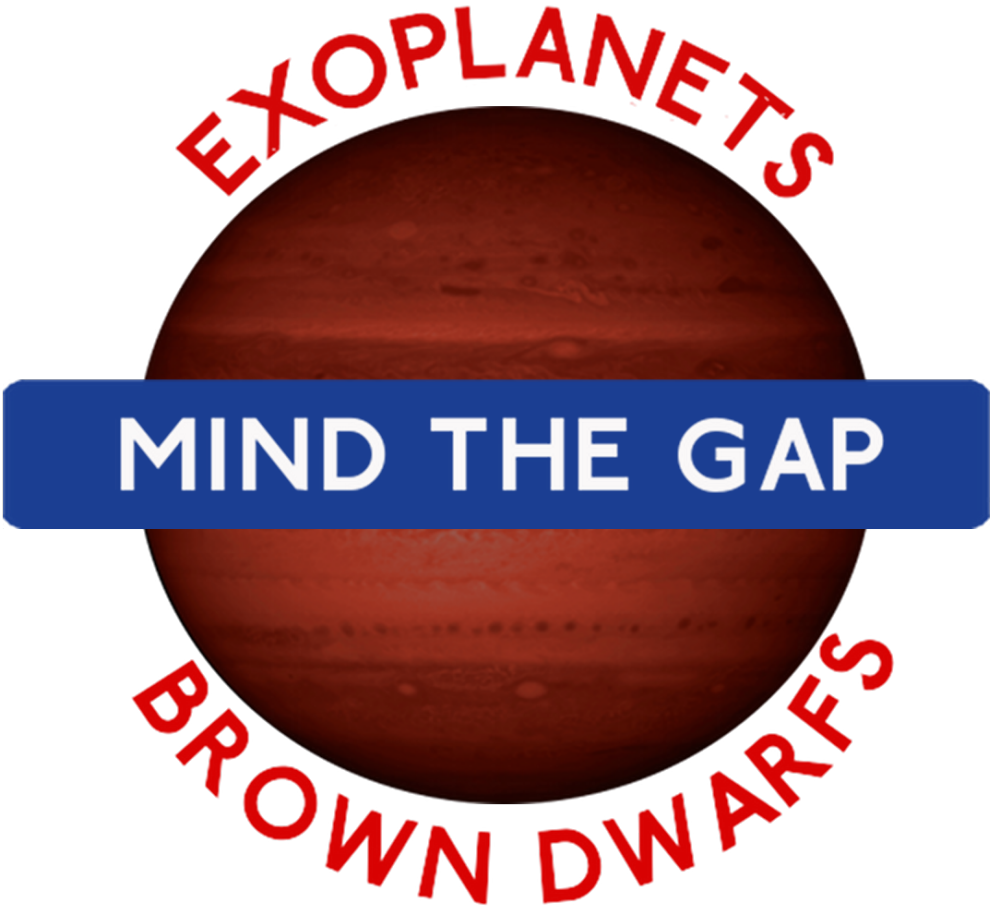

Conference Programme

2nd – 5th September 2013
University of Hertfordshire

Programme Booklet

The University of Hertfordshire is delighted to be hosting “Exoplanets and Brown Dwarfs: Mind the Gap”. This year represents a milestone of sorts as the 18th anniversary of the first discoveries of both planets around Sun-like stars and brown dwarfs. The last 18 years have seen the study of these fascinating objects flourish into diverse and exciting astronomical fields. However, as these scientific siblings reach adulthood, there is a danger of missed opportunities as they drift apart. The aim of this meeting is to bring the exoplanet and brown dwarf communities together to explore common science questions, share exciting results, and foster collaboration to overcome shared challenges.

Welcome to "Exoplanets and Brown dwarfs: Mind the Gap".

Scientific Organising Committee

Suzanne Aigrain
France Allard
Ben Burningham – Chair
Mike Cushing
Jackie Faherty
Jane Greaves
Christiane Helling
Stuart Littlefair
Katharina Lodders
Mark Marley
Subhanjoy Mohanty
Don Pollacco
Frederic Pont

Local Organising Committee

Ben Burningham
Neil Cook
Joana Gomes
Hugh Jones
Federico Marocco
Basmah Riaz
Brigitta Sipocz
Leigh Smith
Zenghua Zhang

With support from...

Schedule

Monday 2nd September

09.00 Directly imaged exoplanets

1) Invited review – Katie Morzinski (40+5)
2) High-resolution/high-contrast near-infrared imaging survey of protoplanetary disks and exoplanets with Subaru/HiCIAO – Jun Hashimoto (15+5)
3) First results of the International Deep Planet Survey: the frequency of wide-orbit massive planets around A-stars – Arthur Vigan (15+5)

10.30 Coffee (atrium)

11.00 Substellar atmosphere models in the context of exoplanet characterisation

1) Invited review – Derek Homeier (40+5)
2) The effect of dynamical simplifications on models of hot Jupiter atmospheres – Nathan Mayne (15+5)
3) Non-Equilibrium Ion-Neutral Chemistry between Brown Dwarfs and Exoplanets – Paul Rimmer (15+5)

12.30 Lunch

14.00 Brown dwarfs as exoplanet analogues

1) Invited review: Emily Rice (40+5)
2) Atmospheric Retrieval Analysis of the Directly Imaged exoplanet HR8799b – Jaemin Lee (15+5)
3) New Evidence for a Substellar Over-Luminosity Problem – Trent Dupuy (15+5)

15.30 Coffee (atrium)

16.00 Session 4: Discussion

"Complexity versus pragmatism in exoplanet and brown dwarf atmospheres" – Chair: Suzanne Aigrain

17.30 Finish

Evening session (in the "pub" – Club de Havilland Comet room):

20.30 – 21.30: Brown dwarfs in Gaia (facilitator: Simon Hodgkin)
21.30 – 00.00: Brown dwarfs and exoplanets pub quiz (Jackie Faherty)

Tuesday 3rd September

09.00 Exoplanets: new discoveries and population characterisation

1) Evolution and Evaporation of Hot Neptunes – James Owen (15+5)
2) Detecting Habitable Zone Planets around M Dwarfs with the AAT – Duncan Wright (15+5)
3) Red Optical Planet Survey: A radial velocity search for low mass M dwarf planets – John Barnes (15+5)
4) A population of small planets in the Solar neighbourhood – Mikko Tuomi (15+)

10.30 Coffee (atrium)

11.00 Direct characterisation of exoplanets

1) Invited review – David Sing (40+5)
2) Clouds on HD 189733b: effects in transmission and eclipse – Joanna Barstow (15+5)
3) Probing the Atmosphere of HAT-P-1b with HST – Nikolay Nikolov (15+5)

12.30 Lunch

14.00 – 17.00 Invited Workshop

The Planet/Exoplanet/Brown Dwarf Knowledge Map: What Can We Share and Where Can We Collaborate?

Facilitator: Adam Burgasser

17.00 – 18.30 Poster session (atrium)

Evening session (in the "pub" – Club de Havilland Comet room):

20.30 - 21.00: Engaging with the media (Genevieve Bjorn)
21.00 – 02.00: KARAOKE!

Wednesday 4th September

09.00 Dusty atmospheres

1) Invited review – Christiane Helling (40+5)
2) Coulomb Explosion of Dust in the Atmospheres of Brown Dwarfs and Exoplanets - Craig Stark (15+5)
3) The peculiar L dwarf ULAS J222711-004547 – Federico Marocco (15+5)

10.30 Coffee (atrium)

11.00 Young brown dwarfs

1) Identifying brown dwarfs in nearby star forming regions – Katelyn Allers (15+5)
2) The kinematics of young brown dwarfs (or free floating planets?) in nearby moving groups – Jackie Faherty (15+5)
3) Towards Precise Ages and Masses of Free Floating Planetary Mass Brown Dwarfs – James Canty (15+5)
4) The Hyades cluster in the Pan-STARRS1 survey – Bertrand Goldman (15+5)

12.00 Lunch

14.00 Weather and activity in brown dwarfs 1

1) Invited review – Aren Heinze (40+5)
2) Diverse and frequent spectroscopic time-variability in Brown Dwarfs observed with HST – Esther Buenzli (15+5)
3) A search for variability in late-T dwarfs – Niall Deacon (15+5)

15.30 Coffee (atrium)

16.00 Weather and activity in brown dwarfs 2

1) Invited review – Jonathan Nichols (40+5)
2) Long baseline- multicolour monitoring of the variable brown dwarf binary Luhman 16 – Rachel Street (15+5)
3) Optical aurorae on brown dwarfs – Stuart Littlefair (15+5)

18.30 Bus departs for banquet at Hatfield House (smart dress)

Thursday 5th September

09.30 Special session: Entering the golden age of exoplanet research
Facilitator: Didier Queloz

10.15 Coffee (atrium)

10.30 Brown dwarfs as companions

1) Observations of irradiated brown dwarf – Sarah Casewell (15+5)
2) Epsilon Indi Ba, Bb: the complete study – Catia Cardoso (15+5)
3) Evolved benchmark brown dwarfs – Avril Day-Jones (15+5)
4) Characterising the frequency and properties of substellar companions to nearby stars – Robert de Rosa (15+5)

12.00 Lunch

13.00 Origins: are dwarfs and planets part of a "mass continuum"?

1) Giant planet and brown dwarf companions: no gap but local minima – Maddalena Reggiani (15+3)
2) Observations of tiny cloud cores – birth sites of substellar objects? – Jane Greaves (15+3)
3) Brown dwarf and rogue planet mass function from gravitational microlensing – David Bennett (15+3)
4) Why BDs are special – evidence from the IMF and the spatial distribution – Ingo Thies (15+3)
5) Population synthesis models of planets and brown dwarfs formed by disc instability and tidal downsizing – Duncan Forgan (15+3)

14.30 Report on outcomes of invited workshop – Adam Burgasser
(followed by final discussion and summing up)

15.00 Conference close (final refreshments served in the atrium)

Abstracts

Invited reviews

Iron Storms and Sunless Aurorae: An Overview of Variable Brown Dwarfs
Aren Heinze (Stony Brook University)

Photometrically variable brown dwarfs have the potential to yield as rich a harvest of information for the study of substellar objects as variable stars continue to for stellar astrophysics. Many brown dwarfs exhibit rotationally modulated variability indicating that their emitted flux is not uniform across all longitudes. This flux inhomogeneity is likely due to patchy cloud cover – possibly to storms comparable to Jupiter's Great Red Spot. However, some brown dwarfs show aperiodic variations and even those with clear periodicity often exhibit rapid light curve evolution suggesting changes in cloud features on a hemispheric scale over just tens of hours far faster than in Solar System giant planets. Multi-band photometry and spectrophotometry allow constraints on the types of cloud inhomogeneities causing the variations and hint at brown dwarf weather patterns. Observations of radio and H-alpha variability also indicate auroral or chromospheric activity in some objects and demonstrate that magnetic phenomena can be important even in the substellar regime.

Clouds and ionisation processes in ultra-cool atmospheres
Christiane Helling (University of St Andrews)

Clouds form in every ultra-cool atmosphere. The formation process is determined by the local atmospheric conditions which are determined by global properties (effective temperature, surface gravity, metallicity). Clouds have a strong feedback on the ambient atmosphere due to their large opacity and because they deplete the gas causing the atmosphere to become metal poor, and also more carbon rich. High-laying clouds in extrasolar atmospheres have been coined 'haze'. Modelling extrasolar cloud formation requires the description of various processes like seed formation, growth, evaporation, gravitational settling, gas-phase depletion, turbulent and convective mixing, plus the gas-phase composition. Only the consistent modelling of these processes allows to predict cloud properties like cloud particle size distributions, material composition, cloud extension. Understanding the whole atmosphere and possible implication for the hosting objects requires a consistent treatment of the cloud formation processes and the atmosphere problem. This is considerably more complex than radiative transfer solutions for a given set of atmospheric and cloud parameters. This talk will summarise cloud formation and provide examples for results of cloud properties for different global parameter (e.g. log(g), element abundances). A summery of model approaches as used by different authors will be provided, incl. those used by retrieval methods. A glimpse on new cloudy ideas is added.

Substellar atmosphere models in the context of exoplanet characterization
Derek Homeier (Centre de Recherche Astrophysique de Lyon)

The theoretical study of low-mass stars and brown dwarf atmospheres has evolved in the frame of classical stellar atmospheres theory mainly employing the forward modelling approach. Based on first principles or well-established experimental studies, such models aim to construct physically and chemically consistent models. Typically this means evolving a model from the assumptions of hydrostatic and radiative equilibrium as well as a chemical equilibrium composition based on given input abundances. In further refinement more complex phenomena such as atmospheric dynamics and departures from chemical equilibrium by gas phase advection, photochemistry or the formation of condensates out of phase equilibrium can be considered. In all cases one generally strives to build the models on a minimal set of parameters, which can then be adjusted by comparison to observations. In contrast, exoplanet atmospheres often show complicating phenomena like global transport of energy and matter triggered by irradiation, a more complex chemistry that may not be based on scaled-solar compositions and apparently unexpected formation of dust or haze layers. Consequently, in the analysis of exoplanet observations an inverse technique the direct retrieval of atmospheric properties from observed data has seen wide-spread application. By making just minimal prior assumptions on the atmosphere this approach has the potential to accommodate a much wider variety of structures that may be encountered in exoplanets. However, in the presence of a possible degeneracy of solutions and with often only few data points to constrain the models this technique is also in danger of failing to produce a unique solution. I shall review the current state of atmosphere models both in 1D and multi-D hydrodynamic with its successes in brown dwarf analysis and the challenges that both forward and retrieval techniques encounter in the characterisation of exoplanet atmospheres. I propose to discuss how the two complementary methods may best be used to combine both their strengths and overcome their respective shortcomings.

Review: Direct imaging of exoplanets
Katie Morzinski (University of Arizona)

Direct imaging of extrasolar planets is challenging yet rewarding. With direct imaging we can study the spectral energy distribution of exoplanets at wavelengths where the bulk of the energy is radiated, as well as viewing orbital motions in exoplanetary systems. I will review what we have learned from the handful of directly-imaged exoplanets, planets which are more massive than Jupiter and younger than the Sun. Finally, I will cover what we can expect from the latest ground-based adaptive optics instruments as well as future space missions.

Ultra-cool dwarf radio emissions: recent advancements and comparison with (extra-)solar system planets

Jonathan Nichols (University of Leicester)

Since the first detection of radio emissions from a brown dwarf by a group of students in 2000, the proportion of ultra-cool dwarfs (UCDs, objects of spectral type M7 or later) detected in the radio band has increased to ~10%. Despite this somewhat low detection rate, significant progress has been made in understanding this emission, such as the observations of a clear dependence of activity on rotation rate, and the detection of cicularly-polarised radio components. However, many questions remain regarding the nature of the various emission sources, and what distinguishes radio active from inactive UCDs. We report on the recent advancements in the study of UCD radio emissions, and relate these to ongoing studies of both exoplanets and solar system planets.

Entering golden age of exoplanet research

Didier Queloz (Cambridge University)

The discovery of new planets beyond our solar system, in particular the detection and characterization of other habitable planets similar to the Earth, is a fascinating intellectual adventure. The completely unexpected characteristics of exoplanets are capturing the imagination and interest of the scientific community. More recently the large population of Super-Earth planet questions the universality of our Solar System as a typical planetary system. While the quest to find bodies similar to the Earth is still on going, the first spectra of exoplanets have been taken, signaling the shift from an era of discovery to one of physical and chemical characterization. The talk will provide an overview of achievements and explore the main questions and challenges of the field.

Young Brown Dwarfs as Exoplanet Analogs
Emily Rice (College of Staten Island- CUNY)

Young brown dwarfs and directly imaged exoplanets have enticingly similar photometric and spectroscopic characteristics including red near-infrared colors and spectral features indicative of low surface gravity and enhanced atmospheric dust. However, the inference of physical and atmospheric properties from observations of these cool, very-low-mass objects is fraught with degeneracies and inconsistencies. While direct observations of exoplanets will be limited to very low-resolution near-infrared spectra for the foreseeable future young brown dwarfs can be studied over broader wavelength regimes and at higher spectral resolution, allowing us to identify and calibrate spectral diagnostics of physical and atmospheric properties constrain age and calibrate substellar evolutionary models and evaluate inferred properties to differentiate between possible formation scenarios. I will review the rapid progression of our understanding of young brown dwarfs in the last decade describe current programs to identify and characterize benchmark objects and describe the ongoing challenges in developing efficient and consistent diagnostics of temperature gravity metallicity and dust/cloud properties that can also be applied to directly-imaged exoplanets. Finally I will explain how a robust understanding of the near-infrared spectra of young brown dwarfs will translate to the characterization of gas giant exoplanets observed at low spectral resolution by high contrast instruments like Project 1640 the Gemini Planet Imager and SPHERE.

Exoplanet Atmospheres: A Decade of Intriguing Observations
David Sing (University of Exeter)

Transiting extrasolar planets have recently passed the ten year milestone for detecting and characterising extrasolar planetary atmospheres. The bulk of the studies have been for hot Jupiter planets, highly irradiated planets who overlap a similar physical parameter space with young brown dwarfs. Many of the initial theoretical interpretations and theories for hot Jupiters originated from our understanding of brown dwarfs and the prediction detection and confirmation of alkali metals in exoplanet atmospheres stands as a powerful by-product of cross-disciplinary ideas. However, as exoplanet observations have matured a large diversity of hot Jupiter atmospheres is being revealed pointing to a rich and complex regime. In this talk I will review the observations that have been done to date and some of the major questions they have helped to address. I will also show and discuss some recent developments and explore the similarities and differences that are emerging between hot Jupiter and brown dwarfs.

Workshops

Complexity versus pragmatism in exoplanet and brown dwarf atmospheres
Suzanne Aigrain (University of Oxford)

Exoplanets and brown dwarf atmospheres are complex, because they cover the range of temperatures and pressures where complex molecules can condensates can form and, for exoplanets, because their energy budget is dominated by external processes. On the other hand, the data we have on these atmospheres tend to be sparse, low resolution, and low signal to noise. We would like our models to be realistic enough, i.e. to include the important physics, but not woefully underconstrained by the data. Is there a way to identify what phenomena are most important for different kinds of planets and brown dwarfs? What is the best way to explore the complex parameter space of the models? How can we make the most of the different approaches currently in use in the community?

The Planet/Exoplanet/Brown Dwarf Knowledge Map: What Can We Share and Where Can We Collaborate?
Adam Burgasser (UC San Diego)

There are many areas of overlap in the study of Solar System planets, exoplanets and brown dwarfs, including atmospheric compositions and dynamics, formation mechanisms and populations, thermal evolution and interior structure, magnetic field generation and satellite habitability. But what knowledge needs to be shared and what work could be done collaboratively to address common questions. I propose a 2-3 hour workshop bringing together observers theorists and experimentalists in planetary, exoplanetary and substellar astrophysics to create a collaborative knowledge map which will identify common major questions resources and research that should be exchanged and areas of productive coordinated investigation. I will then present the results of this work and a preliminary design of a collaborative application that can evolve as research resources become available and new questions emerge.

Brown Dwarfs with Gaia

Simon Hodgkin (Cambridge)

ESA's cornerstone mission Gaia will construct a precise three-dimensional map of our Galaxy by observing a billion stars with exquisite astrometry and photometry. Gaia reaches 20th magnitude in the optical and will observe large numbers of brown dwarfs in the solar neighbourhood. Gaia should see Pleiades-age (~100 Myr) brown dwarfs out to around 400 pc and younger brown dwarfs, such as those in the Orion Nebula Cluster (1–3 Myr), out to about 1 kpc. This volume encompasses numerous young clusters and star-forming regions such as Chamaeleon, Serpens, Taurus etc. For an I = 20 mag brown dwarf at 200 pc, Gaia will obtain a distance accuracy of about 4% and transverse velocities to around 0.2 km s-1. For field objects Gaia will observe many hundreds of L-dwarfs and about 10 T-dwarfs. I will discuss some of the main science that we can hope to achieve when the Gaia results start to become public some 22 months after launch, including (but now limited to): true benchmark brown dwarfs in open clusters, astrometric discovery of substellar companions, searching for eclipsing binary brown dwarfs, and velocity dispersions in young open clusters.

Contributed talks

Identifying Brown Dwarfs in Nearby Star Forming Regions
Katelyn Allers (Bucknell University)

Models for young objects predict that even planetary-mass bodies are within the reach of direct observations. In recent years several candidate planetary-mass objects have been discovered in nearby star-forming regions and many surveys have claimed completeness to masses below the deuterium-burning limit. The low mass end of the initial mass function provides a key test of theories for star and brown dwarf formation. This begs the question: How complete is our current census of local star formation regions? We have undertaken a wide field survey of nearby star formation regions to find new brown dwarfs and planetary-mass objects using a variety of selection criteria. By utilizing new photometric and astrometric selection techniques we report the discovery of new brown dwarfs and evaluate the completeness of existing surveys.

Red Optical Planet Survey: A radial velocity search for low mass M dwarf planets
John Barnes (University of Hertfordshire)

The Red Optical Planet Survey (ROPS) aims to `fill the gap' left by current radial velocity surveys by targeting the mid-late M dwarfs. Observations taken with MIKE/Magellan and UVES/VLT enable 5 m/s precision to be achieved through use of a spectral deconvolution method and telluric lines as a reference fiducial. We can thus achieve sensitivities that are equivalent to the amplitude induced by a 3 M$_\oplus$ planet orbiting in the habitable zone. Estimated rocky planet frequencies of $\eta{_\oplus}$ of up to 1.0 among early M dwarfs lead us to expect high planet yields with modest survey sample sizes.

Clouds on HD 189733b: effects in transmission and eclipse
Joanna Barstow (University of Oxford)

Since the first detection of a planet orbiting another main sequence star hundreds of extrasolar planets have been confirmed and more than 2000 candidates have been identified. One of the most successful methods has been detection via planetary transits where the planet crosses its host star from the point of view of an observer and the resultant drop in total flux from the system can be measured. Planetary transits also provide the opportunity to study the atmospheres of extrasolar planets; if the transit of a planet across the stellar disk is observed at multiple wavelengths an additional drop in flux at some wavelengths due to the presence of atmospheric absorbers may be seen and a transmission spectrum of the planet's atmosphere is measured. When the same planet is eclipsed by its host star, its emission and reflection spectra may be extracted by comparing the in eclipse flux at each wavelength (flux from the star only) with the flux just outside eclipse (combined star and planet contributions). To date one of the exoplanets characterised in most detail is HD 189733b an inflated hot Jupiter orbiting a K1.5 star. This planet shows evidence of clouds in its transmission spectrum (Pont et al. 2013) and also more recently in the albedo spectrum presented by Evans et al. 2013. These two measurements allow some constraint to be placed on the vertical distribution of the cloud and we explore the family of acceptable cloudy atmosphere solutions in the light of all the available data. We also examine the impact of including a cloudy atmospheric model on the abundances of spectrally active gases inferred from the planet's dayside emission spectrum. F. Pont et al. 'The prevalence of dust on the exoplanet HD 189733b from Hubble and Spitzer observations' MNRAS 432 4 (2013) T. Evans et al. 'The deep blue colour of HD 189733b' ApJ 772 L16 (2013)

Brown Dwarf and Rogue Planet Mass Function from Gravitational Microlensing
David Bennett (University of Notre Dame)

The High cadence MOA-II gravitational microlensing survey is sensitive to microlensing by objects with masses down to the planetary mass range. Therefore the MOA-II survey is able to measure the mass functions of old brown dwarfs and rogue planets no longer bound to any star. The MOA-II survey has found that both rogue planets and brown dwarfs are somewhat more common than previously expected. I will also describe the work in progress to address this with a 3.5 times larger data set.

Diverse and frequent spectroscopic time-variability in Brown Dwarfs observed with HST
Esther Buenzli (MPIA Heidelberg)

I present results from two HST programs aimed at characterizing the heterogeneous atmospheric structure of variable brown dwarfs with WFC3 near-infrared spectroscopy. These are the first successful measurements of spectral variability in brown dwarfs. The first program studies three T dwarfs over their full rotation periods: two early L/T transition objects and a T6 beyond the L/T transition. All objects show surprising spectral variability that poses challenges to patchy cloud models. The second program is a snapshot survey that observed 22 brown dwarfs between L5 and T6 for 40 minutes each. Using Bayesian analysis we identify trends that indicate variability in some objects and in some wavelength regions. Overall variability occurs across all spectral types from mid L to mid T. More than half of these brown dwarfs appear to be variable at sub-percent level at least in parts of the near-IR spectrum, which may be missed by ground-based broadband photometric surveys.

Towards Precise Ages and Masses of Free Floating Planetary Mass Brown Dwarfs
James Canty (University of Hertfordshire)

Measurement of the substellar initial mass function in very young clusters is hampered by the possibility of the age spread of cluster members. This is particularly serious for candidate planetary mass objects (PMOs), which have a very similar location to older and more massive brown dwarfs on the Hertzsprung- Russell Diagram. This degeneracy can be lifted by the measurement of gravity sensitive spectral features. We use R~5000 NIFS K band spectra of a sample of late M / early L-type dwarfs to demonstrate a positive correlation between the strengths of the 2.21 μm NaI doublet and the objects' ages. We demonstrate a further correlation between these objects' ages and the shape of their K band spectra and quantify this correlation in the form of a new index, the H2(K) index, which appears to be more gravity-sensitive than the NaI doublet and can be computed for spectra where gravity-sensitive spectral lines are unresolved, while it is also more sensitive to surface gravity at very young ages (<10 Myr) than the triangular H band peak. We show that the H2(K) index can distinguish, at least statistically, populations of ~1 Myr objects from populations of ~10 Myr objects.

Epsilon Indi Ba, Bb: the complete study

Catia Cardoso (Osservatorio Astrofisico di Torino)

Sub-stellar evolutionary models suffer from lack of independent observational constraints due to the difficulty of breaking the brown dwarf mass-age-luminosity degeneracy. Binary systems are the only systems that allow the derivation of masses in a model independent way assuming that the binary components share a similar distance, age and chemical composition. We will present the full characterization of the Epsilon Indi Ba, Bb binary system. Epsilon Indi Ba, Bb are the most suited objects to be used as benchmarks for intermediate age T dwarfs. Epsilon Indi Ba, Bb (two field brown dwarfs T1 and T6) are one of the closest known brown dwarf binaries to Earth. Being part of a triple system, orbiting a main sequence star, Epsilon Indi A. The close distance of 3.6224pc (Hipparcos distance to Epsilon Indi A), and the relatively short period of 11 years allowed the follow up of an almost full orbit of the brown dwarf system using the ESO VLT facilities. The relative motion of the brown dwarf system has been studied over the last decade using high precision astrometry from infrared AO data with the VLT/NACO. The system dynamical mass was determined to be 121.16+-0.17+-1.08 MJup. Measuring the absolute movement of the binary against a reference frame of field stars we have derived the individual masses of the brown dwarfs, for that using optical data from VLT/FORS2.We concluded that the masses derived isochronally were underestimating the system mass by ~60%, due to the likely underestimation of the age of the system. Combining the individual dynamical masses with the results from the 0.63-5.1Mum spectroscopy study of the individual components and their measured luminosities log(L/LSun)=-4.699+-0.017 and -5.232+-0.020, for Epsilon Ba and Bb respectively, the evolutionary models provide a coeval solution for the two brown dwarfs. We concluded that the observational measured parameters would be in agreement with the evolutionary models if the system has an age ~4 Gyr. We have preformed an asteroseismological study of Epsilon Indi A to confirm the age of the system and the results agree with an older age, consistent with 4Gyr. These results show an agreement between the evolutionary models and the observational values. Indicating that the discrepancies found for other younger systems seem to be less significant for older ages.

Observations of irradiated brown dwarfs
Sarah Casewell (University of Leicester)

Recently a new class of Brown dwarf (BD) has been discovered (e.g. Casewell et al. 2012; Steele et al. 2013; Maxted et al. 2006): BDs that are in close post-common envelope binaries with a white dwarf (WD) companion. These objects are in short orbits (hrs) and are probably tidally locked. The WD may be more than 10 times hotter than the BD irradiating its surface creating a situation akin to that in hot Jupiters. Light curves of the systems reveal there are amplitude variations that increase with increasing wavelength. Indeed a very small variability (<1%) in the optical Z, R and I bands increases to 0.13 mag in J, 0.17 mag in H and to 0.29 mag in K, 0.52 mag at [3.6] microns and 0.69 mag at [4.5] microns (Casewell et al. 2013 submitted; Casewell et al. in prep). As these systems are so close and the components are likely tidally locked, we conclude the variability is due to irradiation and a reflection effect: the WD is heating one hemisphere of the BD. Indeed the brightness temperature of the heated side is as high as ~2500K. The cloud chemistry of these objects is also likely to be very different to that of lone BDs: there is a possibility of H3+ and H2 fluorescence photochemistry in the upper atmosphere and high winds caused by atmospheric recirculation. I will discuss these systems and our recent light curves spectra and the derived albedo equilibrium and brightness temperatures. The BDs in these systems provide a unique opportunity to study irradiated atmospheres as we can actually observe the BD directly unlike in exoplanet systems where the heated atmosphere is observed through a secondary mechanism such as transit spectroscopy.

Evolved benchmark brown dwarfs
Avril Day-Jones (University of Hertfordshire)

We describe our searches and the latest results from our program to identify evolved, age benchmark brown dwarfs as members of binary systems with white dwarf companions from UKIDSS, SDSS, SuperCOSMOS and 2MASS, and present a new very widely separated white dwarf + L dwarf binary system. We also present the current population of age benchmark brown dwarfs and how these currently calibrate the Teff/logg/[M/H] ultra-cool parameter space. Finally we look toward future discoveries that can be made from VISTA and WISE.

Characterising the frequency and properties of substellar companions to nearby stars
Robert De Rosa (Arizona State University)

With a combination of imaging and spectroscopy, we are pursuing a series of programs designed to detect substellar companions to A-type stars and to characterise new and previously identified substellar companions. We present the results of a large-scale adaptive optics imaging survey for brown dwarf companions to nearby A-type stars. By combining the results from our Volume-limited A-star (VAST) survey with previously published high-contrast measurements of A-type stars within 75 parsecs, we measure the frequency of wide-orbit (a >~ 100 AU) brown dwarf companions (M >~ 20 Mjup) to intermediate-mass stars. This survey provides benchmark results on the substellar population, quantifying the difference between the stellar, brown dwarf and exoplanet companion populations – an important measurement that is needed to inform formation models. From the VAST survey, we have identified a previously unresolved substellar companion to a nearby A-type star, with an unusually large projected separation of ~900 AU. Since the age is intermediate between the Pleiades and Hyades clusters, the system is ideal for placing empirical constraints on the evolutionary models of substellar objects. In addition to our companion search program, we have been characterising the atmospheric properties of a sample of young, low mass directly imaged substellar companions with multi-wavelength observations. For example, we have obtained the largest wavelength coverage (0.4μm – 5.0 μm) of an exoplanet analogue atmosphere – the planetary mass companion to AB Pic. The thermal IR measurements are particularly sensitive to the effects of clouds, chemistry, and metallicity, and, when combined with near-IR spectroscopy and optical photometry, provide comprehensive wavelength coverage of the bulk of the emergent flux from these young substellar objects. The long-term goal of the study is to use the optical, near-IR, and thermal-IR spectra and photometry of the targets to define an empirical sequence of young object atmospheres spanning the brown dwarf/planet mass transition.

A search for variability in late-T dwarfs
Niall Deacon (MPIA Heidelberg)

Brown dwarfs have complex atmospheres characterised by spectral energy distributions, which are shaped by molecular absorption bands and clouds. In recent years multiple examples of variability have been detected for objects in the transition between cloudy L dwarfs and relatively cloud-free T dwarfs. It has been suggested that this is due to variable coverage of silicate clouds. New models for mid-late T dwarfs have suggested another type of cloud dominated by sulphides play a role in their atmospheres. These clouds may disappear in the late-Ts. We present a survey for variability in late-T dwarfs searching for the signatures of variability associated with the break-up of these sulphide clouds.

New Evidence for a Substellar Over-Luminosity Problem
Trent Dupuy (CfA/SAO)

The first field brown dwarfs to have both dynamically measured masses and a precise age constraint from their solar-type host star were unexpectedly ~2x more luminous than predicted by substellar evolutionary models. However because of the difficulty in determining accurate stellar ages even given a nearly ideal case of a young star where numerous age indicators agree it has been unclear if the apparent over-luminosity could be due to an erroneous age for this unique system. If such large systematic errors actually exist in evolutionary models it could have wide-ranging implications, from determinations of the initial mass function to the masses estimated for directly imaged planets. We present here a new dynamical mass for a pair of brown dwarfs that also have a well-determined age from their young solar-type star. This first check on the substellar "luminosity problem" reveals a nearly identical systematic error as was previously observed. I will discuss possible explanations for this problem and compare the predictions from some commonly used evolutionary models. There are quite large and little appreciated differences in the predicted luminosity evolution of substellar objects which along with the discrepancies of models compared to observations currently limit our ability to characterize the fundamental properties of both brown dwarfs and directly imaged exoplanets.

The Kinematics of Young Brown dwarfs (or Free Floating planets?) in Nearby Moving Groups
Jacqueline Faherty (Universidad de Chile)

Within the vicinity of the Sun lie several 10-150 Myr co-moving collections of high and low-mass stars. Recent work by our team has led to the addition of 30 new late-type M and L brown dwarfs kinematically connected to co-evolving groups such as Argus (30 Myr), Beta Pictoris (10 Myr), Tucanan Horlogium (30 Myr), and AB Doradus (150 Myr). This age-calibrated sample has proven useful for directly imaged exoplanet comparisons as many of the sources have analogous spectral- photometric and luminosity features. Indeed several are isolated clones (in age and effective temperature) of planets such as AB Pic b and Beta Pictoris b. In this talk I will use the full space velocity of our new sample to examine questions related to the formation and evolution of both brown dwarfs and potentially free floating planetary mass objects.

Population Synthesis Models of Planets and Brown Dwarfs formed by Disc Instability and Tidal Downsizing

Duncan Forgan (University of Edinburgh)

Recently, the gravitational instability (GI) model of giant planet and brown dwarf formation has been revisited and recast into what is often referred to as the "tidal downsizing" hypothesis. The fragmentation of self-gravitating protostellar discs into gravitationally bound embryos with masses of a few to tens of Jupiter masses at semi major axes above 30 - 40 au is followed by a combination of grain sedimentation inside the embryo radial migration towards the central star and tidal disruption of the embryo's upper layers. The properties of the resultant object depends sensitively on the timescales upon which each process occurs. Therefore GI followed by tidal downsizing can theoretically produce objects spanning a large mass range from terrestrial planets to giant planets and brown dwarfs. Whether such objects can be formed in practice and what proportions of the observed population they would represent requires a more involved statistical analysis. I will present results from a simple population synthesis model of star and planet formation via GI and tidal downsizing which couples a semi-analytic model of protostellar disc evolution to analytic calculations of fragmentation, initial embryo mass, grain growth and sedimentation, embryo migration and tidal disruption. While there are key pieces of physics yet to be incorporated, it represents a first step towards a mature statistical model of GI and tidal downsizing as a mode of star and planet formation providing an equivalent to the well-established population synthesis models of core accretion planet formation. While tidal downsizing cannot supplant core accretion theory as the primary mode of low mass planet formation, it produces objects at the exoplanet/brown dwarf boundary that are broadly consistent with observations.

The Hyades cluster in the Pan-STARRS1 survey

Bertrand Goldman (MPIA Heidelberg)

The Hyades cluster has been the target of many studies in the past, being the nearest intermediate-age cluster. Its proximity enables a detailed analysis of its morphology and a complete characterisation of its members down to low masses. But until now the data was missing to study the low-mass end out to large cluster radii. The PanSTARRS1 project routinely observes all the sky North of -30° declination in five optical bands several times a year. This unique survey combines depth, image quality and wide sky coverage to yield exquisite photometric and astrometric precision, and unprecedented resolution in the time domain. The massive data set allows a thorough photometric and kinematic selection of the low-mass stellar and sub-stellar content of the Hyades. Now we can use PS1 proper motions and parallaxes to start looking for yet lower-mass members of the Hyades over a large area. In this talk I will present the challenges of searching for high-mass Hyades brown dwarfs at large cluster radius using the first two years of the PS1 survey while maintaining a reasonable and well constrained field contamination.

Observations of tiny cloud cores - birth sites of substellar objects?
Jane Greaves (University of St Andrews)

The pre-brown dwarf candidate Oph B-11 has recently been confirmed as bound and of substellar mass by submillimetre interferometry. I will discuss this archetype and present new SCUBA-2 data confirming very low mass cloud fragments in Oph D down to the ~10 Jupiter mass regime.

High-resolution/high-contrast near-infrared imaging survey of protoplanetary disks and exoplanets with Subaru/HiCIAO
Jun Hashimoto (University of Oklahoma)

HiCIAO is a new high contrast instrument used in combination with the 188 actuator adaptive optics system (AO188) in the 8m Subaru Telescope. It employs the Lyot coronagraph having various imaging modes of direct imaging (DI) but also including spectral or polarimetric differential imaging (SDI/PDI). The angular differential imaging can be combined with DI/PDI/SDI. Using HiCIAO, we performed the strategic campaign of SEEDS (Strategic Exploration of Exoplanets and Disks with Subaru) for exoplanets and disks survey from 2009. The aims of SEEDS are (1) to investigate the morphological and physical evolutions of disk and (2) to directly detect the Jupiter-mass exoplanets around nearby young-stars. In the SEEDS project we have discovered three new exoplanets (GJ 504, GJ 758 and kappa And), more than ten protoplanetary disks (AB Aur, LkCa 15, HD 169142, SAO 206462, PDS 70, UX Tau, Usco J1604, and so on), two new debris disks (HR 4796A and HIP 79977). In this conference, I will review the results of SEEDS and discuss future prospects.

Atmospheric Retrieval Analysis of the Directly Imaged exoplanet HR 8799b
Jaemin Lee (University of Zurich)

The direct-imaged exoplanet HR 8799b is photometrically distinct from its parent star. The spectroscopic measurements at H and K band along with photometric points between 1 and 5 um provide vast information for the thermal and chemical structure of the atmosphere, which have never been made from transiting planets. However, it is still mysterious that the characteristics of the atmosphere shows the mixture of brown dwarfs and gas giants, calling its radius, surface gravity, and mass into a question. Moreover, the photometric radius is larger than the model radius we called "radius ratio problem" which has long been unsolved yet. Here, for the first time, we perform the inverse modelling by exploiting an optimal estimation retrieval technique and sweep the parameterized radius and surface gravity space with phenomenological cloud scenarios. Unlike the previous approaches in which the cloud models are rather sophisticated, we minimise the number of cloud parameters e.g. mono-disperse cloud particle size and optical depth of cloud. We consider that cloud material gives a non-detectable effect to our results because the refractive indices of most of materials plausible in this class of atmosphere are not distinguishable in given wavelengths. We find that an additional opacity from uniformly extended (UC) and intermediate (IN) cloud improve the goodness-of-fit over clear atmosphere case. Consistently, R=0.6-0.7 log g ~ 5 and M~10-20Mj are constrained for all cases leading to the fact that super solar metallicity and non-equilibrium chemistry are more likely. We conclude that particle size ~ 1.5 um and optical depth ~ 2 reproduce the best-fitting spectrum although the radius - ratio problem still remains.

Optical aurorae on brown dwarfs
Stuart Littlefair (University of Sheffield)

Variability surveys are beginning to yield exciting new results on structure in the cloud decks of brown dwarfs. However, some brown dwarfs show periodic radio emission, believed to be similar to the auroral emission of giant planets in the solar system revealing that the activity of brown dwarfs has more in common with planets than stars. Here we present new data which show the *optical* variability of these objects is also produced by the aurorae. Based on our data, we suggest ways to discriminate between cloud and auroral variability in brown dwarfs.

The peculiar L dwarf ULAS J222711-004547
Federico Marocco (University of Hertfordshire)

We present the discovery of a peculiar L dwarf from the UKIDSS Large Area Survey (LAS), ULAS J222711-004547. Its very red infrared colours (MKO J-K = 2.79) make it the reddest brown dwarf discovered so far. The object was discovered as part of a large spectroscopic campaign aiming at constraining the substellar birthrate (Day-Jones et al. 2013). We obtained a moderate resolution spectrum of this target using the echelle spectrograph XSHOOTER on VLT/UT2, and classified it as L7pec, confirming its very red nature. The spectrum does not show the features that are indicative of youth (e.g. Cruz et al. 2009, and references therein), and its kinematic excludes membership of any of the young moving groups. Applying a simple dereddening curve the spectrum of ULAS J222711-004547 becomes very similar to the spectra of the L7 spectroscopic standards. Therefore we conclude that the reddening of the spectrum is mostly due to an excess of dust in the photosphere of the target. This new discovery joins the list of unusually red L dwarfs, whose nature is not yet fully understood (e.g. Gizis et al. 2012), and it poses a new important challenge to atmospheric modeling of substellar objects.

The effect of dynamical simplifications on models of hot Jupiter atmospheres
Nathan Mayne (University of Exeter)

We present models of HD209458b using the same global circulation model (GCM) the united model (UM) used by the UK Met Office for climate research and numerical weather prediction for Earth. This GCM is able using the same numerical scheme to solve the unsimplified dynamical equations for a rotating atmosphere, as well as models with increasing simplification to these equations (as are canonically used for modeling the dynamics of hot Jupiter atmospheres). Our results demonstrate that the bulk atmospheric flow is largely robust to the canonical simplifications if short integration times and small vertical domains are used (i.e. shallow weather layers). However, we present evidence for a dependence of the longer term atmospheric state derived on the completeness of the equations solved. We have adapted the dynamical components of this model for the study of hot Jupiters and used a parameterised radiative transfer scheme. We are also adapting a more complete radiative transfer scheme for the physical conditions of hot Jupiters and I will outline progress and plans for the coupling of this to the dynamical code.

Probing the Atmosphere of HAT-P-1b with HST
Nikolay Nikolov (University of Exeter)

We present an optical to near-infrared transmission spectrum of the hot Jupiter HAT-P-1b based on Space Telescope Imaging Spectrograph (STIS) observations aboard the Hubble Space Telescope (HST). The spectra were obtained using the G430L (two transits) and G750L (one transit) gratings covering the spectral regimes from 2900 - 5700Å and 5240 - 10270Å respectively with resolving power of R = 500. The data is coupled with a recent HST Wide Field Camera 3 (WFC3) G141 grism transit spanning the wavelength range from 1.087 to 1.687microns (R = 130) acquired in spatial scan mode. We perform a joint analysis of the four HST white light curves and derive refined physical parameters of the HAT-P-1 system including the orbital ephemeris finding no evidence for transit timing variations. We further use the derived physical properties and construct a full optical transmission spectrum. We choose custom size spectral bins ranging from 400 to 1000A wide to derive photometric measurements with uniform SNR in each bin. The transmission spectrum shows a strong absorption signature shortward of 5500Å with a strong blueward slope into the near ultraviolet. We detect atmospheric sodium absorption at a 3.3s significance level but see no evidence for the potassium feature. The red data implies a marginally flat spectrum with a tentative absorption enhancement at wavelength longer than ~8500Å. The combined STIS and WFC3 optical to NIR spectra differ significantly in absolute radius level (4.3 ± 1.6 pressure scale heights) implying strong optical absorption in the atmosphere of HAT-P-1b. The optical to near-infrared difference cannot be explained by stellar activity as simultaneous stellar activity monitoring of the G0V HAT-P-1b host star and its identical companion show no significant activity that could explain the result. We compare the complete STIS and WFC3 transmission spectrum with theoretical atmospheric models, which include haze sodium and an extra optical absorber. We find that both an optical absorber and a super-solar sodium to water abundance ratio might be a scenario explaining the HAT-P-1b observations. Our results suggest that strong optical absorbers may be a dominant atmospheric feature in some hot Jupiter exoplanets.

Evolution and Evaporation of Hot Neptunes
James Owen (CITA)

I will present the results of hydrodynamic calculations for the evaporation of the atmospheres of close-in planets. In particular I will discuss the interaction between X-ray and EUV irradiation and which radiation field drives the evaporation in different regions of parameter space. I show that most close in planets (a<0.1AU) will be evaporating hydrodynamically rather than loosing mass via Jean's escape. I will then discuss the results of coupling the evaporation rates to an evolutionary model of the star's high-energy emission and the planets thermal contraction. The inclusion of evaporation into models of the evolution of low-mass planets allows us to break many of the structural degenerate that exist of low-mass planets. It particular I will show that comparing the evolutionary models with the current Kepler Object of Interest sample suggest that there is an upper mass limit of 20 earth masses for low-mass planets. Furthermore, the models suggest that a significant fraction ~50% of the observed planet population has gone through significant evaporation having lost their primordial Hydrogen/Helium envelopes.

Giant planet and brown dwarf companions: no gap but local minima
Maddalena Reggiani (ETH Zurich)

We present new results from the NACO-LP direct imaging survey regarding the companion mass function of sub-stellar objects around solar-type star. Planets and BDs as companions to stars might have different mass functions and semi-major axis distributions but they probably overlap in certain ranges. This means that the companion mass spectrum between roughly 1 and 80 Jupiter masses is the superposition of the two distributions. Therefore, to test different models against the observations we must take into account both planets and BDs. Assuming that we can extrapolate both the stellar Companion Mass Ratio Distribution (Reggiani & Meyer 2013) into the BD regime and the radial velocity planetary Companion Mass Function (Cumming et al. 2008) to larger separations we can run MC simulations to test in which mass range of the substellar companion mass spectrum we expect each one of the two populations to become more important than the other. This simple model turns out to be useful not only to analyze already existing datasets but also to predict the outcome of future surveys for very low mass companions.

Non-Equilibrium Ion-Neutral Chemistry between Brown Dwarfs and Exoplanets
Paul Rimmer (University of St Andrews)

An important characteristic of substellar atmospheric chemistry is the transition at Teff˜1500 K of the dominant equilibrium carbon-bearing species from CO to CH4. The chemical pathways for this transition are not well understood and the observation of CO in the atmosphere of the directly imaged substellar object HR 8799 c along with the non-detection of CH4 suggests that this object is not in thermochemical equilibrium. Non-equilibrium chemistry driven in various sub-stellar objects by atmospheric mixing photoionization and photo dissociation and cosmic ray ionization may cause the CO/CH4 ratio to deviate significantly from equilibrium. In order to properly explore this possibility both the causes of the non-equilibrium chemistry and the specific chemical pathways linking CO and CH4 need to be better understood. In this presentation we explore the role ion-neutral chemistry may play in substellar atmospheres. A simple example of the importance of ion-neutral non-equilibrium chemistry involves both methane and carbon monoxide. When methane is the dominant carbon-bearing species in the substellar atmosphere CH+5 is predicted to be one of the dominant ions; when CO dominates HCO+ is predicted to overcome CH+5. Several neutral species such as ascetyline and ammonia are closely connected to the ion-neutral non-equilibrium chemistry. We present an ion-neutral non-equilibrium gas-phase atmospheric chemical model for substellar objects. This model includes more than 2000 reactions involving over 100 species complete for species of size up to two carbons one oxygen and one nitrogen. This chemical model is applied to the atmosphere of a free-floating substellar object similar to HR 8799 c (Teff=1000 K, logg=3, solar metallicity) and explores how the non-equilibrium abundances of atmospheric species deviate from equilibrium obtained from the Drift-Phoenix model. The differences between an irradiated and non-irradiated substellar object are also examined by comparing an HR 8799-like object to a model hot Jupiter atmosphere. We end by discussing how including ion-neutral reactions may affect the predicted CO/CH4 ratio.

Coulomb Explosion of Dust in the Atmospheres of Brown Dwarfs and Exoplanets
Craig Stark (University of St Andrews)

Ionization processes occur in the atmospheres of low-mass objects creating pockets of plasma that can influence the formation of cloud particles. Dust grains immersed in an atmospheric plasma become negatively charged and are susceptible to electrostatic disruption where the electrostatic stress of a body holding a net charge exceeds its mechanical tensile strength resulting in it breaking up. This paper investigates under what conditions a charged dust grain will be electrostatically disrupted in a substellar atmosphere therefore exploring the upper limit for charged grain survival. Calculations show that spherical grains deep in the atmosphere can accumulate up to 10^6 electrons before disruption whereas high altitude grains can only accrue approximately 10. This is a consequence of the height dependence of the grain sizes and grain composition in substellar atmospheres. For grain geometries with non-zero eccentricity it becomes harder to sustain a stable grain; deep in the atmosphere highly aspherical grains can only harbour approximately 10^3 electrons. These results have implications for inter-grain electrical discharges since a reduced spheroidal dust population reduces the susceptibility of the clouds to discharge events. The electrostatic disruption of dust grains presents an additional process that impacts the local grain size distribution hence the charge carrying cloud surface.

Long baseline multicolour monitoring of the variable brown dwarf binary Luhman 16
Rachel Street (LCOGT)

Luhman 16 (WISE J1049-0053) was recently discovered to be a nearby (~2pc) brown dwarf binary which exhibits a high degree of photometric variability (~10%). This is thought to be due to the evolution of "cloud" features on the photosphere, but Luhman 16 was found to show unusually rapid changes possibly resulting from fast-evolving "weather". This target is of particular interest because it consists of a co-evolutionary pair of brown dwarfs spanning the transition between L and T types (L8 and T1), which is expected to be associated with changes in cloud surface coverage. Being comparatively bright (I~15.5mag) it is well suited for observation with the new LCOGT network of 1m telescopes. We present long-time baseline photometric observations from two of LCOGT's southern hemisphere sites which were used in tandem to monitor Luhman 16 for up to 13.25hrs at a time (more than twice the rotation period) for a total of 42 days in two filters. We use this dataset to measure the changing rotational modulation and propose that this is explained by the evolution of cloud features at varying latitudes on the surface of the T-dwarf.

Why BDs are special - evidence from the IMF and the spatial distribution
Ingo Thies (AIfA- University of Bonn)

The low-mass end of the initial mass function (IMF) is the topic of current debates. Among the most popular concepts is the assumption of a continuous transition from stars to brown dwarfs in both the IMF itself and the binary statistics of stars and BDs. However, advanced analytical star-formation models by Hennebelle & Chabrier (2008- 2009) or Padoan & Nordlund (2002) could successfully reproduce the stellar part while failing to reproduce the substellar region satisfactorily. I will show that the brown dwarf mass function can essentially be described as the residual of these model IMFs with respect to the observed mass functions supporting the concept of a separate substellar population. It is also in agreement with the composite IMF introduced in Thies & Kroupa (2007) and the clump mass function deduced in SPH computations in Thies et al. (2010). In addition, I will present new predictions of the spatial distribution of BDs under the assumption of an ejection kick of about 1--2 km/s which is expected for ejected stellar embryos from fragmenting discs or decaying multiple systems (Reipurth & Clarke 2001, Basu & Vorobyov 2012).

A population of small planets in the Solar neighbourhood
Mikko Tuomi (University of Hertfordshire)

The most common stars in the Solar neighbourhood and in the Galaxy in general, the M dwarfs, are also very common hosts of low-mass planets orbiting them. We present new estimates for the occurrence rate of such planets based on global detectability statistics of planets around a sample of M dwarfs observed by the UVES and HARPS spectrographs. We find that while low-mass planets are not very common on orbits with periods of less than 10 days (0.06 planets per star on average), they are remarkably abundant on longer orbits with periods between 10 and 100 days (1.02 planets per star). We also find evidence for a population of M dwarf planets on long orbital periods of up to 3000 days. Our results suggest that, apart from few exceptions, most M dwarfs are hosts to systems of low-mass planets.

First results of the International Deep Planet Survey: the frequency of wide-orbit massive planets around A-stars

Arthur Vigan (Laboratoire d'Astrophysique de Marseille)

None of the deep-imaging surveys around young solar-type stars in the recent years has ever reported any clear detections of planetary companions leading to the conclusion that long-period extrasolar planets around such stars are rare. However, recent breakthrough discoveries of planetary-mass companions around young A-type stars have opened new perspectives for the search of giant planets at long period. These discoveries come as an interesting corollary to recent radial velocity surveys around old A stars that show a strong correlation between the mass of the star and the mass of the planet companions. This suggests that early-type stars are more favourable targets for direct imaging surveys looking for long-period massive planets. We present the initial results of the International Deep Planet Survey where 38 young nearby A- and F-type stars have been observed at high-contrast in angular differential imaging with VLT/NaCo and Gemini/NIRI. We present the sample selection and observations, as well as the statistical analysis performed using Monte-Carlo simulations. We take into account the detections around HR8799 and beta Pictoris to estimate that the fraction of A-stars having at least one massive planet (3-14 MJup) in the range 5-320 AU to be inside 5.9-18.8% at 68% confidence.

Detecting Habitable Zone Planets around M Dwarfs with the AAT

Duncan Wright (UNSW)

Finding Earth-like planets orbiting in the habitable zone of other stars is one of the major goals of modern astronomy. Detecting Earth-like planets in Earth-like orbits around Sun-like stars is currently beyond reach of any facility except Kepler (and was problematic even then). What is possible now is the detection of Earth-like planets in habitable-zone orbits around low-mass stars using the radial velocity technique. Early indications from both Doppler planet searches and Kepler are that rocky planets around low-mass stars are very common. A new program searching for habitable-zone exoplanets orbiting M4-M6 dwarfs on the Anglo-Australian Telescope began in late 2012. This program uses the new CYCLOPS fibre-feed working in the near infrared to obtain high-precision velocities. This presentation outlines the techniques developed specifically to detect these planets and the first results from this survey.

Posters

A variationally computed line-list for hot formaldehyde

Ahmed Al-Refaie (University of London)

The goal of the ExoMol project is to produce a molecular line list database with spectroscopic data important in characterising atmospheres of brown dwarfs and (exo)planets. Here we introduce formaldehyde (H2CO) as an addition. Formaldehyde has been detected in interstellar medium. Its spectral characteristics have provided a means of examining the composition of carbon isotopes and to perform densitometry in star forming regions in galaxies. Certain models (T Tauri BD2e 9 etc) of brown dwarf accretion disks display regions of carbon dominance and contain organic molecules such as actelyene and formaldehyde. However, there is limited spectral data on formaldehyde at higher vibrational and rotational excitations necessary for modelling high temperature atmospheres of different astronomical bodies such as hot planets and cool stars. As we begin to see the molecule's ever growing involvement in various astrophysical phenomena (that include a recent detection in comets) it makes it vital to have a robust line list over a large range of transitions. This work presents a preliminary ro-vibrational spectra of formaldehyde for elevated temperatures. Around 3 billion transitions at up to 9600cm^-1 were computed using the variational ro-vibrational solver TROVE with an empirical potential energy surface and a new ab initio dipole moment surface. To reach high rotational excitations required for high temperature applications, large-scale state-of-the-art variational computations were carried out for fully coupled rotational vibrational problem. Comparison to the experimental spectra is presented.

Parsec's astrometry direct approaches

A.H. Andrei (Observatório Nacional - ON/MCTI, Brazil)

To be direct it is fair to say that still nowadays the very most of all knowledge from celestial bodies comes from the interpretation of the photons arriving from them. And that the interpretation is severely handicapped when their distance is not determined. Trigonometric parallaxes are the fundamental stone upon which the scale of distances is built. However trigonometric parallaxes are hard to derive. They are smaller than one arcsec even for the closest stars, and just a fraction of the tiny apparent ellipse that the parallactic movement traces can be seen from any location of observation. For brown dwarfs the task is further complicated by their dimness. The PARSEC observational program was created to obtain trigonometric parallaxes at 50mas level for 140 southern brown dwarfs, significantly improving the interpretation templates of this class. The PARSEC program has been described and discussed in detail previously (Smart et al., 2009; Penna et al., 2010; Bucciarelli et al., 2011; Andrei et al., 2012), here it suffices to point out that the observations were taken to enforce the repetition of conditions, to maximize the signal to noise ratio, and to tightenly sample the parallactic ellipse. As a result, unlikely to most approaches, the astrometric solution can use the average of several independent methods to define the centroid of the target and reference stars; the target apparent path can be built using a re-sampling combination of frames; and a direct fitting of an ellipsis parallel to the ecliptic be used to derive the parallaxes, thus freeing the solution from Earth´s ephemeris. We discuss details of the method above outlined and present results for 39 targets. The final errors and the comparison to the classical solution support the direct approach. This work is much in debt to Richard Smart (OATo/INAF), Beatrice Bucciarelli (OATo/INAF), and Jucira Penna (ON/MCTI) for enormous amounts of observation, data reduction, and fruitful discussions.

Multiplicity of stars hosting transiting exoplanets

Carolina Bergfors (IoA Cambridge)

We present results from our high resolution Lucky Imaging survey utilising the two AstraLux instruments to study the multiplicity among hosts to transiting exoplanets. About half of solar type stars in our neighbourhood are part of a binary or multiple star system. It is however not fully understood how a secondary star affects the formation and evolution of planets in the system. The first aim of our survey is to provide clues to planet formation in binary star systems from observed multiplicity properties. In addition an unresolved secondary star may also contribute flux to the transit light curve and affect the accuracy with which stellar and planetary parameters can be derived. Several previously unknown stellar companion candidates have been detected in this survey including the faint and close companion candidates to the host stars WASP-12- HAT-P-8-TrES-2 and TrES-4. We show that even though the flux contribution is small, light curve deduced parameters systematically deviate from previously determined values and may be larger than the assumed statistical uncertainties. Our statistical analysis suggests that the binary fraction and mass ratio distribution of exoplanet host stars is similar to that of solar-type field stars but that the binary separation is on average larger for planet hosts.

The brown dwarf companions of white dwarfs

Matthew Burleigh (University of Leicester)

I will review the small but growing population of detached brown dwarf plus white dwarf binary systems, including their orbital period distributions, and their contribution to understanding extreme mass ratio binary formation, the brown dwarf desert, post main sequence binary evolution and common envelope evolution.

A radiative-convective equilibrium model for young giant exoplanets: Application to beta Pictoris b

Jean-Loup Baudino (Obseratoire de Paris)

We developed a radiative-convective equilibrium model for young giant exoplanets. Input parameters are the planet's surface gravity, effective temperature 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 molecular lines from H2O, CO, CH4, NH3, VO, TiO, Na and K. Line opacity is modeled using k-correlated coefficients pre-calculated over a fixed pressure-temperature grid. Cloud absorption can be added above the expected condensation level (e.g. iron or silicates) with given scale height and optical depth at some reference wavelength. Scattering is not included at the present stage. Model predictions will be compared with the existing photometric measurements of Planet Beta Pictoris b in the J- H- K- L and M bands (Lagrange et al. 2009; Quanz et al. 2010; Bonnefoy et al. 2011- 2013). This model will be used to interpret future photometric and spectroscopic observations of exoplanets with SPHERE mounted at the VLT with a first light expected in mid-2014.

Extrasolar climate-change: Searching for secular variability on brown dwarfs

Fraser Clarke (University of Oxford)

We present the results of a search for multi-year variability in a sample of brown dwarfs. This study appears to indicate that brown dwarf atmospheres are stable on long timescales, and we do not detect any major changes in brightness for the duration of the observations (4-7 years). Whilst studies of short-term variability (minutes/hours/days) can probe the structure of the atmosphere, longer-term studies probe its stability. The lack of long-term variability in brown dwarfs also suggests that photometric stability could be a good additional indicator in direct imaging planet searches.

A search for close substellar binaries to M dwarfs using WISE and 2MASS

Neil Cook (University of Hertfordshire)

Locating unresolved brown dwarfs and exoplanet companions to M dwarfs is important to enable dynamical mass and transit radii tests of brown dwarf models, identifying warm exoplanets and, constraining planet formation models. The recent Wide-Field Infrared Survey Explorer (WISE) all sky data release combined with the Two Micron All Sky Survey (2MASS) provides unprecedented near to mid infrared multi-band coverage for all bright M dwarfs across the sky. We present an optimised method for identifying brown dwarf and exoplanet companions to very low mass stars. We identify an all sky sample of bright M dwarfs based on optical and near-infrared colours, reduced proper motion, with strict E(H-W2) constraints and H-W2 photometric uncertainty less than 0.04. We hunt for excess in the mid infrared using the H-W1 and H-W2 colours, and comparison samples of other M dwarfs from common multi-colour parameter space (not including H-W1 and H-W2). These candidates will be followed up with adaptive optics, radial velocities, and light curves (for transit) where appropriate. We present the method used and an overview of the preliminary candidates detected as well as insight into future work.

The transition between planets and brown dwarfs as seen by gravitational microlensing

Martin Dominik (SUPA- University of St Andrews)

Gravitational microlensing provides a means of studying the population of sub-stellar objects down to lunar mass without being affected by how bright they are. This provides us with a view that is substantially different from what any other technique delivers. Microlensing signatures of binary systems are specifically characteristic, and our current inventory includes brown dwarf companions to stars, brown dwarf binaries, and planetary-mass bodies orbiting brown dwarfs.

Is TiO responsible for a temperature inversion in the hot Jupiter HD 179949b?

James Frith (University of Hertfordshire)

We conduct a high resolution 0.6 - 0.9 μm spectral study of HD 179949b aimed at searching for the signatures of TiO and VO. These molecules may be responsible for the temperature inversion found in the most highly irradiated hot Jupiters. We obtained spectral time series of HD179949 with UVES over two nights, at phase angles when the planet is expected to be at its brightest. Using tomographic techniques, combined with signal enhancement via deconvolution, we probe planet/star contrast ratios of $F_{p}/F_{\star}=10^{-4}-10^{-5}$ at which the TiO/VO signatures are expected.

VISTA-VVV High Proper Motion Survey

Mariusz Gromadzki (Universidad de Valparaiso)

The ESO public survey VISTA variables in the Via Lactea (VVV) targets 562 square degree in the Galactic bulge and an adjacent plane region. VVV provides multi epoch Ks-band images, which allow searching for high proper motion objects. Providing better spatial resolution and deeper (4) magnitude range than 2MASS, VVV has higher potential for finding free floating very low-mass stars, brown dwarfs and also common proper motion companions of previously known high proper motion stars. The searching method we used is based on cross-matching with radius scaled to 5 arcsec per year photometric catalogs obtained for various epochs. The first stage of our global search is spread out only over the brightest sample (Ks<13.5mag) and we have detected ~3500 objects with proper motion higher than 0.05 arcsec per year. Founded candidates were visually inspected on the VVV 2MASS and SuperCOSMOS images. Our list includes dozens of new high proper motion stars and common proper motion pairs some common proper motions companions of previously known high proper motion stars and one brown dwarf. During visual inspection of SuperCOSMOS images we have also identified few white dwarf common proper motion companions of previously known proper motion stars.

The boundary between brown dwarfs and planets

Eike W. Guenther (Thueringer Landessternwarte Tautenburg)

Radial-velocity surveys have shown that intermediate mass (1.3-2.1 MSun) stars quite often have companions with minimum masses that are close to the boundary between brown dwarfs and planets. What are these objects and how did they form? In order to shed more light onto these objects we have to know more about them. What is their mass, radius and density? This requires to the detection of transiting objects. Using the CoRoT database we have initiated a survey for close-in transiting objects with the size of a brown dwarf orbiting early F and A stars. Although these stars are usually rapidly rotating, brown dwarfs with orbital periods of a few days can be detected. In this contribution I will present the current status and first results obtained.

New planets in the 7:5 MMR

James Jenkins (Universidad de Chile)

I will present two new planetary systems with pairs of planets orbiting in or nearby the 7:5 MMR. The systems both contain two super-Earth's, with one of those orbiting in the Habitable Zone. I will discuss the implications of these results and show how systems like these can be built.

A Survey of Substellar Atmospheric Properties in L/T-transition and Peculiar Brown Dwarfs from an SDSS/2MASS Cross-match

Kendra Kellogg (University of Western Ontario)

We are studying a broad sample of brown dwarfs that are either in the process of sedimenting dust from their atmospheres or have peculiar atmospheric characteristics such as low surface gravities metallicities or unusual cloud properties. Our study has uncovered 25 candidate peculiar early L to early T dwarfs which are mostly completely new objects with only a few having been previously discovered but with no published spectra. With spectroscopic observations, we confirmed that 12 from our prioritized sample and one from our complete sample are moderately peculiar or are potentially L/T binaries including one which with a J-Ks color of 2.62 is the reddest field dwarf currently known. These new discoveries come from the SDSS and 2MASS surveys, which have already been subject to considerable scrutiny demonstrating that our exploration of these surveys is not yet complete. The ultimate goal of this program is to produce a flux-complete estimate of the fraction of peculiar ultra-cool dwarfs in large-area surveys and improve our ability to classify these objects on a more finely gradated classification scheme.

New insights on beta Pictoris comets: discovery of two different populations

Flavien Kiefer (IAP CNRS)

High resolution spectroscopic observations of beta Pictoris made with HARPS bring new informations on the exocomets falling onto the star (FEB scenario). With more than thousand spectra gathered between 2003 and 2011 we have around 6000 variable absorptions detected. Using this huge catalogue of events we achieved an unprecedented statistical and temporal study of beta Pic comets. We will present the results of this statistical analysis and display the evidences that allowed us to discover two very different populations of comets in this young planetary system.

Photometric Variability at the L/T transition

Radostin Kurtev (Universidad de Valparaiso)

L/T transition brown dwarfs present large-amplitude variability on rotational timescales. Photometric monitoring from warm Spitzer reveals that the L3 dwarf DENIS-P J1058.7-1548 varies sinusoidally in brightness with a period of ~4.25hr and an amplitude of ~0.4% (peak-to-valley) in the 3.6micron band confirming the reality of a 4.3±0.3hr periodicity detected in J-band photometry from the SOAR telescope. The J-band variations are a factor of 2.2±0.3 larger in amplitude than those at 3.6micron while 4.5micron Spitzer observations yield a 4.5/3.6micron amplitude ratio of only 0.23±0.15 consistent with zero 4.5micron variability. This wide range in amplitudes indicates rotationally modulated variability due to magnetic phenomena and/or inhomogeneous cloud cover. However, inhomogeneous cloud cover alone can explain all our observations and our data align with theory in requiring that the regions with the thickest clouds also have the lowest effective temperature. DENIS-P J1058.7-1548 is only the first of nearly two dozen low-amplitude variables discovered and analyzed by the Weather on Other Worlds project. Here we present also variability results for another two of our targets based on SPARTAN/SOAR and SOFI/NTT NIR observations.

HST/WFC3 spectroscopy of T dwarf candidates in young clusters

Phil Lucas (University of Hertfordshire)

We present HST/WFC3 spectra of the T dwarfs S Ori 70 and S Ori 73 located towards the Sigma Orionis cluster, and the peculiar object PLZJ 100 in the Pleiades. Both S Ori 70 and S Ori 73 are confirmed as T dwarfs, with spectral types similar to those previously reported in the literature. However the spectra do not appear atypical in any way, which reinforces the view derived by published proper motions that these are foreground objects rather than cluster members with very low surface gravities and masses. PLZJ 100 is marginally spatially resolved (~0.2 arcsec) indicating that it is an external galaxy. This extended nature of the source is probably responsible for the Pleiades-like proper motion that was previously reported at low signal to noise. This is a relatively new form of contamination that is likely to become more common as imaging surveys probe ever deeper for faint brown dwarfs and planets.

A new massive CoRoT planet

Hannu Parviainen (Oxford)

We report the discovery of a new ~10 MJup transiting planet orbiting around a G4 star.

Brown dwarfs detections from microlensing

Clément Ranc (Institut d'Astrophysique de Paris)

Galactic gravitational microlensing is a powerful technique to detect extrasolar planets at large orbital distances from their stars as well as low-mass binary stars and brown dwarfs. Recently several brown dwarfs detections have been reported by microlensing. Here we present the detection of a new brown dwarf and discuss its mass and orbit size in comparison to previous discoveries.

Direct Imaging of Anglo-Australian Planet Search Targets

Graeme Salter (University of New South Wales)

We are finally entering an era where radial velocity and direct imaging parameter spaces are starting to overlap. Radial velocity measurements provide us with a minimum mass for an orbiting companion (the mass as a function of the inclination of the system). By following up these long period radial velocity detections with direct imaging we can determine whether a trend seen is due to an orbiting planet at low inclination or an orbiting brown dwarf at high inclination. In the event of non-detection we are able to put a limit on the maximum mass of the orbiting body pushing it towards the planetary regime. The Anglo-Australian Planet Search is one of the longest baseline radial velocity planet searches in existence amongst its targets are many that show long period trends in the data. Here we present our direct imaging survey of these objects with our results to date. ADI Observations have been made using NICI (Near Infrared Coronagraphic Imager) on Gemini South and analysed using an in house LOCI-like post processing.

The Gaia Brown Dwarf Content

R. L. Smart (Osservatorio Astrofisico di Torino)

We examine the current dwarfarchive compilation of Brown Dwarfs and estimate that Gaia will detect over 500 of them. We examine their distributions in spectral type, G magnitude, and position in the sky. Using the SDSS sample as a comparison we find the completeness across the full sky and estimate the expected Gaia sample. We discuss what observations are required today to maximize the scientific exploitation of this sample. This work was carried out under an ESF GREAT short-term visitor grant.

Photo - type: A faster way towards a large sample of brown-dwarfs

Nathalie Skrzypek (Imperial College London)

We developed a new method 'photo-type' to accurately classify brown dwarfs using multi-waveband photometry alone. This allows us to produce a statistically significant sample of L- and T-dwarfs that can be used for determining characteristics of these objects without having to wait for spectroscopic follow up. By investigating the outliers, we can find binary candidates and peculiar sources for further investigation. We also present an updated accurately classified sample of over 1000 brown dwarfs from UKIDSS+SDSS+WISE.

New high proper motion sources from the UKIDSS Galactic Plane and Large Area Surveys

Leigh Smith (University of Hertfordshire)

Proper motion surveys allow us to investigate the space motions of brown dwarfs, identify thick disk/halo objects, identify benchmark binaries and discover previously overlooked objects very close to the sun. The UKIDSS Large Area Survey (LAS) covered 1500 sq degrees at 2 epochs in J band, while the Galactic Plane Survey (GPS) has so far covered 1400 sq degrees at 2 epochs in K band. We have developed a proper motion pipeline that calculates motions for all sources in each WFCAM array using a unique set of reference stars for each source. We present a proper motion catalogue of 121,000 stars from the LAS with motions above the 5-sigma level. This includes 16 new candidate ultracool benchmark binary systems and two candidate thick disc/halo T dwarfs. Furthermore, we present the discovery of ~160 new high proper motion sources in the GPS with PM>200 mas/yr.

Characterizing Atmospheres: A Complete Line List for Phosphine

Clara Sousa-Silva (UCL)

The ability to characterise the atmospheres of cool stars, brown dwarfs and exoplanets requires fundamental data for all species contributing significantly to their opacity. However, with notable exceptions such as water and ammonia, existing molecular line lists are not sufficiently accurate or complete to allow for a full spectroscopic analysis of these bodies. ExoMol (www.exomol.com) is a project that aims to rectify this by generating comprehensive line lists for all molecules likely to be detected in the atmospheres of cool astrophysical objects in the foreseeable future. The spectral data is generated by employing ab initio quantum mechanical methods performing empirical refinement based on experimental spectroscopic data and harnessing high performance computing. Here we present our work on phosphine an equilateral pyramidal molecule (the phosphorus analogue to ammonia). Phosphine is known to be important for the atmospheres of giant planets, cool stars and many other astronomical bodies. Rotational transition features of phosphine have been found in the far infrared spectra of Saturn and Jupiter where it is a marker for vertical convection zones. Our current computed room temperature line list for phosphine is presented here as a precursor to a high temperature equivalent currently in progress. This will be necessary for the analysis of cool stars and brown dwarfs. All the transitions' energy levels and Einstein A-coefficients were computed using the program TROVE.

Finding Binary Brown Dwarfs in HST Archival Data

Denise Stephens (Brigham Young University)

In many instances brown dwarf binary systems tend to have very close separations and similar spectral types. This makes it difficult to detect these systems with ground-based photometry or through fitting binary models to spectral energy distributions. Building on work I have done to identify binary transneptunian objects in Hubble Space Telescope data (HST) I am now using those same programs to look for marginally resolved binary brown dwarf systems in the HST archives. In this poster I will explain how the code works and give an update on findings so far. The extremely high resolution of the HST telescope and the incredible stability of the point spread function makes it possible to identify potential binary systems through point spread function modeling. The programs I use are able to return separations position angles and relative magnitudes for the most likely unresolved binary systems. The list of potential HST binaries is valuable to observers who are trying to resolve these systems from the ground as it gives them a list of priority targets on which to focus their efforts. The parameters returned by the models also provide early data points that can be used to constrain future orbital solutions.

CoRoT 101186644: A transiting low-mass dense M-dwarf on an eccentric 20.7-day period orbit around a late F-star

Lev Tal-Or (Tel-Aviv University)

We present the study of the CoRoT transiting planet candidate CoRoT 101186644 also named LRc01_E1_4780. Analysis of the CoRoT light curve and the HARPS spectroscopic follow-up observations of this faint (m_V = 16) candidate revealed an eclipsing binary composed of a late F-type primary (T_eff = 6090 +/- 200 K) and a low-mass dense late M-dwarf secondary star on an eccentric (e = 0.4) orbit with a period of 20.7 days. The M-dwarf has a mass of 0.096 +/- 0.011 M_Sun and a radius of 0.104 +0.026 / -0.006 R_Sun which makes it probably the smallest and most dense late M-dwarf reported so far. In addition contrary to the well-known problem of inflated M-dwarfs the radius of the secondary is probably consistent or might even be below the radius predicted by theoretical M-R models for M stars. The high uncertainty of the secondary radius is due to the limited ability to place an upper limit on light contribution from a possible background star. Nevertheless this discovery adds yet another piece to the puzzle of the mass-radius relations at the bottom of the main sequence. We review the current agreement between observations and theory of very-low-mass stars (M <~ 0.2 M_Sun) and conclude that a large scatter of radii probably exists in this mass domain but no clear discrepancy between models and observations can be deduced at this point.

Disks around Brown Dwarves with ALMA

Gerrit van der Plas (University of Chile)

Brown Dwarves (BD) and low-mass stars are the most numerous (sub)stellar objects in our universe. At young ages these objects have disk fractions similar to those around the more massive solar-like stars which suggests that they can possibly host a vast reservoir of planets. However, although differences may exists in the internal properties of the disks around solar-mass stars compared to low-mass stars (i.e. timescales for grain growth and disk dissipation) several of the key structural parameters of the disks around low-mass stars and BDs remain poorly constrained observationally in particular size mass and gas content. Yet these properties are critical to assess and understand their capacity to form planets. With this poster we introduce and present our ongoing high priority cycle 1 ALMA program to study the dust and gas content of disks around 32 BD and very low mass stars in two nearby star formation regions of different age. We focus on the spectral types around the stellar/sub-stellar boundary in the range M4 - M8 a group whose disk properties are still poorly known today. This program is designed to understand (1) whether there is enough dust and gas to form planets around the objects located at the lower end of the IMF (2) how the disk mass scales with central object mass and (3) how the properties of the disks evolve over the two age groups spanning the range of 2-10 Myr. Quantitative information will be extracted from the data with a state-of-the-art and automatized suite of codes: the radiative transfer code MCFOST (Pinte et al. 2009) and the thermo-chemical code ProDiMo (Woitke et al. 2009).

Identifying the ejected population from disintegrating multiple systems

Alex Yip (University of Hertfordshire)

Kinematic studies of the Hipparcos catalogue have revealed associations that are best explained as disintegrating multiple systems, presumably resulting from a dynamical encounter between single/multiple systems in the field (Li et al. 2009). In this project we explore the possibility that known ultra cool dwarfs (UCD) may be components of disintegrating multiple systems, and consider the implications for the properties of these objects. We show the results obtained cross-matching Dwarf Archive (hereafter DA), Hipparcos Main Catalog (hereafter HMC) and Gliese-Jahrei Catalog (hereafter GJC). We will use these catalogues and place distance and proper motion constraints on objects with colour magnitude information, to identify candidate multiple systems. We will then try to search for additional fainter objects in these associations using the Two Micron All Sky Survey (2MASS; Skrutskie et al.2006), the Sloan Digital Sky Survey (SDSS; York et al. 2000), the United Kingdom Infrared Deep Sky Survey (UKIDSS; Lawrence et al. 2007) and the Wide-field Infrared Survey Explorer (WISE; Wright et al. 2010).

A preliminary line list for methane up to 1500K

Sergey Yurchenko (UCL)

Methane plays an important role in atmospheric and astrophysical chemistry. Its rotation–vibration spectrum is of key importance for models of the atmospheres of bodies ranging from Titan to brown dwarfs. However the lack of precise data on methane spectra, particularly at higher temperatures, has severely limited models for atmospheres as diverse as Jupiter, exoplanets and brown dwarfs and made it difficult to determine its actual quantity. Consequently we have embarked on a major project ExoMol [J. Tennyson and S. N. Yurchenko, Mon. Not. R. Astron. Soc. 2012, 425, 21] to fill this gap. Here we present a preliminary line list for methane containing almost ten billion transitions that should be sufficiently complete and accurate to replicate observed spectra at temperatures up to 1500 K. This computationally derived line list details transition frequencies and associated Einstein coefficients lower energy levels and quantum numbers. Hot temperature spectra of methane simulated using this line list will be presented and compared to different experimental spectra of methane available in the literature as well as generated using other line lists. Our '10to10' line list for CH4 will be suitable for use in modelling the spectra of planetary and stellar objects. This work was supported by the ERC under Advanced Investigator Project - 267219 and the UK STFC. The calculations were performed on the DiRAC facilities COSMOS and Darwin.

Identifying the substellar subdwarf gap

Zenghua Zhang (University of Hertfordshire)

The evolutionary models show that there is an effective temperature gap of old populations (> 10 Gyr) at the stellar/substellar boundary (~ 80 Jupiter mass; e.g. Burrows 2001) because brown dwarfs are cooling down while low-mass stars keep shining. Simulations of substellar mass function also suggest there is a lack of objects with effective temperature between 1200 and 2000 K in the halo (Burgasser 2004a). Massive brown dwarfs of the halo should have more distinguishable spectral features from halo low-mass stars than those of the disk. Such features have not been discussed because there are too few L subdwarfs at the stellar/substellar transition. There are only eight L subdwarfs been reported (Burgasser et al. 2003; Burgasser 2004b; Cushing et al. 2009; Sivarani et al. 2009; Lodieu et al. 2010, 2012; Kirkpatrick et al. 2010). Only one L subdwarf (Burgasser et al. 2003) has mass below the hydrogen burning minimum mass according to theoretical models, thus a brown dwarf. I am leading a project to search for L subdwarfs with SDSS, UKIDSS and large telescopes (VLT, Magellan, GTC). We have successfully discovered several new substellar subdwarfs (Zhang et al. in preparation), which allow us to discuss the spectral features of halo brown dwarfs and location of the substellar subdwarf gap. We have followed up another 43 L subdwarf candidates with the Gran Telescopio Canarias and Magellan Telescopes.