, where signal-to-noise ratios (SNRs) are low and data sparsely sampled. In the light of these challenges, we developed a novel, bayesian atmospheric retrieval suite, Tau-REx (Waldmann et al. 2015a,b, Rocchetto et al. 2015). Tau-REx is a full line-by-line emission/transmission spectroscopy retrieval code based on the most complete hot line-lists from the ExoMol project. For emission spectroscopy, the correct retrieval of the atmosphere's thermal gradient is extremely challenging with sparse and/or low SNR data. Tau-REx implements a novel two-stage retrieval algorithm which allows the code to iteratively adapt its retrieval complexity to the likelihood surface of the observed data. This way we achieve a very high retrieval accuracy and robustness to low SNR data. Using nested-sampling in conjunction with large scale cluster computing, Tau-REx integrates the full Bayesian Evidence, which allows for precise model selection of the exoplanet's chemistry and thermal dynamics. Precision and statistical rigour is paramount in the measurement of quantities such as the carbon-oxygen ratio of planets which allow insights into the formation history of these exotic worlds. At this conference I will discuss how Tau-REx can be used to interpret the data from both transiting and directly imaged extrasolar planets and what we can learn from the current data.

Posters

Aoi Takahashi	**Development of a Cryogenic Deformable Mirror for Direct Detecting of Exoplanets with Space Infrared Telescopes** Tue, 15:33 • P6-23	Space infrared telescopes have originally figure-error of the mirror surface, and confront deformation due to cooling and being free from gravity. These cause wavefront-error in lights from objects. Therefore, direct detecting of exoplanets with a coronagraph needs to correct the wavefront-error and reduce speckles. As one solution of it, we consider correcting the wavefront-error with an additional small deformable mirror (DM). Because space infrared telescopes are cooled in order to decrease the thermal radiation from themselves, a DM needs to precisely deform at the cooling temperature of the telescope. For the use at cryogenic temperature, we adopted Micro Electrical Mechanical Systems (MEMS) technology based DMs. The type of DM is deformed by coulomb attraction, which does not depend on temperature. Conventional MEMS-based DMs, however, have been thought used at ordinary temperature and their substrate units have mismatched coefficients of thermal expansion (CTE) among their parts. We developed a cryogenic MEMS-based DM with a substrate unit's design adapted for cryogenic temperature. The prototype with 32 actuators has been confirmed to precisely deform at 95 K. In this presentation, we will introduce the cryogenic MEMS-based DM with 1020 actuators, which we have manufactured for using at 5 K. At present, we are testing operating characteristics of the DM.
Eduardo A. Bendek	**ACESAT: The first small telescope space mission to directly image the Habitable Zone of Alpha Centauri** Tue, 15:34 • P6-24	The inner edge of Alpha Cen AB Habitable Zone is found at exceptionally large angular separations of $0.7''$ and $0.4''$ respectively. This enables direct imaging of the system with a 30 cm class telescope. Contrast ratios in the order of 1010 are needed to image Earth-brightness planets. Low-resolution (5-band) spectra of all planets, will allow establishing the presence and amount of an atmosphere. This star system configuration is optimal for a specialized small, and stable space telescope, that can achieve high-contrast but has limited resolution. This paper describes an innovative instrument design and a mission concept based on a full Silicon Carbide off-axis telescope, which has a Phase Induce Amplitude Apodization coronagraph embedded in the telescope. This architecture maximizes stability and throughput. The Multi-Star Wave Front algorithm is implemented to drive a deformable mirror controlling simultaneously diffracted light from the on-axis and binary companion star. The instrument has a Focal Plane Occulter to reject starlight into a Low Order Wavefront Sensor that delivers high-precision pointing control. Finally we utilize the ODI post-processing method that takes advantage of a highly stable environment (Earth-trailing orbit) and a continuous sequence of images spanning 2 years, to reduce the final noise floor in post processing to $\sim 2\times 10^{-11}$ levels, enabling high confidence and at least 90% completeness detections of Earth-like planets.
Charles-Philippe Lajoie	**Improving JWSTs Coronagraphs Performance with Small-Grid Dithers** Tue, 15:35 • P6-25	The James Webb Space Telescope (JWST) will be equipped with a suite of coronagraphs allowing observers to detect faint sources near or around bright stars and galaxies. For example, the JWST coronagraphs will allow for the imaging and characterization of exoplanets close to bright stars as well as disks around quasars and young stars. Coronagraphic observations typically rely on subtracting a reference star point spread function (PSF), which we know to be featureless (e.g., planets, disk), from the science target in order to remove the bright stellar speckles, exposing any faint surrounding objects. In recent years, coronagraphic observations have greatly benefited from advances in post-processing techniques. Here, we discuss the results of simulations aimed at demonstrating a possible new JWST mode that utilizes many sub-pixel dithered reference images, called Small-Grid Dithers, to optimize coronagraphic PSF subtraction. Using realistic noise sources and jitter in our simulated images, we find that Small-Grid Dithers can improve contrast by a factor ranging from 2 to more than 10 for both NIRCam and MIRI coronagraphs respectively.
Valeri Orlov	**Speckle Interferometry of exoplanet host stars.** Tue, 15:36 • P2-1	We present observational project of speckle interferometric study of exoplanet host stars. The observing lists for these observations not been pre-selected for known double stars. First observations were performed during April of 2012 at the 2.1 m telescope of the Observatorio Astronómico Nacional at SPM (México). During four night, we have observed fifty objects. Each host star was observed in five Johnson filters (U,B,V,R,I). Relatively small telescopes can be effectively used for this purpose because thay allow to reach the Rayleigh resolution limit R = 1.22 λ/D. For instance, the resolution of 2m telescope in V band is $0.055''$.
Anne-Marie Lagrange	**SPOT: a scheduler for Adaptive Optics, High Contrast Imaging Surveys** Tue, 15:37 • P2-2	The surveys for extrasolar planets with the recently installed Planet Imagers generally include hundreds of targets, to be observed possibly repeatedly, generally in Angular Differential Mode. Each observation has to be carefully scheduled to maximize the Field of View rotation amplitude. We have developed a software (SPOT) that allows both long term (months, years) and short term (night) optimized scheduling of such surveys, taking into account constraints that include so far the runs dates, targets positions and associated observing modes, dates of observations if relevant, instrumental set-up, distance to meridian passage constraints, air masses constraints, Field of View rotation angle if relevant, overheads, and calibrations. Priorities and urgencies may be assigned to each target, to ensure that the most interesting ones will be scheduled and, if required, as soon as possible. SPOT can also be used to determine the best observing dates given a list of targets and, once the dates of observations are known, to compute the detailed schedule of the observations. SPOT is developed in C++, and is currently based on simulated annealing, but more efficient local search heuristics are under study. The range of applications can be extended to different scheduling needs and constraints. We will describe the code, its excellent performances in terms of execution time and optimizing capabilities, and show examples of outputs in the present context.

Posters

Janis Hagelberg	**The brown dwarf desert between 5 and 50 AU probed by combined direct imaging and radial velocity.** Tue, 15:38 • P2-3	I will present the results of the completed direct imaging campaign for stars with radial velocity drifts in the HARPS and CORALIE planet-search surveys. Using the radial velocity data which spans over more than a decade, we selected promising targets for direct imaging of sub-stellar companions to solar-type stars. The direct imaging observations were carried out on VLT/NaCo using the angular differential imaging technique. By combining the constraints from direct imaging and radial velocity we derived the frequency of brown dwarfs around Sun like stars in the 5 to 50 AU range. First results of the ongoing extension of this project in the northern hemisphere using Subaru/SCExAO will also be presented.
Tiffany Meshkat	**Searching for planets in Holey Debris Disks** Tue, 15:39 • P2-4	Directly imaging planets provides a unique opportunity to study young planets in the context of their formation and evolution through spectroscopic examination of its emergent flux. However, only a handful of planets have been directly imaged, and thus the stars best suited for planet imaging are still a subject of debate. The "Holey Debris Disk" project was created in order to help determine if debris disks with gaps are signposts for planets. These gaps may be dynamically caused by planets accreting the debris material as they form. We present the results from our survey with VLT/NACO and the apodized phase plate coronagraph. We demonstrate that these disks with holes are good targets for directly detecting planets with the discovery of a planet around two of our targets, HD 95086 and HD 106906, at L'-band. Our non-detection of HD 95086 b in H band demonstrates the importance of thermal infrared observations. The detected planets likely shepherd the outer cool debris belt. The relatively dust-free gap in these disks implies the presence of one or more closer-in planets. We discuss our new constraints on planets around other targets in our survey as well as disk properties of these targets and describe how future instruments will find the inner planets.
Justine Lannier	**M-dwArfs Statistical Survey for direct Imaging massiVe Exoplanets with NACO: probing the frequency of planets around low-mass stars.** Tue, 15:40 • P2-5	In recent years, about 30 giant exoplanets have been detected by Direct Imaging. These discoveries have greatly challenged our understanding of giant planets formation and evolution, as these few planets are massive and located at large separations from their host star. There are still uncertainties on the formation scenarios for wide-orbit giant planets : depending on their mass and semi-major axis, their formation can be explained by core accretion, gravitational instabilities, or pebble accretion. Studying giant planets orbiting M-dwarfs is very promising since these stars are the most common in the Galaxy, and since the planet-star contrast is favorable to current instruments to probe less massive giant planet (around 1 Jupiter mass). I propose to highlight my ongoing statistical work on MASSIVE (M-dwArfs Statistical Survey for direct Imaging massiVe Exoplanets with NACO), a survey made of 58 young and nearby M-dwarfs. The results that emerge from this study represent a first step in the field of Giant Planets formation in terms of their occurence (as a function of mass and separation) and favoured formation model.
Dmitry Savransky	**GPIES Planet Yield Simulation Update** Tue, 17:55 • P2-7	The Gemini Planet Imager Exoplanet Survey (GPIES) is an 890 hour survey of 600 nearby stars to directly image young, massive exoplanets with the Gemini Planet Imager instrument at the Gemini South Observatory. Having observed over 20% of its nominal target list, GPIES now has a solid baseline of instrument operating performance in the form of single-image and post-processed, angular separation-dependent contrasts for a wide variety of operating conditions and targets. This has allowed us to update our pre-survey performance simulations and to produce updated predictions for the expected overall survey yield as a function of planetary formation models. Here we present an overview of GPI performance parameterized by target elevation at the time of observation, time of year and other key metrics. We briefly review the pre-survey modeling efforts and show updated results incorporating data from the initial part of the survey.
Étienne Artigau	**Occurence of Giant Planets on Ultra-Wide Orbits (500-5000 AU)** Tue, 17:56 • P2-8	Most direct imaging exoplanet surveys use AO systems and target the inner few arcseconds around host stars, probing orbits only slightly larger than the extent of the outer Solar System. These surveys probed separations corresponding to the extent of the largest proto-planetary disks and one would naturally expect to find planets out to these separations and not much beyond. On the other hand, planetary orbits out to thousands of AUs are expected to be stable for Gyrs around Sun-like stars, and at least two mechanisms could put planets on such wide orbits; dynamical excitation from tighter orbits and hierarchical collapse of molecular clouds, where planetary-mass objects would represent the very low-mass tail of stellar binaries. We have undertaken a program to constrain the abundance of very wide (500-5000 AU) planetary companions around young, nearby stars.
Marco Rocchetto	**On the detection of planetary remnants around evolved stars** Tue, 17:57 • P2-9	In the last decade, it has become clear that planetary systems around Sun-like and intermediate-mass stars survive, at least in part, the post-main sequence phases of their hosts. Metal-enriched white dwarf stars commonly exhibit closely orbiting dust and gas discs, resulting from the tidal disruption of rocky minor planets. The debris-polluted atmospheres of these stars are a unique and powerful laboratory to infer the bulk composition of terrestrial exoplanets, via their tidally destroyed and accreted fragments or building blocks. Despite the clear evidence of planetary system remnants around such evolved stars, no white dwarf planets have yet been confirmed. However, current direct imaging surveys have only been sensitive to planets more massive than about 10 M_J. New facilities such as SPHERE and GPI will enable to search for $3-7\,M_J$ planets in orbits as close as one AU and as wide as 70 AU. This is a region so far unprobed in which white dwarf planets are expected. I will present a recent double-blind Spitzer/HST survey that has unambiguously determined the fraction of detectable planetary debris at relatively young white dwarfs. Given this unbiased statistics, I will also discuss the potential of detecting such planets with new ground based facilities. The discovery of white dwarf planets would provide crucial clues for understanding the evolution and architecture of planetary systems around Sun-like stars.

Posters

Brendan Bowler	**An Efficient Search for Giant Planets Orbiting New Young M Dwarfs** Tue, 17:58 • P2-10	Direct imaging surveys have shown that the frequency of giant planets between 10-100 AU is inconveniently low, altogether perhaps a few percent or less. This implies that sample sizes of several hundred are required to measure weak statistical trends like a planet frequency-stellar host mass correlation as predicted by the disk instability model of giant planet formation. To complement large ongoing programs targeting high mass stars, we are carrying out an expansive adaptive optics imaging survey primarily at Keck Observatory focusing on 400 newly identified M dwarfs in young moving groups. In addition to planet population statistics from the first phase of this program (the Planets Around Low-Mass Stars survey; PALMS) we will present initial results from our new efficient program, for which we have already observed over 300 stars. Altogether this survey will measure the occurrence rate of long-period massive giant planets around young M dwarfs with a precision of about 1%, providing definitive statistics for comparison with Sun-like and massive stars.
Andreas Quirrenbach	**Giant planets around nearby young stars - a large L' band imaging survey** Tue, 17:59 • P2-11	We are starting a deep NaCo L' band coronographic angular differential imaging survey for wide-separation giant planets around young nearby stars. Our main goal is the discovery and characterization of the theoretically hypothesized but observationally only partially characterized wide-separation ($> 5 - 10$ AU) giant planet population. With the combination of L' band observations, the use of the new AGPM coronograph to minimize the inner working angle, and a strategy for going significantly deeper than previous surveys, we will optimize the sensitivity to lower-mass and older planets than targeted by other surveys. We will also probe smaller separations, thus bridging the gap between orbital separations probed by RV and direct imaging surveys.
Kimberly Ward-Duong	**Stellar and Substellar Companions to Field M-dwarfs and Nearby Young Stars from the GPI Exoplanet Survey Campaign** Tue, 18:00 • P2-12	Stellar multiplicity provides a critical observational signature of the star formation process, and binaries and higher-order systems have important implications for planet formation and evolution. High-resolution direct imaging provides the capability to search for companions with projected separations covering a few AU outwards for the nearest stars. We present results from two studies probing the binary properties of nearby stars: (1) The MinMs (M-dwarfs in Multiples) volume-limited survey of 245 field M-dwarfs within 15 pc, and (2) an on-going MagAO/Clio2 L' imaging search for wide orbit giant planets and brown dwarfs to Gemini Planet Imager (GPI) Exoplanet Survey targets. By combining adaptive optics and wide-field imaging, the MinMs Survey provides new measurements of the companion star fraction, separation distribution, and mass ratio distribution for the nearest K7-M6 dwarfs, and includes on-going efforts to characterize their substellar companions. We find a companion star fraction of $23.5 \pm 3.2\%$ over the 3 AU to 10000 AU separation range, a stellar companion separation distribution peaked near 6 AU, and a flat mass ratio distribution similar to that of multiple systems with solar-type primaries. In addition to the nearby M-dwarf survey, we report on early results from our MagAO/Clio2 L' wide companion search. The initial MagAO observations include a number of interesting candidate companion systems at separations $> 2''$, complementary to the GPI search space and essential to understanding the full companion distribution of the GPI Exoplanet Survey sample. The MinMs and MagAO studies cover both old (>5 Gyr) and young ($10 - 70$ Myr) populations, respectively, and provide benchmark measurements on the distribution of stellar and substellar companions to field M-dwarfs and a population of young, Solar-type stars.
Frédérique Baron	**Wide Imaging Search for Benchmark Planets** Tue, 18:01 • P2-13	We currently do not know what does the emission spectrum of a young 1-2 Jupiter-mass planet look like, as no such object has yet been directly imaged. Arguably, the most useful Jupiter-mass planet would be one that is bound to a star of known age, distance and metallicity but which has an orbit large enough that it can be studied as an "isolated" object. We are currently gathering a large dataset to try to identify such objects through deep $[3.6]$ and $[4.5]$ imaging from SPITZER and deep seeing-limited J (with Flamingos 2 and WIRCam) and z imaging (with GMOS-S and MegaCam) of all 181 known confirmed members of a known young association (<120 Myr) within 70 pc of the Sun. Our study will reveal distant planetary companions, over the 20-3000 AU separation range, through their distinctively red $z - J$ and $[4.5] - [3.6]$ colors. The sensitivity limits of our combined Spitzer+ground-based program will allow detection of planets with masses as low as 3 M_{Jup} with very low contamination rates. Here we present some preliminary results of our survey.
Ryan Varley	**Exoplanets, Catalogues and Big Data** Tue, 18:02 • P2-14	Exoplanet science often involves using system parameters of real exoplanets as a primer to fitting routines or calculations and searching catalogues for preferable targets to observe. Up to date accurate catalogues are well established with many catalogues in the exoplanet space but code friendly interfaces to access these catalogues are sparse and they often lack a version history. Software that bridges the barrier between the catalogues and code enables users to improve provide repeatability of results by easily being able to retrieve the exact catalogue version used in a researchers results along with reducing bugs in the equations and interfaces. It also allows advance querying of the exoplanet population for use in target selection. ExoData is a python interface and exoploratory analysis tool for the Open Exoplanet Catalogue. It allows the loading of exoplanet systems into python as objects (Planet, Star, Binary etc) from which common orbital and system equations can be calculated and measured parameters retrieved. This allows researchers to use tested code of common equations they require (with units) and provides a large science input catalogue of planets for easy plotting and use in research. Advanced querying is possible using the database and Python programming language. Examples of use cases are integration of equations into data reduction pipelines, selecting planets for observing proposals and as an input catalogue to large scale simulation and analysis of planets. ExoData is a python package available on GitHub. It is open source and community contributions are encouraged.

Posters

Elena Sissa	**High contrast sensitivity of the ZIMPOL Halpha mode** Tue, 18:03 • P2-15	SPHERE had the first light in April 2014 and has completed Commissioning and Science Verification phases, being now fully operative. It includes a visible differential polarimeter (ZIMPOL). The prime objective of SPHERE is the discovery and study of new extrasolar giant planets orbiting nearby stars by direct imaging of their circumstellar environment but it can be a powerful instrument also for other scientific fields. Very young planets are expected to accrete material from the circumstellar disk: it is expected that this accreting material might be detectable through H emission lines. At the corresponding wavelength (in particular, at that of H, at 656 nm), the contrast between the star and the planet may be substantially reduced, possibly leading to planet detection in spite of the strong background due to the halo of the stellar image. First results will be shown.
Abhijith Rajan	**A study of the contrast and planet detection sensitivity for the GPI Exoplanet Survey** Tue, 18:04 • P2-16	We present an analysis of the initial Gemini Planet Imager Exoplanet Survey (GPIES) campaign data to quantify the contrast and planet-mass detection sensitivity. The contrast analysis focuses on both the raw individual data cubes ($\sim$1 minute) as well as the typical 40 minute sequence with advanced image processing techniques applied. We have looked for correlations in instrument performance as a function of three factors: target properties, conditions, and analysis techniques. Specifically, we examine relationships between target brightness, elevation, seeing, field rotation, Angular Differential Imaging, Spectral Differential Imaging, or a combination of approaches. We also investigate the achieved contrast over different observational wavelengths. We combine predictions of planet brightness with the range of ages in the GPIES sample and compare results to explore the range of planet masses to which the data are sensitive. The contrast and sensitivity will form an important component of the final planet population statistics from the GPIES campaign.
France Allard	**Modelling the transition between cool stars to brown dwarfs and planetary mass objects** Tue, 18:05 • P3-1	Since infrared observations of M dwarf stars (late 80's), brown dwarfs (mid 90's), and extrasolar planets (mid-2000s) are available, one of the most important challenge in modelling their atmospheres as become the understanding of molecular opacities (including the pressure-induced H2 bands), solar elemental abundances, cloud formation, disequilibrium chemistry, and quasi-static collisional broadening. Their atmospheric composition is mostly constituted of molecular hydrogen, helium, molecular nitrogen/ammonia, carbon monoxide/methane, and water vapour. But their SED is also governed by trace elements in the form of SiH, CaH, TiO, VO, CrH, FeH molecular absorption bands, resonance absorption lines of alkali elements, Al, Ti, Fe, Cu, etc., and condensed species (rocks, metals, silicates, salts, and ices crystals).
Yasuhiro Hasegawa	**Planet Traps and Super-Earths: Implications for the Mass-Radius Diagram** Tue, 18:06 • P3-2	The discovery of a large number of super-Earths both by the radial velocity and by the transit has enabled a careful investigation of their composition that can provide fundamental constraints on their formation mechanisms. We present a statistical analysis for the population of planets that grow by the core accretion process at planet traps where rapid type I migration is halted. Evolutional histories of forming and migrating planets in evolving gas disks are computed theoretically in this model. We show statistically that the minimum mass of planets formed at planet traps via the core accretion scenario is about 5 Earth masses. These low-mass planets formed in our model are regarded as failed gas giants that contain a negligible or low mass atmosphere. Our results therefore imply that the composition of super-Earths may change from solid materials to gaseous/icy ones at about 5 Earth masses. Using a latest empirical mass-radius relationship, this transition value of planetary mass roughly corresponds to the recent estimate inferred from the Kepler data.
Michael Liu	**Young Brown Dwarfs as Gas-Giant Exoplanet Analogs** Tue, 18:07 • P3-3	Direct detections of gas-giant exoplanets and discoveries of young ($\sim$10-100 Myr) field brown dwarfs from all-sky surveys are strengthening the link between the exoplanet and brown dwarf populations, given the overlapping ages, masses, temperatures, and surface gravities. In light of the relatively small number of directly imaged planets and the modest associated datasets, the large census of young field brown dwarfs provides a compelling laboratory for enriching our understanding of both classes of objects. However, work to date on young field objects has typically focused on individual discoveries. We present a large comprehensive study of the youngest field brown dwarfs, comprising both previously known objects and our new discoveries from the latest wide-field surveys (Pan-STARRS-1 and WISE). With masses now extending down to $\sim$5 M_{Jup}, these objects have physical properties that largely overlap young gas-giant planets and thus are promising analogs for studying exoplanet atmospheres at unparalleled S/N, spectral resolution, and wavelength coverage. We combine high-quality spectra and parallaxes to determine spectral energy distributions, luminosities, temperatures, and ages for young field objects. We demonstrate that this population spans a continuum in the color-magnitude diagram, thereby forming a bridge between the hot and cool extremes of directly imaged planets. We find that the peculiar IR colors and magnitudes of the planets around 2MASS J1207-39 and HR 8799 do occur in some young brown dwarfs, but these properties do not have a simple correspondence with age, perhaps contrary to expectations. We find young field brown dwarfs can have unusually low temperatures and suggest a new spectral type-temperature scale appropriate for directly imaged planets. To help provide a reference for extreme-contrast imaging surveys, we establish a grid of spectral standards and benchmarks, based on membership in nearby young moving groups, in order to calibrate gravity (age) and temperature diagnostics from near-IR spectroscopy. Finally, we use our data to critically examine the possibility that free-floating objects and companions may share different evolutionary histories, thereby complicating the brown dwarf-exoplanet connection.

Posters

Jonathan Gagné	**The search for brown dwarfs and very low mass stars in young moving groups** Tue, 18:08 • P3-4	I will present in this talk the current status of the BANYAN All-Sky Survey (BASS) for >M5 low-mass stars and brown dwarfs in young moving groups of the solar neighborhood. We have identified several hundred moving group candidate members from an all-sky cross-match of the 2MASS and AllWISE catalog, and initiated a near-infrared and optical spectroscopic follow-up. I will unveil some of our newest discoveries, including several new young L dwarfs with estimated masses down to $< 10\,\mathrm{M_{Jup}}$, and a new low-gravity L4 companion to an M6 low-mass star in Tucana-Horologium. Additionally, I will present new constraints on the space density of isolated planetary-mass brown dwarfs in Tucana Horologium. I will show the first hints of a turn-off of the young sequence in a J versus $J-K$ color-magnitude diagram, indicating that we are about to reach the T spectral type.
Sasha Hinkley	**New Extreme Mass Ratio Companions in Sco-Cen** Tue, 18:09 • P3-5	I will present the discovery of seven low mass companions to intermediate-mass stars with BAF spectral types ($1.5-4.5$ solar masses) in the Scorpius-Centaurus Association using nonredundant aperture masking interferometry at Keck and VLT. With masses as low as $\sim$20 $\mathrm{M_{Jup}}$, and mass ratios of only a few percent, our newly detected objects span the Brown Dwarf desert. With projected separations of only $10-30$ AU, our aperture masking detections provide a powerful complement to previous adaptive optics imaging of intermediate mass Scorpius-Centaurus stars (e.g. Lafrenière et al. 2014, Janson et al. 2013) covering much larger orbital radii ($\sim 30-3000$ AU). At these orbital separations, our newly detected objects resemble higher mass versions of the directly imaged planetary mass companions to the 10-30 Myr stars HR 8799, beta Pictoris, and HD 95086, providing a new constraint on models of the formation of low-mass companions to intermediate-mass stars.
Trent Dupuy	**Testing Models of Substellar Evolution with Dynamical Masses** Tue, 18:10 • P3-6	We critically examine the accuracy of current evolutionary and atmospheric models used to derive physical properties for substellar objects. In particular, we focus on the relationship between mass, luminosity, and age using a newly expanded sample of dynamical masses and parallaxes for substellar binaries from our long-term astrometry programs at Keck, CFHT, and HST. This sample provides a foundation for rigorous tests of models at temperatures and luminosities comparable to that of giant planets found by directly imaging, and it includes systems as young as $\sim$200-500 Myr, overlapping the ages probed by current and upcoming planet-imaging instruments. We present the first direct evidence that cloud dispersal plays a significant role in the cooling timescales of substellar objects, causing a remarkably shallow mass–luminosity relation in the L/T transition. Also, for the two systems where mass, luminosity, and age are well determined, models seem to systematically underpredict luminosities by a factor of $\sim 2\times$. We speculate that this too could be caused by the details of cloud dispersal not captured by current models. Finally, we provide quantitative estimates for the systematic errors that may be expected when these models are used to estimate the physical properties of directly imaged planets.
Philippe Delorme	**Free floating planet or high metallicity atypical brown dwarf ?** Tue, 18:11 • P3-7	We conducted a multi-wavelength, multi-instruments observational characterisation of the candidate free-floating planet CFBDSIRJ214947.2-040308.9, in order to ascertain its nature and determine its physical properties. This enabled us to fully characterise its flux, from the visible to 5 μm, encompassing most of the energy emitted by such a cool late T-type object. We were also able to determine its kinematics with 3D position determined as well as accurate 2D motion. While the spectral information confirm the low gravity or high metallicity of CFBDSIR2149 atmosphere, the new kinematics safely rule out membership to any known young moving group. Therefore CFBDSIR2149 is not a free-floating planet in AB-Doradus as proposed by Delorme et al. 2013 but a peculiar late T dwarf, perhaps still a young free-floating planet or an older, heavier brown dwarf with supersolar metallicity.
Jacqueline Radigan	**Discovery of a visual T-dwarf triple system and binarity at the L/T transition** Tue, 18:12 • P3-8	We present new high contrast imaging of eight L/T transition brown dwarfs (BDs) using the NIRC2 camera on the Keck II telescope. One of our targets, the T3.5 dwarf 2MASS J08381155+1511155, was resolved into a hierarchal triple (T3/T3/T4.5) with projected separations of 2.5 ± 0.5 AU and 27 ± 5 AU for the BC and A(BC) components, respectively. Resolved OSIRIS spectroscopy of the A(BC) components confirms that all system members are T dwarfs. The system therefore constitutes the first triple T-dwarf system ever reported. Relying on empirical trends and evolutionary models we infer a total system mass of $0.034-0.104\,\mathrm{M_\odot}$ for the BC components at ages of $0.3-3$ Gyr, which would imply a period of $12-21$ yr assuming the system semimajor axis to be similar to its projection. We also infer differences in effective temperatures and surface gravities between components of no more than $\sim$150 K and $\sim$0.1 dex. Given the similar physical properties of the components, the 2M0838+15 system provides a controlled sample for constraining the relative roles of effective temperature, surface gravity, and dust clouds in the poorly understood L/T transition regime. Combining our imaging survey results with previous work we find a volume-corrected binary frequency of 13% for L9-T4 spectral types, which is similar to values of $\sim 9-12\%$ reported outside the L/T transition.

Posters

Sandie Bouchard	**Photometric Variability of the L/T Transition Brown Dwarf SIMP0136+0933** Tue, 18:13 • P3-9	We have been monitoring SIMP0136+0933, the brightest known isolated T dwarf in the sky, since 2008. At first, we detected strong periodic ($\sim$2.4 h) J-band (ΔJ $\sim$50 mmag) and Ks-band (ΔKs ΔJ=0.48$\pm$0.06) modulations in SIMP0136+0933. The object has since then been showing some variation in its variability, passing through periods of stronger and weaker variability. The observed photometric variability is likely caused by the presence of a patchy atmosphere for this early T-dwarf (T2.5), with both grain-free and colder (by $\sim$100K) grain-bearing regions. The time-variability is probably explained by the rotation and/or temporal evolution of these patterns. We discuss this long-term variability observations that allows us to better constrain the physical properties of SIMP0136's clouds, as well as their evolutive properties. We also present some results for our SIMP0136 observations from the CFHT, that is $\sim$7.75 h in the J band and $\sim$5.11 h alternating between the J, H, K_s, and Y bands. The former will help us to determine whether the measured period has changed and the latter will help us to further constrain the relative temperature between cloudy and clear regions using different atmosphere models.
Esther Buenzli	**Characterization of patchy clouds in substellar atmospheres with HST** Wed, 10:20 • P3-10	The atmospheres of brown dwarfs have similar effective temperatures as the young directly imaged giant planets, and they share many of their atmospheric properties. Without the bright glare of a host star, detailed characterization of isolated brown dwarfs is considerably easier. Significant progress in the understanding of cloud structure and cloud dispersal in substellar atmospheres at the transition from L to T spectral types has recently been made by characterizing brown dwarfs in the time domain by measuring their variability. In many brown dwarfs, the variability is explained by heterogeneous cloud cover that results in flux changes as the object rotates. We have conducted several programs with the Hubble Space Telescope (HST) studying in detail the spectral variability for brown dwarfs before, in and after the L/T transition. The stability of HST/WFC3 combined with its broad wavelength coverage, including absorption features not easily accessible from the ground, have provided an unprecedented view into the three-dimensional atmospheric structure of substellar objects. I will summarize the most important results and discuss how they are relevant to atmospheric studies of directly imaged giant planets such as the HR8799 planets, for which first indications for a patchy cloud structure have already emerged. Similar observations may soon be obtained for wide-separation planetary mass companions or free-floating planetary mass objects.
Beth Biller	**Cloud-Driven Variability on Young Brown Dwarfs and Giant Exoplanets** Wed, 10:21 • P3-11	Variability has now been robustly observed in a range of L and T type field brown dwarfs, primarily at near-IR and mid-IR wavelengths. The probable cause of this variability is surface inhomogeneities in the clouds of these objects, causing a semi-periodic variability signal when combined with the rotational modulation from the 3-12 hour period expected for these objects. Variability at similar or even higher amplitudes may be expected for young brown dwarfs and giant exoplanets, which share similar Teff as field brown dwarfs, but have considerably lower surface gravities. Variability studies of these objects relative to old field objects is then a direct probe of the effects of surface gravity on atmospheric structure. I will discuss ongoing efforts to detect variability from these young objects, both for free-floating objects and companions to stars. I will present preliminary results from an ongoing survey of young, low surface gravity objects with NTT SOFI, including a potential variability detection in a young L/T transition object. Dedicated high contrast imagers such as SPHERE and GPI enable variability searches for exoplanet companions as well; I will discuss prospects for detecting variability in these objects.
Dino Mesa	**New constraints on the mass of HD142A c from SPHERE high contrast imaging data** Wed, 10:22 • P3-12	With SPHERE we now have the ability to image planets previously discovered with the Radial velocity (RV) technique. Such a combination of techniques allows us to strongly constrain the physical characteristics of companions. The binary system HD142 is known to host two planets (the first one with a minimum mass of 1 M_{jup} at a separation of $\sim$0.05$''$ and the second one at a separation of $\sim$0.3$''$ with a minimum mass of 5.3 M_{jup}) around the primary star HD142A discovered by RV data. Through Monte Carlo simulation we are able to investigate the probability of detection of RV companions through imaging. Using our calculated orbital properties, we estimate a probability of detection of HD142Ac with SPHERE/IFS of $\sim$12%. HD142A has been observed during the early guarantee time observations (GTO) in October 2014 with a total exposure time of $\sim$ 1hr and a FOV rotation of 35 degrees. We present here our data reduction and results obtained from these observations.
Eleanor Bacchus	**Observing HD 114174 B as a demonstration of high contrast imaging spectroscopy with Project 1640** Wed, 10:23 • P3-13	Project 1640 is a direct imaging survey with the ability to simultaneously obtain images and low resolution spectra of faint companions around nearby stars. The spectra span the H and J bands in the near infrared and enable the detection of broad molecular absorption lines, allowing basic atmospheric modelling to be done and helping to characterise imaged companions. We are currently conducting a survey of near A-F type stars with the aim of detecting young, Jupiter mass planets at separations of around $1' - 2'$ from their host stars. We have also undertaken several observations of known companions, in order to both test our pipeline and provide spectra and further astrometric data to help refine photometric and orbital parameters for these objects. One of these is the TRENDS object HD 114174 B, a faint white dwarf around a nearby G star, for which we present astrometry and spectroscopy.

Posters

Blake M. Pantoja	**A SPHERE Discovery of an M-dwarf Companion to a Sun-Like Star** Wed, 10:24 • P3-14	Radial velocity measurements have long proven to be a powerful method of detecting low-mass companions to bright stars, but they come with the inherent limitation that only minimum masses can be constrained for these companions, since the system inclinations are unknown. Direct imaging, on the other hand, allows us to constrain the companion's inclination relative to an Earth-bound observer, and when combined with radial velocities, allows us to directly probe into the mass/period parameter space of any detected companions. By searching for targets with long-period radial velocity trends, we are able to search for objects with a known but unseen companion. I will present the direct detection of a fully convective, mid M-dwarf companion to one of the metal-rich and Sun-like stars from the CHEPS project, using ESO-SPHERE during Science Verification. The companion was found to be 4.5 mag fainter than the primary, at a separation of 25 AU. This discovery provides us with the exciting opportunity to further constrain the mass-luminosity relation for low-mass stars, particularly for super metal-rich stars, allowing us to expand our understanding of the most-common types of stars and substellar objects.
Claudio Caceres	**On the nature of the planetary mass companion candidate in the FW Tau system.** Wed, 10:25 • P3-15	It is thought that planetary mass companions may form through gravitational disk instabilities or core accretion. Identifying such objects in the process of formation would provide the most direct test for the competing formation theories. One of the most promising candidates for a planetary mass object still in formation is the third object in the FW Tau system. We here present a summary of current observations and present for the first time a clear detection of a CO gas line, providing direct evidence for the simultaneous existence of a gas disk. We perform radiative transfer modeling of the third object in FW Tau, which results will be discussed in this talk, including future possibilities for definitively unveiling the nature of this object.
Julien H. Girard	**Probing for planetary-mass companions around Luhman 16 AB, our closest brown dwarf neighbours** Wed, 10:26 • P3-16	Luhman 16 AB is a L/T brown dwarf binary system located only 2 pc from us. Discovered by Kevin Luhman in early 2013 thanks to the WISE mission and its high proper motion, it has already been extensively studied (spectral types, variability, doppler imaging / cloud map, astrometry, etc.). In this contribution I will show the results of our deep NACO L'-band campaign. Our 5-sigma detection limits are around 2 to 5 M_{Jup} from 0.5 to 50 AU, extremely low for such old (1-3 Gyr) stars. In our search zone, we do not detect the potential companion reported by Boffin et al. 2014 from astrometry data, hence, such companion's projected orbit would have to be closer and/or less massive. I will also briefly expose our pathfinder search with VLTI/PIONIER H-band (4×8.2 m telescopes) to probe down to the Earth-Moon distance ($\sim$0.0026 AU) or a few resolution elements within the temporary/unstable "habitable zone" of the same system. Our preliminary conclusion is that neither A or B is an obvious binary. Adaptive Optics with infrared wavefront sensors are the winning solutions to pursue such quest around the closest, low-mass stars, red neighbours. Such object(s) offer a whole new parameter space for high contrast and high angular resolution studies, at the limit of the currently available facilities.
Jean-Loup Baudino	**What precision on physical parameters can we expect from modeling the atmosphere of directly imaged planets?** Wed, 10:27 • P3-17	We developed a radiative-convective equilibrium model with the objective of interpreting exoplanet direct imaging data with the minimum (or the simplest) assumptions and a rigorous determination of error bars. Input parameters are the planet's surface gravity (g), effective temperature (T_{eff}) and elemental composition. Under the additional assumption of thermochemical equilibrium, the model predicts the equilibrium temperature profile and mixing ratio profiles of the most important gases. Opacity sources include the H2-He collision-induced absorption and eight molecular/atomic line lists (included updated CH_4 with the Exomol database). Absorption by iron and silicate cloud particles is added above the expected condensation levels. Scattering was not included at this stage. We then use VLT/SPHERE broad band photometry and low resolution spectroscopy to study the accuracy of the derived parameters (T_{eff} and $\log g$) as a function of the quality of observations.
Maxime Cudel	**Monitoring of planet variability based on SPHERE science verification time data** Wed, 10:28 • P3-18	Most young L and early T-type planetary mass companions (PMC) and bound brown dwarfs (BD) exhibit redder colors and are less luminous than field ultracool dwarfs with the same overall spectral classes. This is most likely due to the presence of thick clouds related to the low-gravity atmosphere, which may strongly modulate the photometric fluxes with the rotation. Other possibilities are magnetic spots and chromospheric activities, mostly on earlier late-M toearly L-dwarfs. In this context, our study aims at investigating the photometric accuracy achieved with the new planet imager SPHERE at VLT. Our objective is to detect flux variability in young BDs and PMCs to investigate their origins. We used the waffle-on calibration method creating satellite PSFs to enable a continuous monitoring of the companion flux variation during the observing sequence. In this poster, we will present the results for two cases, 1) the bright companion α Eri Band 2) β Pic b. We will show that various regimes exist for which this method can be applied to correct for the instrumental and atmospheric variation to improve the final photometric accuracy.
Klaus Hodapp	**Keck OSIRIS spectroscopy of all components of the 2MJ044144/2MJ044145 quadruple system** Wed, 10:29 • P3-19	The two low mass stars 2MJ044144 and 2MJ044145 form a wide binary system while each component itself is a close binary with a mass near the planet/brown-dwarf limit. All components of this quadruple system are young with estimated ages of order 1 million years. We are reporting the results of Keck OSIRIS integral field spectroscopy in the H and K bands of all components of this system. Based on various spectral indices, the spectral types for 2MJ044144 are A: M8 and b: L3, while 2MJ044145 has A: M8 and B: M9.5.

Posters

Mickaël Bonnefoy	**Characterization of the binary brown-dwarf companion to the intermediate-mass star HR6037** Wed, 10:30 • P3-20	HR6037 BaBb is presently the only binary brown-dwarf companion identified at large separation around a 200 Myr old intermediate-mass star. It widens our understanding of the architecture of systems discovered around A-type stars such as HR8799, Beta Pictoris, or HR7329. We present VLT/SPHERE images of the HR6037 system at an unprecedented angular resolution as well as new 1-5 μm spectra and photometry of the companion. We use these data to refine the physical (mass, surface gravity, $T_{\rm Teff}$) and orbital properties of HR6037BaBb. The binary companion may offer the first opportunity to calibrate the mass/luminosity relations of substellar objects at intermediate ages through the monitoring of its orbit within the next decade.
Mickaël Bonnefoy	**The SINFONI spectral library of young M, L, and T dwarfs objects** Wed, 10:31 • P3-21	Direct imaging instruments such as VLT/SPHERE, LBTI/LMIRCam, or Gemini/GPI can now routinely provide the near-infrared spectra and photometry of young (20-30 Myr) self-luminous exoplanets such as HR8799 bcde and Beta Pictoris b. The spectra and photometry of these objects challenge the understanding of the physical, dynamical and chemical processes involved in low-gravity and relatively cool ($T_{\rm eff}$=1000-2700 K) atmospheres. We present a complete (updated) library of 20 medium-resolution (R$= 1500 - 2000$) near-infrared (1.1-2.5 μm) integral field spectra of young companions and isolated objects at the planet/brown-dwarf boundary obtained with the VLT/SINFONI instrument. This library provides a rare set of spectra obtained in an homogeneous way, down to spectral types T2.5. It can be used to characterize empirically any known companion. We use it to test the ability of atmospheric models to represent the formation and settling of refractory dust in the photosphere of low-gravity objects. We refine the physical (mass, radii, surface gravity) and chemical (composition) properties of each individual objects. We also report the detection of accretion signatures in the spectra of a low-mass brown-dwarf companion and of a planetary-mass object.
François-René Lachapelle	**Characterization of Low-mass, Wide-separation Substellar Companions to Stars in Upper Scorpius: Near-infrared Photometry and Spectroscopy** Wed, 10:32 • P3-22	We present new $0.9 - 2.45\,\mu$m spectroscopy (R$\sim$ 1000), and Y, J, H, Ks, L' photometry, obtained at Gemini North, of three low-mass brown dwarf companions on wide orbits around young stars of the Upper Scorpius OB association: HIP 78530 B, [PGZ 2001] J161031.9-191305 B, and GSC 06214-00210 B. We use these data to assess the companions' spectral type, temperature, surface gravity, and mass, as well as the ability of the BT-SETTL and DRIFT-PHOENIX atmosphere models to reproduce the spectral features of young substellar objects. For completeness, we also analyze the archival spectroscopy and photometry of the Upper Scorpius planetary mass companion 1RXS J160929.1-210524 b. Based on a comparison with model spectra we find that the companions, in the above order, have effective temperatures of 2700$\pm$100, 2500$\pm$200, 2300$\pm$100, and 1700$\pm$100 K. These temperatures are consistent with our inferred spectral types, respectively M7β, M9γ, M9γ, and L4γ, obtained from spectral indices and comparisons with templates. From bolometric luminosities estimated from atmosphere model spectra adjusted to our photometry, and using evolution models at 5-10 Myr, we estimate masses of $21 - 25$, $28 - 70$, $14 - 17$, and $7 - 12\,{\rm M_{Jup}}$, respectively. [PGZ 2001] J161031.9-191305 B appears significantly overluminous for its inferred temperature, which explains its higher mass estimate. Synthetic spectra based on the BT-SETTL and DRIFT-PHOENIX atmosphere models generally offer a good fit to our observed spectra, although our analysis has highlighted a few problems. For example, the best fits in the individual near-infrared bands occur at different model temperatures. Also, temperature estimates based on a comparison of the broadband magnitudes and colors of the companions to synthetic magnitudes from the models are systematically lower than the temperature estimates based on a comparison with synthetic spectra.
Jonathan Aguilar	**Brown dwarf science at Project 1640: near-IR spectrum and RV mass constraints for the T dwarf HD 19467 B** Wed, 10:33 • P3-23	Project 1640 is an extreme-AO, coronagraphic, hyperspectral direct-imaging instrument designed to characterize substellar companions in the giant planet to brown dwarf mass regime. We present a recent highlight from Project 1640 – a near-IR spectrum of the important benchmark T dwarf HD 19467 B. Imaged as part of the ongoing TrenDS survey, HD 19467 B is the only directly-imaged T dwarf known to induce a measurable Doppler acceleration around a solar-type host. J- and H-band spectra taken by the Project 1640 integral field spectrograph were fitted against SpeX/IRTF T dwarf standards and synthetic spectra from BT-Settl atmospheric models. Spectral typing classified HD 19467 B as a T5.5 +/- 1 brown dwarf with an effective temperature of Teff = 978^{+20}_{-43} K. The new spectrum helps resolve a previous disagreement about the system age, helping constrain the range of allowed masses for the companion. We expect that new data from the ongoing TrenDS survey will provide important standards for testing our understanding of substellar atmospheres, especially as Project 1640 pushes through its own search for substellar companions around nearby solar-type stars.

Formation, architecture, and dynamics of planetary systems

Lison Malo	**Fundamental properties of planet-candidate host stars** Thu, 10:25 • P4-1	Determining fundamental properties (effective temperature, radii, bolometric luminosity, metallicity and the age) of host star is critical in order to better characterize the mass of the planet-candidate. Moreover, a precise determination of their fundamental properties is useful to guide the selection of the best objects for exoplanet searches. A major obstacle to progress is still the lack of parallax and radii measurements to derive effective temperature and bolometric luminosity. Recent studies have show that these parameters can be accurately estimated by using photometric and spectroscopic observations. Of all the fundamental parameters, age is probably the most difficult to constrain because its determination inevitably relies either on model-dependent methods or on common kinematics. In principle, age estimates from all these model-dependent methods should be consistent, but many studies have unveiled some inconsistencies. These discrepancies perhaps suggest that other physical factors (e.g., metallicity, magnetic field strength, accretion history) are needed to fully account for the observational properties of stars. This talk will quickly review the recent literature on the subject before focusing of how magnetic field strength and chromospheric activity impact the determination of fundamental properties of planet-candidate host.
Alan Boss	**Formation of Multiple Protostar and Brown Dwarf Systems with Wide Separations** Thu, 10:26 • P4-2	Initially rapidly rotating, dense molecular cloud cores are likely to collapse and fragment into systems composed of multiple clumps with initial masses in the range of brown dwarfs to low mass protostars and with initial separations in the range of 100s to 1000s of AU. These results apply even in the case of magnetic cloud cores, provided that the initial magnetic field strength is low enough for the clouds to be supercritical, with mass to flux ratios at least about 14 times the critical mass to flux ratio (Boss and Keiser 2014). The 3D collapse calculations were performed with the adaptive mesh refinement (AMR) code Enzo 2.2 in the ideal magnetohydrodynamics (MHD) approximation, starting with initially prolate or oblate, centrally condensed, cloud cores with masses of 1.73 or 2.73 $M_\odot$, respectively. The magnetic field was initially uniform and aligned with the clouds' rotation axes, with initial ratios of rotational to gravitational energy ranging from 0.0001 to 0.1. The initial magnetic field strength ranged from 6.3 to 100 μGauss, corresponding to clouds that were strongly to marginally supercritical, respectively, in terms of the mass to magnetic flux ratio. Single protostars with spiral arms typically resulted for clouds with initial mass to flux ratios less than 14 times critical, whereas fragmentation into multiple systems resulted for higher mass to flux ratios. However, a barotropic equation of state was used to represent the transition from low density, isothermal phases, to high density, optically thick phases. This approximation is often employed in order to avoid the computational complexity and burden associated with three dimensional radiative transfer. The Enzo 2.4 code includes the option of using radiative transfer in the flux-limited diffusion (FLD) approximation, a major improvement over the barotropic approximation. Models are underway to test the extent to which the Enzo 2.4 FLD code is able to reproduce the results of state-of-the-art spherically symmetric protostar collapse calculations using multigroup radiative transfer (Vaytet et al. 2013). We will then use the Enzo 2.4 FLD code to recalculate some of the models of Boss and Keiser (2014), to see how the results may change when a superior treatment of the collapsing cloud's thermodynamical evolution is included.
David Tsang	**Gap Heating and The Eccentricity Evolution of Giant Planets: Shedding Light on the Eccentricity Valley** Thu, 10:27 • P4-3	We show that eccentricity evolution for giant gap-clearing planets embedded in a disk is sensitive to the entropy structure of the disk. We demonstrate that stellar illumination can heat the gap enough for the planet's orbital eccentricity to instead be excited. We also discuss the "Eccentricity Valley" noted in the known exoplanet population, where low-metallicity stars have a deficit of eccentric planets between $\sim$0.1 and $\sim$1 AU compared to metal-rich systems. We show that this feature in the planet distribution may be due to the self-shadowing of the disk by a rim located at the dust sublimation radius $\sim$0.1 AU, which is known to exist for several T Tauri systems. In the shadowed region between $\sim$0.1 and $\sim$1 AU, lack of gap insolation allows disk interactions to damp eccentricity. Outside such shadowed regions stellar illumination can heat the planetary gaps and drive eccentricity growth for giant planets. We suggest that the self-shadowing does not arise at higher metallicity due to the increased optical depth of the gas interior to the dust sublimation radius.
Olivier Wertz	**On the use of MCMC for orbit fitting: a new open source Python package** Thu, 10:28 • P4-4	When dealing with parameter fitting, one often has to face the challenge of determining the uncertainties affecting the derived model parameters. A robust and elegant way to achieve this consists in taking advantage of Bayesian inference using Markov chain Monte Carlo (MCMC) methods by constructing the marginalized probability distribution for each model parameter. For several years, such an approach has been used in the framework of orbital fitting (see e.g. Chauvin et al. 2012, Nielsen et al. 2014, Bonnefoy et al. 2014, Pueyo et al. 2015). The most commonly used MCMC algorithm is the Metropolis-Hastings (M-H) algorithm. However, recent papers (Goodman and Weare, 2010; Foreman-Mackey et al. 2013: emcee, the MCMC hammer) have highlighted the efficiency of the Affine-Invariant Ensemble Sampling (AI) algorithm, formally called the stretch move. This algorithm has been recently used in Pueyo et al. (2015) for characterizing the orbits of the four planets around HR 8799. In this poster, we present the results of the comparison between an M-H algorithm implemented in Python and the emcee package, applied to the cases of beta Pic b and HR 8799bcde orbit fitting, based on the latest available astrometric measurements. These two algorithms have been included in an open source Python package dedicated to orbit fitting. This package includes a number of useful tools required at all stages of the orbit fitting procedure.

Posters

Tim Pearce	**Constraining the orbits of sub-stellar companions imaged over short orbital arcs** Thu, 10:29 • P4-5	Imaging a star's companion at multiple epochs over a short orbital arc provides only four of the six coordinates required for a unique orbital solution. Probability distributions of possible solutions are commonly generated by Monte Carlo (MCMC) analysis, but these are biased by priors and may not probe the full parameter space. We suggest alternative methods to characterize possible orbits, which compliment the MCMC technique. Firstly the allowed ranges of orbital elements are prior-independent, and we provide means to calculate these ranges without numerical analyses. Hence several interesting constraints (including whether a companion even can be bound, its minimum possible semi-major axis and its minimum eccentricity) may be quickly computed using our relations as soon as orbital motion is detected. We also suggest an alternative to posterior probability distributions as a means to present possible orbital elements, namely contour plots of elements as functions of line of sight coordinates. These plots are prior-independent, readily show degeneracies between elements and allow readers to extract orbital solutions themselves. This approach is particularly useful when there are other constraints on the geometry, for example if a companion's orbit is assumed to be aligned with a disc. As examples we apply our methods to several imaged sub-stellar companions including Fomalhaut b, and for the latter object we show how different origin hypotheses affect its possible orbital solutions. We also examine visual companions of A- and G-type main sequence stars in the Washington Double Star Catalogue, and show that > 50 per cent must be unbound.
Jean-Philippe Beaulieu	**Measuring masses of planetary systems discovered by microlensing thanks to high angular adaptive optics observations** Thu, 10:30 • P4-6	Ground based microlensing mostly probes the unique niche of exoplanets outside the snow line down to Earth masses. The star and planet parameters are extracted after a complex modeling procedure of light curve data collected by a worldwide network of telescopes. Nevertheless, additional high angular resolution can greatly improve our knowledge of the systems, by confirming the models, and/or giving additional constraints to refine their properties. First, in most cases it is possible to detect and study (or to put upper limits on) the host lens stars with Adaptive Optics observations on 8m class telescopes or using HST. High angular resolution allows us to resolve the source stars from their unrelated neighbors, while the images of the source and lens stars will be still blended. Using the estimated magnitude of the source star from the modeling, it is possible to estimate the magnitude of the blended lens star, and to constraint its mass. Such observations can be done already few months after the end of the microlensing events. A complete understanding of the physical properties of the microlensing systems is possible when the source and the lens are separated enough (50+ mas) on adaptive optics images. Indeed this enables both the measurements of the lens flux and the amplitude and direction of the relative lens-source proper motion. This provides the lens mass and distance unambiguously. Using KECK and HST, we clearly resolved the lens and the source for the microlensing event OGLE-2005-BLG-169, harboring a Neptune-like planet detected in 2005. This is the first case where source and lens of a planetary microlensing events are resolved and the amplitude and direction of the proper motion are measured. We confirm the original discovery (Gould et al. (2006), and then we refine the properties of the system (Batista et al. 2015, Bennett et al., 2015). This is a new opportunity to refine the physical parameters of the planets discovered by microlensing, bringing down the uncertainties of the parameter of the system below 10 %. We are paving the road to EUCLID and WFIRST microlensing programs which will do such measurements in a routine way during the next decade for a large number of their detected systems.
Quinn Konopacky	**Updated Astrometry for the HR 8799 Planets: Orbital Architecture Constraints** Thu, 10:31 • P4-7	We present new and updated astrometric measurements for the four planets orbiting HR 8799. These measurements were obtained using the NIRC2 camera on the W.M. Keck II 10-m telescope. New reduction and analysis of data sets from 2004-2009 results in an improvement in astrometric uncertainties by an average of $\sim 30\%$, and removal of noted systematic offsets between epochs. These improvements, plus new data through the summer of 2014, allow us to perform new analysis of the allowed orbital solutions for the four planets. We are able to detect acceleration to $3\,\sigma$ in three of the planets. An additional epoch of precise astrometry should yield acceleration detections for all four planets. With acceleration detected and systematics removed, orbital fits are much improved. In particular, we find improved constraints on the orbital inclinations, all of which are consistent with each other within 1-σ. Combining improved orbits from astrometry with dynamical stability analysis will give tighter constraints on the mass upper limits for these planets.
Michihiro Takami	**Subaru-HiCIAO Studies of Possible Star-Disk Interaction and Wind-Disk Interaction Toward Active Young Stellar Objects** Thu, 10:32 • P5-1	Ground-based coronagraphy and imaging polarimetry at optical and near-IR wavelengths are powerful tools for observing scattered light from dust grains in protoplanetary disks and remnant envelopes. Observations to date have allowed us to observe a variety of disk structures which may be related to ongoing planet formation. These techniques should also allow us to search for signatures of stellar encounters and/or interaction between stellar winds and disks. We present our observations of a few active young stellar objects (classical FU Ori-type stars) and the T Tauri star SU Aur using Subaru-HiCIAO. The high angular resolution and high sensitivity of the observations have allowed us to reveal circumstellar structures, possibly caused by the above interactions, in unprecedented detail. We discuss how our new findings could constrain mechanisms of mass accretion onto low-mass protostars, and possible ongoing planet formation in such environments.

Posters

Antonio Garufi	**Forming planets and their interaction with disks imaged by SPHERE and NACO** Thu, 10:33 • P5-2	Imaging of planet formation in the act is now possible. Astonishing results in this direction are being achieved both with the direct detection in the near-IR of (forming) planets and with the high-contrast imaging of those protoplanetary disk features which are peculiar of planet-disk interaction. We present and discuss several new coronagraphic and polarimetric high-resolution and high-contrast images of circumstellar environments obtained with VLT/NACO and VLT/SPHERE both at optical and near-IR wavelengths. These observations are setting higher standards for the planet and disk imaging and are revealing an ever-increasing diversity of frameworks for the planet formation. In particular, these new images of well-known Herbig and T Tauri stars are providing crucial information on (1) the disk morphology throughout the process of planet formation, (2) the circumplanetary environments, and (3) the evolution of the global disk geometry within the first 20 Myr.
Francisco Rendón	**Geometry of Internal Walls and Gaps in Transitional and Pre-transitional Disks.** Thu, 10:34 • P5-3	In some young stellar systems with planet formation, protoplanetary disks with a dust-free central hole (transitional disks) have been discovered. In other younger systems, in addition to the central hole, disks also show a dust-free gap (pre-transitional disks) that separates an inner disk from an outer one. These holes and gaps in both types of systems have internal walls that originally were modeled as vertical. However, recent theoretical studies suggest that the geometry of such walls must be curved. We use the fargo-3d code to develop 3D simulations in spherical coordinates of transitional and pre-transitional disks with a single planet embedded in the disk. Our results suggest that the forming planet is the physical mechanism responsible for the curvature in the wall. Such a curvature implies two things: first, the incoming stellar radiation strikes the wall at an angle different from its normal, changing the temperature distribution of the wall. Secondly, the wall is more visible to the observer than a vertical wall, thus the brightness distribution of the wall increases for some wavelengths in the IR band.
Carol Grady	**The Transitional Disks of Herbig Ae/Be Stars** Thu, 10:35 • P5-4	Transitional disks, those with characteristic dips in their IR spectral energy distributions, central cavities in sub-millimeter dust, and sometimes millimeter gas transitions are not limited to T Tauri stars, but are also found among Herbig Be through Fe stars, where they form the Meeus group I objects. We review what has been learned about these disks from high-contrast NIR and some mid-IR imaging, principally using the 8.2m Subaru telescope and the HiCIAO imager as part of the Strategic Exploration of Exoplanets and Disks with Subaru (SEEDS) survey, and compare the disk properties with those of the T Tauri transitional disks observed with the same instrument.
David Kasper	**HL Tau Disk Models** Thu, 10:36 • P5-5	As the Atacama Large Millimeter/submillimeter Array (ALMA) produces observations of protoplanetary disks, the structure of these systems are revealed in detail. HL Tau is a prime example of this. Circumstellar ring-shaped deficits in emission appear in the HL Tau disk at many radii. In general these 'gaps' are thought to be indicative of the existence and formation of planets in circumstellar disks. By comparing a radiative transfer model with the 2014 ALMA Long Baseline Campaign Science Verification data release, the morphology of the HL Tau system can be explored in new detail. We model the gap areas observed in the ALMA data to give constraints on the presence and mass of a yet to be imaged planet or planets. At continuum wavelengths in the Rayleigh-Jeans part of the disk spectrum, it is difficult to discern whether the gaps represent cooler regions or less dense regions. We can break this degeneracy by self-consistently modeling the density and temperature together. This modeling is based on stellar irradiation heating of the disk which depends sensitively on the angle of incidence at the optical surface of the disk, which in turn depends on the density structure. We model the gaps as ad hoc density perturbations at the empirically observed gap locations, calculate the radiative heating and shadowing of the gaps, and simulate thermal emission of the disk models to match the observations of HL Tau. By modeling such observational data with physically self-consistent processes a better understanding of planet formation can be found.
Hannah Jang-Condell	**Gaps in the Disk of TW Hya** Thu, 10:37 • P5-6	TW Hydrae, one of the most nearby protoplanetary disk systems, has been well-studied across all wavelengths. The disk has been imaged from the optical to the radio and everything in between. Despite the large amounts of data acquired on the system, puzzles remain about the interpretation of the disk structure and its relation to planet formation processes. Indeed, much like the Hydra itself, just as one problem seems solved, two more rise in its place. The disk of TW Hya appears to have an inner hole of about 7 AU in radius, and a gap consistent with a planet embryo at 80 AU. More recently, scattered light imaging suggests the presence of a second gap at 20 AU in the disk. We explore the hypothesis that this gap at 20 AU might indicate the presence of another forming planet in the system, using self-consistent radiative transfer modeling. If TW Hya is indeed forming multiple planets outside 10 AU, this could change present theories about planet formation in general.

Tomoyuki Kudo	**Direct Imaging of Dual Differential Structures of Transition Disk around RXJ1852.3-3700.** Thu, 10:38 • P5-7	Transitional disk objects are categorized as young stars with little or no near-mid infrared(IR) excess and significant far IR excess in their SED, implying the presence of inner gaps of the surface density distribution of their circumstellar disk. This gap could be related to the early phases of planet formation. Therefore, transition disk objects are particularly important for understanding when, where and how planets form. We have clearly detected a nearly face-on transitional disk around a single K3 T Tauri star, RX J1852.3-3700, at H-band (1.6 μm) using HiCIAO+AO188 mounted on Subaru 8.2m telescope. The most important result of our PDI observations is that we have discoverd a difference of the surface brightness profiles with a radius of $\sim$30 AU. Since there were no images with very extended radio interferometric observations of RXJ1852.3-3700, our result is the first successful imaging of dual ring structures in this system. On the basis of our near-IR image and SED, we adopt Monte Carlo radiative transfer codes to RXJ 1852 system. In this poster, we describe the detailed disk structures.
Esther Buenzli	**Deep L$'$-band imaging search for protoplanets and structures in pre-transitional disks with the LBT** Thu, 10:39 • P5-8	We present first results from a small survey of known circumstellar disks carried out at the Large Binocular Telescope (LBT). Using angular differential imaging or reference PSF subtraction, we obtained the first L' band images of these disks, as well as deep detection limits on the presence of substellar companions. We reveal asymmetric structures at small separation ($< 1''$) from the host star and compare them to polarimetric observations taken at shorter wavelengths.
Schuyler Wolff	**Gemini Planet Imager Observations of the Protoplanetary Disk around the Young Star PDS 66** Thu, 10:40 • P5-9	We present H and K band imaging polarimetry for the PDS 66 circumstellar disk obtained during the commissioning of the Gemini Planet Imager, along with preliminary radiative transfer modeling efforts. The PDS 66 disk appears un-evolved for its age (estimates range from $6 - 17$ Myrs) with a higher than average accretion rate indicative of a near transition disk morphology. Evidence for grain growth within the disk has been seen in both the FIR and millimeter. These GPI data, obtained during early commissioning, provide a modest detection of the disk, but they can still yield useful constraints on polarization levels for analysis in combination with existing HST imaging in total intensity at multiple wavelengths using NICMOS and STIS. The disk has an apparent outer radius of $\sim$ 70 AU which is in agreement with HST scattered light imaging. GPI achieves an inner working angle of $\sim 0.3''$ which surpasses the $\sim 0.4''$ result accomplished with HST STIS. GPI data reproduce the brighter scatter on the east side of the disk which is inferred to be nearer to us. There is evidence for a slightly brighter outer ring with a fainter gap which may provide a measure of the outer disk flaring. By comparing the observed polarization fraction to radiative transfer models we can probe the geometry (degree of flaring) and grain distributions (size, density) of the disk.
Robert Stencel	**Structure revelead of the transiting disk in the extreme binary ϵ aurigae** Thu, 10:41 • P5-10	A new class of binary stars with transiting disks, is being recognized, and these provide the unique opportunity to study disk structure and dynamics during transit. The brightest member of the class is the bright star ϵ Aurigae, for which interferometric imaging during 2010, has revealed an 8 AU diameter disk transiting in front of an F-type supergiant star. Time-dependent spectroscopy during this transit revealed sub-structure in the disk, including possible spiral density waves and an accretion-powered inner disk. The former is defined by neutral potassium line strength variations, and the latter is defined by strong variation in the He I 10830 A absorption line during transit, as observed with IRFT SpeX and APO Triple-Spec instruments, plus a far-UV excess. In this paper we detail those and related observations, and develop a model for the central star, accretion rate and implications for the formation and evolution of similar circumstellar and circumbinary disks. Details at: http://adsabs.harvard.edu/abs/2015ApJ...798...11P .
Johan Mazoyer	**Deep Inside Circumstellar Disks Investigating the Near-Infrared Coronagraphic Imager Archive** Thu, 10:42 • P5-11	While hundreds of Kuiper-like debris disks have been detected using thermal emission, only a few tens have actually been resolved in the near infrared. Most of them have been first imaged by HST coronagraphic instruments (ACS, STIS and NICMOS) and reveal many various features (asymmetries, warps, gaps), but only a few of these disks have been imaged from the ground at similar wavelengths. Indeed, the detection of these faint objects can be impossible without the very high sensitivity of HST instruments. However, when possible, observations with 8m class telescopes can be very rewarding and often allows to access to the inner regions and finer structures of circumstellar disks. Looking specifically for these objects, we conducted a consistent reanalysis of some of the Near-Infrared Coronagraphic Imager archival data with several recent angular differential imaging techniques. Ten targets have been processed and we obtained images of three circumstellar disks with unprecedented quality. We first detected the HD 100546, identifying a set of multiple spirals southeast of the star (Boccaletti et al. 2013). Secondly, the analysis of the very inclined HD 15115, have unveiled a inner cavity as well as a surprising geometrical symmetry (Mazoyer et al. 2014). Finally, images of the complex transitional disk HD 141569A (Mazoyer et al. in prep.) resolve the inner part of the disk, so far unobserved, as a strongly depleted cavity.

Min-Kai Lin	**Vertical shear instability in the outer parts of protoplanetary disks** Thu, 10:43 • P5-12	Cold astrophysical disks such as protoplanetary disks (PPDs) may not develop magneto-hydrodynamic turbulence, usually invoked to enable mass accretion, due to poor ionization. Instead, hydrodynamic turbulence could play an important role in PPDs in terms of angular momentum transport, planetesimal dynamics, and hence planet formation. Recently, the 'vertical shear instability' (VSI) has been proposed as a route to purely hydrodynamic turbulence in PPDs. The VSI feeds off the vertical gradient in the disk's rotation frequency, which is a generic feature in accretion disks. However, the VSI is sensitive to disk thermodynamics, typically requiring 'rapid' cooling. A quantitative understanding of the thermodynamic dependence of the VSI is thus critical to evaluating its applicability to PPDs. We present recent analytical and numerical results on the linear VSI, including a quantitative thermodynamic criteria for instability. We show that the VSI can indeed operate in typical protoplanetary disk models at tens of AU, where heating is dominated by external irradiation, with a characteristic growth timescale of $\sim$30 local orbital periods. We thus suggest that the VSI is dynamically important for dust evolution and planet formation in the outer parts of protoplanetary disks.
Marc Kuchner	**AO Imaging of Debris Disks found via DiskDetective.org** Thu, 12:15 • P5-13	Have you discovered a planetary system today? If not, don't worry. At DiskDetective.org, you can help scour the WISE data archive to find new debris disks and YSO disks. Volunteers at this NASA citizen science website have already performed more than 1.2 million classifications of WISE sources, searching a catalog 8x the size of any previously published survey. The new disk candidates we generate feed a follow-up campaign of spectroscopy and imaging with Robo-AO on Mt. Palomar, with volunteers participating at every level. We report on the first science results from this campaign.
William Danchi	**The LBTI HOSTS Project: Determining the amount of warm zodiacal dust in the habitable zones of nearby solar type stars** Thu, 12:16 • P5-14	The Large Binocular Telescope Interferometer (LBTI) consists of two 8.4 m telescopes separated by a 14.4-m baseline on Mt. Graham in southern Arizona. The LBTI operates in a nulling mode in the mid-infrared spectral window (8-13 μm), in which light from the two telescopes is coherently combined with a 180 degree phase shift between them, producing a dark fringe at the location of the target star. In doing so the starlight is suppressed, increasing the contrast, analogous to a coronagraph operating at shorter wavelengths. NASA has funded a project called the Hunt for Observable Signatures of Terrestrial Systems (HOSTS) to survey nearby solar type stars to determine the amount of warm zodiacal dust in their habitable zones. The goal is not only to determine the luminosity distribution function but also to know which individual stars have the least amount of zodiacal dust. It is important to have this information for future missions that directly image exoplanets as this dust is the main source of astrophysical noise for them. The LBTI is a unique instrument, having only three warm reflections before the starlight reaches cold mirrors, giving it the best photometric sensitivity of any interferometer operating in the mid-infrared. It also has a superb Adaptive Optics (AO) system giving it Strehl ratios greater than 98% at 10 μm. During the past year LBTI has been undergoing commissioning and the team recently published papers on the target sample, modeling of the nulled disk images, and initial results such as the detection of warm dust around eta Corvi. We will report recent progress, new results, and plans for the survey, which is expected to begin this fall.
John Krist	**Roll Subtraction for Debris Disk Imaging on HST** Thu, 12:17 • P5-15	Debris disk imaging with HST requires subtraction of the halo of scattered light surrounding the stars caused by imperfect optics, even with the use of a coronagraph to suppress the diffraction pattern. This is typically done by subtracting the image of another star, with the assumption that the scattered light pattern is stable between observations. An alternative is to use the same star observed at different roll orientations of the telescope. This has the advantage of not requiring images of other, typically uninteresting stars, as well as providing a perfect spectral match (especially important for the unfiltered STIS camera). The danger is the potential of the disk to partially self-subtract itself. We present here an overview of our roll subtraction results on debris disks using the ACS and STIS coronagraphs.
Farisa Morales	**Herschel-Resolved Two-Belt Spitzer Debris Disks Around A-type and Solar-type Stars and Candidate Exoplanets** Thu, 12:18 • P5-16	We present a unique set of stars that host on going activity in the terrestrial planet zones as seen by Spitzer Space Telescope, and the presence of an outer/colder dust component spatially resolved by the Herschel Space Observatory. The 18 solar and Atype stars have combined Spitzer IRS+MIPS (5 to 70 μm) and Herschel PACS (70 or 100 and 160 μm) SEDs suggesting a tworing disk architecture, mirroring that of the asteroidal-Kuiper belt geometry of our Solar System, and between which exoplanets are inferred to exist. Spatially resolved systems help breach the degeneracy between the grain properties and the dust's radial location important for SED modeling. We find icy grains best model the majority of outer dusty debris belts. Furthermore, we have begun to identify candidate exoplanets around some of these dusty debris systems using high-contrast direct imaging carried out using the 10-m Keck Observatory.
Jean-François Lestrade	**Debris disks around M-type stars in the Herschel survey DEBRIS.** Thu, 12:19 • P5-17	The Herschel program DEBRIS is a volume-limited survey to search for debris disks around M, K, G, F and A-type stars. This program observed 89 nearby M-type stars located within 8.6 pc. Two disks were discovered around the M3 star GJ 581 and the M4 star Fomalhaut C, so that the frequency of detection is $\sim$2 %, significantly less than for the solar-type stars (FGK) and the A-type stars in the survey with a uniform sensitivity for all observations. We use these far-IR data and a disk model to estimate upper limits on surface brightness of debris disks in scattered light for low-mass stars, and compare with sensitivities of future facilities.

Posters

Li-Wei Hung	**Discovery of Resolved Debris Disk Around HD 131835** Thu, 12:20 • P5-18	We report the first resolved images of the debris disk around HD 131835 using T-ReCS on Gemini South. HD 131835 is a $\sim$15 Myr A2 star in the Scorpius-Centaurus OB association at a distance of 122.7 pc. The extended disk has been detected to $\sim 1.5''$ (200 AU) at 11.7 μm and 18.3 μm with an inclined angle of $\sim$75 degrees. By fitting both the spectral energy distribution and the images simultaneously, we find a satisfactory model composed of three grain populations: a hot continuous power-law disk and two rings. The grain temperature profile shows that the grains in all three populations are hotter than blackbodies. In particular, the grains in the continuous disk are unusually warm, even when considering small graphite particles as the composition. We can potentially test the grain model with high-contrast scattered-light imaging using the new generation of instruments such as GPI.
Benjamin Gerard	**Imaging the HR 8799 Dust Halo with HST/STIS** Thu, 12:21 • P5-19	We present a new algorithm for space telescope high contrast imaging of planetary disks. This algorithm is used on unpublished archival Huble Space Telescope data of HR 8799, showing an overluminosity after a reference star PSF subtraction that may be from the known disk and/or halo components of this system. The overluminosity radial profiles in two separate epochs from 2011 and 2012 are consistent with one another, and using self-subtracted reference images in the algorithm consistently shows no overluminosity in both epochs, suggesting that the overluminosity is of astrophysical origin. We explore a number of possible "false-positive" scenarios that could explain to the observed overluminosity, including unrealistic algorithm throughput, telescope breathing, and spectral differences between HR 8799 and the reference star (using archival optical spectra and spectral templates). None of these scenarios explain the observed overluminosity, indicating a possible origin from the HR 8799 dust halo, although more spectral data over a broader wavelength range for both HR 8799 and the reference star is needed to better rule out the origin as spectral differences between the two stars.
Anne Boucher	**New debris disk candidates around young low mass stars and brown dwarfs.** Thu, 12:22 • P5-20	It is now common knowledge that debris disks are signposts of past planetary system formation. Their presence and their properties, in relation to those of their host star, also bear valuable information about the process of star formation itself. To address these questions, we started a project to uncover new debris disks around newly identified low mass star and brown dwarf candidates in nearby young kinematic associations. Being near the stellar/substellar mass boundary, these hosts - and their potential debris disks - are particularly interesting to study both star and planet formation. We used a least squares approach to fit synthetic spectra to the observed photometric data of each star, covering from 0.8 μm up to 22 μm, and then identified candidates showing a significant excess compared to the best fits. We then carefully looked at the data for these candidates to filter out those biased by contaminants or other artefacts. We ended up with a list of 5 young stars and brown dwarfs strongly suspected of being surrounded by a debris disk. Here we will present our search method and some properties of our newly identified disk-bearing candidates.
Tom Esposito	**Sculpting The Moth with an Inclined, Eccentric Perturber** Thu, 12:23 • P5-21	The HD 61005 debris disk ("The Moth") is notable for its unusual swept-back morphology, brightness asymmetries, and dust ring offset. Previously proposed mechanisms revolving around disk-ISM interaction can explain some, but not all, of these features. Here we investigate an alternate scenario in which an unseen substellar companion on an inclined, eccentric orbit is perturbing the disk material. To test this scenario, we used secular perturbation theory to construct 3-D dust distributions that informed 2-D scattered-light models. The resultant models demonstrate that an inclined, eccentric companion can produce morphological features similar to those observed in this disk. We constrained the parameters of the companion and disk by comparing these models with 1.6- and 2.2-μm Keck NIRC2 angular differential imaging (ADI) data that show the disk's scattered-light morphology at projected separations of 25-145 AU. To make the models and data comparable, we forward-modeled the brightness bias introduced to the data by ADI PSF-subtraction and applied that bias to our scattered-light models. We also present a Gemini Planet Imager 1.6-micron detection that reveals the disk at projected separations down to 10 AU with a high signal-to-noise ratio.
Christine Chen	**Does the HR 4796 Debris Disk Contain Icy Grains?** Thu, 12:24 • P5-22	High resolution scattered light and thermal emission images of the dusty debris disk around HR 4796 indicate that its dusty disk is generated by a ring of orbiting planetesimals at $\sim$70 AU from the star. Since this material is located beyond the snow line, the parent bodies and the collisionally produced dust grains may be icy. We have obtained deep GPI IFS $K1$ and $K2$ observations to characterize weaker reflectivity at 2 μm as expected from scattering off icy grains.
Marshall Perrin	**HST STIS Coronagraphy of Four Debris Disks around Young Solar Analogs** Thu, 12:25 • P5-23	We present new deep Hubble Space Telescope STIS coronagraphy of four debris disks around nearby young solar type stars ($<$40 Myr, G2-F3), corresponding to the age at which terrestrial planet formation was being completed in our own solar system. The four disks were first seen by our team in a reprocessing of the NICMOS archive using modern principal component analysis PSF subtraction algorithms. Our new STIS observations surpass the earlier NICMOS imagery in angular resolution, contrast, and sensitivity to extended diffuse scattered light, enabling a much clearer view of the diverse disk structures and asymmetries. Visible to near-infrared colors from HST STIS and NICMOS can constrain the dust particle properties. Our analysis and interpretation of these new views of is ongoing.