Abstracts for "Extreme Solar Systems"

Talk Abstracts

"Pulsar Planets"

Wolszczan, A.

I will review the history and current status of our understanding of the PSR B1257+12 planetary system. I will also discuss neutron star planet formation scenarios and their relevance to formation and evolution of planetary systems around other stars.

"Extrasolar Planets: The Golden Age of Radial Velocities"

Udry, S.

Twelve years after the discovery of 51Pegb more than 220 planets have been detected with the radial-velocity technique. The information gathered on the orbital-element distributions, as well as on the characteristics of the planet-host stars, have largely contributed to improve our understanding of planet formation. In this presentation I will review these results with a special focus on the recent efforts of the past few years to improve the parameter space of stellar and planetary properties. The complementary and fundamental role of radial velocities in the planetary transit cases and the additional information they bring on the planet structure and on the geometry of the systems will be discussed as well.

"From Hot Jupiters to Hot Super-Earths"

Mayor, M.

In the last twelve years, more than 200 exoplanets have been detected. These discoveries have revealed the impressive diversity of exoplanet orbital properties.

The past twelve years have also witnessed a remarkable improvement of the precision of radial velocity measurements with a gain of about a factor 100. Thanks to the HARPS spectrograph installed in 2003 at la Silla Observatory ,numerous planets with masses as small as a few earth-masses have been detected. Several statistical properties are already emerging and help constraining the formation mechanisms of these systems.

Is it possible to expect further significant progresses of Doppler measurements? Such a possibility could be of interest to permit radial velocity follow-up measurements of planetary transit candidates expected from the COROT and KEPLER space missions: the goal being to get a precise determination of mass-radius relations from terrestrial planets to brown dwarfs. Recently, we have been able to get a first insight in the internal composition of a Neptune analogue,...from ground based observations.

A radial velocity precision at the level of 0.1 m/s does not seem out of reach. With an observing strategy adapted to minimize the influence of the stellar intrinsic variability (magnetic activity, acoustic modes) we should be in position to explore statistical properties of terrestrial planetary systems.

"Multiple-Planet Systems"

Wright, J.T.

The number of known multiple-exoplanet systems now stands at more than twenty. I will present some new systems and discuss the trends that are beginning to emerge from this sample. I will show how these systems allow us to test theories of planet formation, study the origins of eccentricities, and constrain orbital inclinations.

"Sub-stellar Companions to Young Stars and Brown Dwarfs"

Jayawardhana, R.

The detection of giant planets around young stars would provide direct constraints on the timescale for their formation (and migration). Unfortunately, stronger stellar activity in young stars poses a challenge for spectroscopic and photometric searches. However, some young stars are relatively less active and are slow rotators, making it possible to achieve sufficient radial velocity precision to detect sub-stellar companions in short-period orbits. Moreover, giant planets are expected to be much more luminous when young, thus easier to image directly than their older counterparts, especially if they happen to be in wide orbits around low mass primaries. Here I will report on the results of both radial velocity and adaptive optics imaging surveys, targeting a large sample of young stars and brown dwarfs in search of sub-stellar companions.

"Very Low-mass Spectroscopic Companion of the Brown Dwarf ChaHa8"

Joergens, V.

I report the discovery of a spectroscopic companion around the very young brown dwarf candidate ChaHa8 based on UVES/VLT spectra. With it, ChaHa8 is the fourth known spectroscopic companion of a brown dwarf or very low-mass star with a radial velocity orbit solution, and the second known very young one. The companion is likely a very low-mass brown dwarf and might have a mass close to the planetary mass regime. It will be discussed what can be learned from this system for substellar formation and evolution.

"New Results from the McDonald Observatory and ESO/VLT Planet Surveys"

Endl, M., Cochran, W.D., Kürster, M., Wittenmyer, R.A., & Bean, J.L.

We discuss the current status of our precision radial velocity surveys at the Hobby-Eberly Telescope (HET) and 2.7-m telescope at McDonald Observatory, as well as at the ESO/VLT in the southern hemisphere. With the HET we have just detected a planetary system, consisting of 2 Jovian-type planets, around a very metal-poor star ([Fe/H] = -0.68). Furthermore, using the VLT data for Barnard's star and Proxima Cen we will demonstrate that our current sensitivity for low-mass planets around late M dwarfs approaches 1 Earth mass.

"Retired A Stars and Their Planets"

Johnson, J.A., Marcy, G.W., & Fischer, D.A.

Very little is known about the occurrence rate and orbital properties of planets around A type stars, corresponding to stellar masses ranging from 1.5 $M_{\odot}$ to 2.5 $M_{\odot}$. This apparent lack of planets around massive stars is due to a strong selection bias against early-type, main-sequence stars in Doppler-based planet searches. One method to circumvent the difficulties inherent to massive dwarfs is to instead observe these stars after they evolve onto the subgiant branch of the H-R diagram. We show how the cooler atmospheres and slower rotation velocities of subgiants make them ideal proxies for A stars in Doppler-based planet searches. We present the early results from our planet search, including 4 new exoplanets and 4 additional strong planet candidates orbiting stars with masses greater than 1.5 $M_{\odot}$. Our preliminary results reveal a paucity of planets orbiting within 0.8 AU of their host stars. We also present evidence of a rising trend in giant planet occurrence with stellar mass.

"Properties of Planets around G & K Giants"

Sato, B.

I'll talk about preliminary statistical properties of planets around intermediate-mass G, K giants based on the sample of planet search programs now ongoing at Okayama (Japan), Xinglong (China), and Bohyunsan (Korea) observatories. A few new discoveries will be included.

"The PSU/TCfA Search for Planets around Evolved Stars"

Niedzielski, A.

In my talk I will present the PSU/TCfA search for planets with HET, its motivation, status and first results.

"Latest Results from the PLANET Collaboration"

Beaulieu, Jean-Philippe

TBD

"Ground-based Surveys of Transiting Planets"

Pont, F.

Ground-based surveys now discover transiting planets at a steady rate. The diversity of the structure of close-in planets caught in transit has been just as baffling as that of exoplanets found by Doppler searches. Here I review the status of ground-based photometric and spectroscopic surveys for transiting planets at the time of the first results from the space Corot mission.

"Planets in the Galactic Bulge"

Sahu, K.C.

The SWEEPS (Sagittarius Window Eclipsing Extrasolar Planet Search) project used HST to monitor 180,000 stars in the Galactic bulge continuously for 7 days to look for transiting extrasolar planets. The SWEEPS sample represents the farthest such sample, and includes stars down to 0.45 solar mass. We discovered 16 candidates with orbital periods between 0.4 and 4.2 days. In two cases, radial-velocity measurements support the planetary nature of the companions. Five candidates are ultra-short-period planets (USPPs) with orbital periods below 1.0 day, something that had not been seen before, and which occur only around stars of less than 0.88 solar mass. This indicates that those orbiting very close to more luminous stars might be evaporatively destroyed, or that jovian planets around lower-mass stars might migrate to smaller radii. The resulting frequency of planets in the Galactic bulge is similar to that in the solar neighborhood.

"High-Precision Transit Photometry and Spectroscopy"

Winn, J.

A planetary transit produces both a photometric and a spectroscopic signal. Precise measurements of the transit light curve reveal the planetary radius and allow a search for timing anomalies caused by satellites or additional planets. Precise measurements of the stellar Doppler shift throughout a transit (the Rossiter effect) place a lower bound on the stellar obliquity, which may depend on the planet's migration history. I will review recent results of the Transit Light Curve project, and of a parallel effort to measure the Rossiter effect for many of the known transiting planets.

"News and Preliminary Results of the Corot Space Mission"

Deleuil, M.

CoRoT is the first instrument aiming at detecting exoplanets from space, using the transit method. It has been built in order to explore the domain of planets with orbital period less than two months, and size down to about two Earth radius. Successfully launched on the 27th of December 2006, the instrument started its science observations by the beginning of February this year. We will briefly describe the instrument, the mission profile, and present some preliminary results, assessing the on-flight performances and detection capabilities.

"Pulsar Planets in Globular Clusters"

Stairs, I.

The first planet in a globular cluster was discovered orbiting the 11-millisecond pulsar/white-dwarf binary B1620-26 in M4. We present a timing solution for the pulsar incorporating nearly 20 years of data, over 1/3 of the planet's orbit. The most recent observations have been taken with the sensitive Green Bank Telescope (GBT) and will allow stringent constraints on the masses and inclination angles in the system.

A separate project involves deep GBT observations of multiple globular clusters to search for new binary and millisecond pulsars. With the search and timing follow-up observations, we have extensive data sets with which to search for low-mass companions to the new pulsars. We present an overview of the results of this search.

"A Debris Disk Around a Young Neutron Star"

Chakrabarty, D., Wang, Z., & Kaplan, D.

We have found evidence for a dusty debris disk around the anomalous X-ray pulsar 4U0142+61 using Spitzer data. We infer that the disk formed from supernova fallback material. The properties of this putative disk resemble those of protoplanetary disks around ordinary young stars, suggesting the possibility of planet formation. We discuss possible tests of this disk hypothesis as well as that status of searches for similar disks around other neutron stars.

"Second Chance Planets"

Sigurdsson, S.

Planetary systems can be very fragile, with collisions, ejections, engulfment and violent rearrangement of planets taking place after formation, sometimes long after formation. Such processes are generally detrimental both to the persistence of life, and for prospects for detection of planets. Sometimes, however, planets may get a second chance, where they survive in spite of the adversity; in some such cases there are possibilities for life persisting or re-appearing, or, it may become easier for us to detect the planets, thereby getting indirect evidence for properties of otherwise unobservable planetary systems through dynamical transformation.

"Searching for Planetary Transits in Star Clusters"

Weldrake, D.T.F.

Star clusters provide an excellent opportunity to study the role of environment on determining the frequencies of short period planets. They provide a large sample of stars which can be imaged simultaneously, with a common distance, age and pre-determined physical parameters. Several groups are attempting to detect transiting planets in open clusters. Three previous surveys have also targeted the two brightest globular clusters. I shall present a brief overview of the field, highlighting the pros and cons of performing such a search, and present the expected and current results with implications for planetary frequencies in regions of high stellar density and low metallicity.

"N-body Simulations of Solar Systems in Open Clusters"

Shara, M.

The remarkably low eccentricity orbits of the planets in our Solar System suggest that the Sun was born in a low density stellar evironment. We have used GRAPE-6 N-body simulations to follow the orbital evolution of Earth-Jupiter and Neptune-Jupiter systems in open star clusters, with 10% to 30% binaries, from birth to cluster dissolution. Most systems are ejected with at most small orbital eccentricity, but moderately hot Jupiters in very eccentric orbits are occasionally created.

"Dust Disks around Externally-Polluted Single White Dwarfs"

Jura, M.

Very approximately 2% of single white dwarfs with effective temperatures between 10,000 K and 20,000 K have infrared excesses apparently produced by opaque, flat passive dust disks lying within the tidal radius of the star. These same stars also exhibit metal abundances produced by external pollution, and in some objects, carbon is very deficient, reminiscent of the composition of the inner Solar System. We appear to be witnessing systems of tidally-disrupted asteroids of diameters greater than 100 km being accreted onto their host white dwarf. If so, we can now measure the bulk composition of extrasolar minor planets.

"Gaseous Debris Disks around Warm White Dwarfs"

Gaensicke, B.

The moderately hot (∼20000K) white dwarfs SDSS1228+1040 and SDSS1043+0855 exhibit double-peaked emission lines of the CaII 8600 triplet, which we interpret as the signature of the Keplerian motion of a ring of gas around these stars. Both stars also exhibit significant photospheric Mg abundances, classifying them as DAZ white dwarfs and indicating ongoing accretion from the circumstellar material. The absence of H emission from the disk, and He absorption in the white dwarf photospheres demonstrates that the circumstellar material is depleted in volatile elements, and the most likely origin of the gaseous rings is the tidal disruption of rocky asteroids. SDSS1228+1040 and SDSS1043+0855 represent hence the "warm" extension of the cold DAZ white dwarfs G29-38, GD362, GD40, WD1150-153, and WD2115-560 exhibiting IR excess from warm dust.

Observations of another hot DAZ with a relatively low Mg abundance, WD1337+705, fail to detect CaII emission, and suggest a possible correlation between the photospheric metal abuncances and the presence of CaII emission lines. In order to establish the frequency of "SDSS1228+1048" stars, we have investigated the SDSS spectra of 8000 DA white dwarfs, and find a total of only 10 candidate systems displaying CaII emission, with SDSS1228+1040 and SDSS1043+0855 clearly being the most obvious ones.

"An HST Imaging Survey of Cluster and Field White Dwarfs for Self-luminous Giant Planets"

Zinnecker, H., Burleigh, M., Correia, S., & Friedrich, S.

We discuss the rationale and results of our high resolution HST/NICMOS imaging search for self-luminous giant planets around seven white dwarfs in the 625 Myr old Hyades cluster. We also discuss the prospects of a similar HST/NICMOS programme (not approved) on the best possible sample of a dozen nearby and relatively young field white dwarfs.

“Planets around Pulsating White Dwarfs”

Mullally, F., & Winget, D.E.

We present the results of a search for planetary companions to variable white dwarf stars (WDs) by searching for periodic changes in the arrival times of the otherwise very stable pulsations. WDs are the end point of stellar evolution for ∼98% of all stars and are thus representative of main sequence systems. We present evidence of a companion to one star in our sample and discuss the potential for confimation through direct detection with Spitzer.

"Planets and Stellar Evolution: A Theoretical Perspective"

Livio, M.

I will review the fate of planets as the host star evolves off the main sequence. In particular, I will examine whether the engulfment of planets has observational signatures, and I will argue that this is a new effect in stellar evolution. I will also describe a scenario for the formation of disks and planets around massive white dwarfs.

"Planets Surviving Stellar Evolution"

Villaver, E., & Livio, M.

Over the last few years several groups have surveyed white dwarfs in the search for planets. The underlying assumption has been that planets can survive the parent star's evolution. We have explored this hypothesis by determining: (1) the planet survival during the Asymptotic Giant Branch (AGB) phase and the orbital changes due to the AGB mass-loss, and (2) the range of parameters under which an outflow from the planet caused by irradiation by the Planetary Nebulae central star will lead to the total destruction of the planet. We show that planets with masses less than one Jupiter mass do not survive the Planetary Nebula phase if located initially at orbital distances less than 3 to 5 AU. Planets more massive than two Jupiter masses around low-mass (1 Msun on the Main Sequence) stars survive the Planetary Nebula stage down to orbital distances of 3 AU. Planets around white dwarfs with masses of 0.7 Msun are generally expected to be found at orbital radii $r > 15$ AU. If planets are found at smaller orbital radii around massive white dwarfs, they have to be formed as the result of the merger of two white dwarfs.

"Probing the Impact of Stellar Duplicity on Planet Occurrence"

Eggenberger, A., Udry, S., Chauvin, G., Beuzit, J.-L., Lagrange, A.-M., & Mayor, M.

The presence of a close stellar companion is likely to affect planet formation and evolution but the precise effects and their actual impact on planet occurrence are still debated. In an effort to bring observational constraints on the occurrence and characteristics of planets in binaries and multiple stars, we have used VLT/NACO to conduct a systematic adaptive optics search for stellar companions to 130 nearby stars, some with planets and some without, for comparison. In this talk we will present the observational results from this survey and discuss how these new data can be used to probe the global impact of stellar duplicity on planet occurrence in binaries with mean semimajor axes between $\sim$35 and $\sim$230 AU.

“Planets in Binaries from RV Searches”

Desidera, S.

Planets in binary systems are crucial for the determination of global planet frequency, more than half of solar type stars being in multiple systems, and to understand the effects of dynamical environment on the formation and evolution of planetary systems. In spite of selection biases against binaries in most of radial velocity surveys, several planets in multiple systems have been discovered. I summarize their properties and the differences with respect to those orbiting single stars I then describe the on-going radial velocity surveys that specifically target binary systems, focusing my attention on the the radial velocity survey on going at TNG. I also discuss the second goal of this project beside planet detection, the search for abundance anomalies caused by the ingestion of planetary material by the central star. Finally, I present a preliminary discussion of the frequency of planets in binary systems and its dependence on binary separation considering the uniform detectability sample by Fischer & Valenti 2005 and the SARG sample, the implications of these results and future research directions.

"Planetesimal Accumulation in Binary Star Systems"

Marzari, F., Thabault, P., & Scholl, H.

I will present recent numerical modelling of planetesimal accumulation in circumbinary and circumprimary disks. The dynamical evolution of planetesimals under the influence of the gravitational pull of the companion star and gas drag will be described in detail. Hydrodynamical simulations will be presented to confirm the goodness of the standard averaged equation describing the effect of the gas friction on the planetesimal trajectories. The relative velocity between different size planetesimals is estimated and compared to the erosion velocity to derive the radial distance either from the barycenter of the binary or from the primary star where accretion is possible. In the simulations different binary mass ratios, semimajor axes and eccentricities are sampled to perform a complete exploration of the parameter space. I will also show that the present dynamical configuration of planets in binary star systems may not reflect their formation process if the binary orbit changed in the past after the planet formation process was completed.

"Terrestrial Planet Formation in Binary Star Sytems"

Quintana, E.V., Lissauer, J.J., Adams, F.C., & Chambers, J.E.

A binary star system is the most common result of the star formation process, and binary companions can disrupt both the formation of terrestrial planets and their long term prospects for stability. We present results from a large set of numerical simulations of the final stages of terrestrial planet formation - from Moon- to Mars-sized planetary embryos to planets - in main-sequence binary star systems. We examine planetary accretion around both stars ('P-type' circumbinary orbits) or individual stars ('S-type' orbits) in binary systems, including terrestrial planet formation around each star in α Centauri AB, the closest binary star system to the Sun. For comparison, we also simulate planetary growth from the same initial disk placed in the Sun-Jupiter-Saturn system and also around the Sun with neither giant planets nor a stellar companion perturbing the system. Our simulations show that giant and stellar companions not only truncate the disk, but hasten the accretion process by stirring up the planetary embryos to higher eccentricities and inclinations. Terrestrial planets similar to those in our Solar System formed around individual stars in simulations with the binary periastron (closest approach) greater than about 5 AU. Terrestrial planet growth within circumbinary disks was uninhibited around inner binary star systems with binary apastrons (maximum separation) less than $\sim$0.2 AU. Results from our simulations can be scaled for different stellar and disk parameters. Approximately 50 - 60% of binary star systems - from contact binaries to separations of nearly a parsec - satisfy these constraints. Given that the galaxy contains more than 100 billion star systems, a large number of systems remain habitable based on the dynamic considerations of this research.

"Dynamical Evolution of Planetary Systems in Binaries"

Takeda, G., Kita, R., & Rasio, F.A.

Currently, $\sim 20\%$ of extrasolar systems are associated with one or more stellar companions. Most of them are hierarchical systems in which the ratio of the planet's semimajor axis ($a_{\rm pl}$) to the binary semimajor axis ($a_{\rm b}$) is small ($a_{\rm pl}/a_{\rm b} \ll\sim 0.01$). The Kozai mechanism predicts that in such hierarchical systems the pericenter argument of the planet can precess on secular timescale, provided that the planetary orbit is sufficiently inclined ($> 40^\circ$) with respect to the binary plane. Consequently, the planetary eccentricity and inclination oscillate on secular timescales while the semimajor axis remains nearly constant. We investigate the evolution of hierarchical four-body systems in which *two planets* orbit a component of a wide stellar binary. With the presence of the other planet and a stellar companion, the orbital evolution of a planet is estimated by the precession frequency of the argument of periastron. The most important precessions are caused by the Kozai oscillation ($\dot{\omega}_{\rm Koz}$) and the secular planet-planet interaction ($\dot{\omega}_{\rm PP}$). Kozai oscillation is suppressed when the timescale of the secular interaction between planets is shorter than the Kozai precession rate ($\dot{\omega}_{\rm PP}/\dot{\omega}_{\rm Koz} < 1$). However, when the two precession frequencies are comparable, the orbital elements of the planets evolve in a highly chaotic manner. When the planets can maintain the Hill stability throughout their evolutions, the outer planet with secularly increasing eccentricity typically locks the inner planet into synchronized eccentricity oscillations. In such synchronized oscillations the outer planet propagates the torque from the stellar companion to the inner planet and excites its eccentricity even in the situation where the inner planet is too close to the primary for the Kozai oscillation to act within the age of the system.

"The Formation of Planetesimals with Particle Feedback"

Youdin, A.

I will review the proposed formation mechanisms for km-sized planetesimals from dust grains: collisional coagulation and gravitational instability of solid particles. The diffusion of particles in a turbulent gas disk has been identified as the main obstacle to gravitational collapse. I will present recent calculations of turbulent particle stirring that include orbital dynamics (Youdin & Lithwick, submitted). I will emphasize the importance of aerodynamic feedback effects, i.e. when particle inertia influences gas dynamics through drag forces. Drag feedback generally produces particle clumping. The basic mechanism is the linear streaming instability, which arises from aerodynamic feedback in idealized unstratified disks (Youdin & Goodman 2005, Youdin & Johansen 2007). Numerical simulations show that the non-linear saturation of the streaming instability naturally produces particle overdensities of several hundred (Johansen & Youdin 2007). By including additional physics – vertical settling, self-gravity, MRI turbulence, and multiple particle sizes – Johansen et al. (submitted to Nature) show that overdense particle clumps collapse into gravitationally bound planetesimals.

"Terrestrial Planet Formation: A Review and Current Directions"

Leinhardt, Z.

The standard model of terrestrial planet formation is well established and supported by numerical simulations. Once planetesimals have grown large enough to decouple from the gaseous disk gravity becomes the dominant force governing their interactions. The planetesimals continue to grow via accretion dominated collisions. The population becomes bimodal due to runaway growth with a few large planetesimals and a background of small planetesimals. Once the large planetesimals can significantly alter the velocity dispersion of the background the large planetesimals, protoplanets, approach a similar mass. Although it is clear that terrestrial planets form easily under the standard assumptions the initial conditions of the stellar accretion disk are vitally important. In addition, observations strongly suggest that our own solar system is only one of a diverse population of solar system configurations. In this review I will discuss the standard model for terrestrial planet formation in the context of the diversity of known planetary systems and present results on how the initial conditions of the disk can effect the formation process.

"Giant Planet Formation by Core Accretion"

Mordasini, C., Alibert, Y., Benz, W., & Naef, D.

A review of the standard paradigm for giant planet formation, the core accretion theory is presented.

First, an overview of the basic concepts and results of the original core accretion model is given.

Then, later improvements of the model are discussed, like the inclusion of concurrent disk evolution, planetary migration, opacity changes or more accurate solid accretion rates. It is especially shown that these improvements solve the major problem from which early core accretion models suffered, namely planetary formation timescales comparable to or even longer than observed protoplanetary disk lifetimes.

The number of known extrasolar planets is now large enough that this population provides a testbed for statistical comparisons with formation models. In the last part of the talk it is shown that enhanced core accretion models have evolved into a state where they can be successfully put into such statistical tests, by means of generating synthetic populations of extrasolar planets, and comparing quantitatively their properties with the observed extrasolar planet population.

"Giant Planet Formation via Gravitational Instability"

Mayer, L.

I will review the current status of simulations of gravitationally unstable disks, with emphasis on the possibility of direct giant planet formation via disk fragmentation. I will briefly present the results of a large code comparison on disk instability that involves for the first time both SPH and adaptive mesh refinement (AMR) codes as well as more conventional codes with static grids. I will then show the results of new 3D SPH simulations with radiative transfer having a resolution exceeding a million particles and discuss how fragmentation is sensitive to the details of cooling and heating in the disks. The specific case of binary star+disk systems will also be covered. Binary systems can yield interesting constraints on giant planet formation models owing to how self-gravitating disks respond to the tidal perturbation of the companion.

"Forming Hot Super-Earths"

Terquem, C., & Papaloizou, J.C.B.

Cores and terrestrial planets may undergo migration as they form. In this talk, we describe the evolution of a population of cores with initial masses in the range 0.1-1 earth mass embedded in a disk. Mutual interactions lead to orbit crossing and mergers, so that the cores grow during their evolution. Interaction with the disk leads to orbital migration, which results in the cores capturing each other in mean motion resonances. As the cores migrate inside the disk inner edge, scatterings and mergers of planets on unstable orbits together with orbital circularization causes strict commensurability to be lost. Near commensurability however is usually maintained. All the simulations end with a population of typically between two and five planets, with masses depending on the initial mass. These results indicate that if hot super-Earths or Neptunes form by mergers of inwardly migrating cores, then such planets are most likely not isolated. We would expect to always find at least one, more likely a few, companions on close and often near-commensurable orbits. To test this hypothesis, it would be of interest to look for planets of a few to about 10 earth masses in systems where hot super-Earths or Neptunes have already been found.

"Super-Earth Planets: Extreme Interiors"

Sasselov, D.

Detailed models for planets of 1-10 Earth masses of different compositions, and preparations and prospects to derive observationally the bulk mineral compositions of such transiting planets identified by Kepler and Corot.

“Carbon Planets”

Kuchner, M.

If planet formation occurs in an environment where the carbon to oxygen ratio is high, planetestimals should form primarily from reduced silicaes and even carbon-rich compounds, like silicon carbide. In our solar system, formation of the enstatite chondrite meteorites may follow this pathway. In other planetary systems, like those around pulsars and white dwarfs and possibly even in systems like the solar system, the carbon-rich planet formation may dominate. I’ll review some recent ideas on this subject in light of the discovery of carbon-rich gas around Beta Pictoris, and the latest spectroscopic observations of hot jupiters.

"Structure and Evolution of Close-In Exoplanets"

Baraffe, I.

The number of exoplanets newly discovered increases rapidly with time, providing new and sometime puzzling informations about their formation and their structure. In this talk, I will describe the properties of planets orbiting their parent star at close orbital distances. The former undergo irradiation effects from their parent star and eventually evaporation effects. Both processes can severely affect the properties of close-in planets, in terms of atmosphere structure, emitted flux and evolution. I will also discuss the discrepancy found between the observed radii and the model predictions for half of the transit planets detected up to now and present some possible explanations.

"Evaporation of Hot Jupiters: Constraints from Observations"

Lecavelier des Etangs, A.

The talk will focus on the HST observations and the resulting constraints on the evaporation of the "Hot-Jupiters".

The observations allowed the discovery that the planet orbiting HD209458 has an extended atmosphere of escaping hydrogen and showed the presence of oxygen and carbon at very high altitude. This observations give unique constraints on the escape rate and mechanism in the atmosphere of these planets.

The most recent Lyman-alpha HST observations of HD209458b, and hopefully the ones of HD189733b scheduled to be executed by mid-June 2007 will be presented, allowing for the first time to compare the evaporation from two different planets in different environments.

Models to quantify the escape rate from the measured occultation depths, and an energy diagram to describe the evaporation state of Hot-Jupiters will be presented. Using this diagram, it is shown that few already known planets could be remnants of formerly giant planets.

"Obliquity Tides in Hot Jupiters"

Peale, S.

Tidal dissipation in HD209458b while it has a very high obliquity has been proposed as a means for inflating the planet to its observed oversize. (Winn and Holman, 2005). The high obliquity is maintained by the planet's being trapped into Cassini state 2 at a high obliquity while maintaining a rotation rate synchronous with its orbital mean motion. In a Cassini state the spin axis and orbit normal remain coplanar with the normal to the Laplace plane as they precess around the latter, where the orbit has a significant inclination to the Laplace plane. The orbit of HD209458b is inclined to equatorial plane of the star by about 4°. If the stellar equator plane is coincident with the plane of the initially massive nebula, that plane is the Laplace plane on which the orbit is precessing. A planet can evolve to Cassini state 2 by tidal dissipation on a time scale comparable with that of the retardation of the spin rate. The latter time scale can become relatively short as the planet migrates toward the star. While the nebula is there, the orbital precession rate is rapid and Cassini state 2 has a small obliquity, and the planet will evolve to that state with overwhelming probability. That evolution may not occur for cases where the obliquity of state 2 is relatively large. As the nebula is dispersed, the orbital precession slows with the result the the Cassini state obliquity increases. The spin follows the Cassini state to high obliquity because the solid angle traced by the spin as it precesses about the Cassini state position is an adiabatic invariant. With no nebula, only the quadrupole moment of the star is left to cause the orbit to precess. At the slow precession rate thus induced the obliquity of the Cassini state is nearly 90°, which if maintained causes the dissipation inferred by Winn and Holman.

Implicit in this scenario is the assumption that the synchronous rotation is somehow maintained. Authors of two papers have pointed out that this is not so (Levrard *et al.* 2007; Fabrycky *et al.* 2007). The rotation continues to decrease below the synchronous value with increasing obliquity, As is perhaps expected, state 2 becomes unstable as the planet slows. The planet then rapidly evolves to Cassini state 1 with a negligibly small obliquity, and all hot Jupiters will evolve to nearly circular orbits with their spin axes nearly normal to their orbit planes. Obliquity tides cannot be invoked as means of additional heating of hot gaseous planets.

"Eccentricities from Planet-Planet Interactions"

Juric, M.

The eccentricities of currently known extrasolar planets exhibit a distribution unlike that of the Solar System, with moderately and highly eccentric planets being the rule rather than the exception. Various origins of high eccentricities have been proposed, ranging from early on excitation by protoplanetary disk, excitation by binary companions, to direct planet-planet scattering. In this talk, I will review the successes and problems of planet-planet interactions as an eccentricity excitation mechanism. I will discuss the ability of planet-planet scattering to reproduce the observations, and the possible implications for planet formation.

"Dynamically Unstable Planetary Systems Emerging Out of Gas Disks"

Matsumura, S., Pudritz, R.E., & Thommes, E.W.

One of the most surprising properties of extrasolar planets is the range of their orbital eccentricities — from nearly circular (e$\sim$0) to highly eccentric (up to e$\sim$0.9). Planet-planet scattering (with no dissipation) in unstable systems can successfully reproduce the observed eccentricities of most planets. However, this scenario alone cannot explain the distribution of planetary semi-major axes if giant planets form outside of $\sim$ 1 AU. Taking into account the effects of a residual gas disk after planet formation, we investigate the onset of dynamical instability in young planetary systems. Using a hybrid symplectic integrator + gas dynamics code, we demonstrate how planet-disk interactions along with planet-planet dynamical interactions could explain both the observed semi-major axis and eccentricity distributions of extrasolar planets.

“Testing Planet Formation Models with Extrasolar Planets”

Ford, E.B.

The first discoveries of extrasolar planets demonstrated that nature produces a much greater diversity of planetary systems than astronomers had anticipated. In an attempt to explain these surprises, theorists have proposed numerous generalizations to the classical model of planet formation. Recently, researchers have begun to tests some of these theories by comparing the predicted distributions of planet periods, eccentricities, and masses to those of the observed population of extrasolar planets. Such comparisons are becoming increasingly powerful thanks to the increasing number of known planets, improving measurement precision, increasing temporal baselines, and improving capability to control for detection biases. I will discuss some of the orbital properties of the extrasolar planet population based on a systematic analysis of radial velocity planets and discuss implications for the formation and evolution of planetary systems.

“Resonant Planets: From Stability to Violent Upheaval”

Thommes, E., Bryden, G., Wu, Y., & Rasio, F.

Young planetary systems are thought to undergo extensive migration, which naturally results in the establishment of mean-motion resonances among the planets. This can produce systems which initially have “exotic” dynamical configurations, but become violently unstable on longer timescales. I will show how this seemingly extreme sequence of events may be a commonplace phase in the evolution of planetary systems. Even the Solar System may have experienced a relatively mild version of such an instability.

"Gas and Dust in Debris Disks: What is Normal?"

Roberge, A.

The basic character of debris disks was established soon after their discovery: they are composed mostly of dust produced by collisions and/or evaporation of solid planetary bodies. However, several fundamental observational questions about debris disks remain unanswered. How much material do they typically contain and how does it evolve with time? How much gas do they contain? What is the composition of their dust and gas? Answers to these questions will provide insights into the late-stages of planetary system formation.

This talk will cover some recent progress toward addressing these questions. Observations with the Spitzer Space Telescope have shown that the amount of dust in debris disks decreases with time on average, but also indicate that dust production is stochastic. At least some debris disks contain small amounts of gas which has very different characteristics from gas in younger protoplanetary disks. The most complete inventory of gas in a debris disk to date unexpectedly showed that the gas is extremely carbon-rich. Finally, recent studies of the albedo of dust in debris disks have shown an extraordinary range of colors, including very red colors indicative of organic material.

"The Dust, Planetesimals and Planets of HD 38529"

Moro-Martin, A.

HD 38529 is a post-main sequence G8III/IV star (3.5 Gyr old) with a planetary system consisting of at least two planets having Mxsin(i) of 0.8 MJup and 12.2 MJup, semimajor axes of 0.13 AU and 3.74 AU, and eccentricities of 0.25 and 0.35, respectively. Spitzer observations show that HD 38529 has an excess emission above the stellar photosphere, with a signal-to-noise ratio (S/N) at 70 micron of 4.7, a small excess at 33 micron (S/N=2.6) and no excess ¡30 micron. We discuss the distribution of the potential dust-producing planetesimals from the study of the dynamical perturbations of the two known planets, considering in particular the effect of secular resonances. We identify three dynamically stable niches at 0.4–0.8 AU, 20–50 AU and beyond 60 AU. We model the spectral energy distribution of HD 38529 to find out which of these niches show signs of harboring dust-producing plantesimals. The secular analysis, together with the SED modeling resuls, suggest that the planetesimals responsible for most of the dust emission are likely located within 20–50 AU, a configuration that resembles that of the Jovian planets + Kuiper Belt in our Solar System. Finally, we place upper limits (8E-6 lunar masses of 10 micron-sized particles) to the amount of dust that could be located in the dynamically stable region that exists between the two planets (0.25–0.75 AU).

"The Triggering of Planet Formation by Gravitational Instability in Dense Stellar Clusters"

Clarke, C., Lodato, G., Meru, F., & Harper-Clark, L.

It is often hypothesised that the formation of planets by gravitational instability (GI) is likely to be favoured in dense cluster environments, on the grounds that close stellar encounters may be able to trigger the fragmentation of self-gravitating protostellar discs. This view is based on the twin notions that encounters may be both necessary and sufficient for inducing fragmentation: *necessary* because it is argued that fragmentation requires that discs enter a regime of efficient cooling on a short ($\sim$ dynamical) timescale (which is not readily achievable except through a dynamical disturbance of the disc), and *sufficient* because in any case the strong compressions induced during encounters may be able to trigger fragmentation even in discs where the cooling timescale is relatively long. The results of our recent simulations do *not* however support either of these arguments. We have shown that the effect of a close stellar encounter on a self-gravitating disc where the cooling timescale is long is in fact to *stabilise* the disc further (Lodato et al 2007). We have also shown that fragmentation does *not* require that the regime of rapid cooling is entered on a rapid (dynamical) timescale and thus that secular evolution of the disc can bring it to the point of fragmentation (Clarke et al 2007). Taken together, these results imply that the cluster environment influences the production of planets by GI only inasfar as it influences the thermodynamics of the disc.

"Effects of Clusters on Forming Solar Systems"

Adams, F.C.

Star clusters provide one type of extreme environment and this talk discusses how clusters affect the planetary systems forming within them. N-body simulations are used to study the dynamical evolution of young clusters. Multiple realizations of equivalent cases are run to build up a robust statistical description of these systems, e.g., distributions of closest approaches and radial locations. These results then provide a framework from which to assess the effects of clusters on planet formation. The distributions of radial positions are used in conjunction with FUV luminosity distributions to determine the radiation exposure of circumstellar disks. Photoevaporation calculations then determine mass loss rates and loss of planet forming potential. The distributions of closest approaches are used in conjunction with scattering cross sections to determine probabilities for solar system disruption. This study thus provides a quantitative assessment of how clusters affect forming planetary systems.

"Surveying the Youngest Stars for the Youngest Substellar Companions"

Prato, L., Johns-Krull, C.M., Huerta, M., Hartigan, P., & Jaffe, D.T.

This radial velocity survey was initiated to study the earliest stages of planet formation with a primary goal to study the origins of the brown dwarf desert. After three seasons of observations, our search for spectroscopic signatures of substellar companions to young stars in the Taurus star forming region is yielding intriguing results. We have observed several dozen targets at high cadence to date using the Coude echelle spectrograph at the McDonald Observatory 2.7 meter telescope. We obtain a measurement precision of ∼120 m/s. Our expectation is that faux radial velocity variations induced by star spots will be substantial in these systems. While we see clear evidence of this, we also see indications for the presence of a true substellar companion in at least one case so far. Longterm, well-sampled programs are crucial for the unambiguous identification of the first generation of brown dwarfs and planets.

"Imaging a Companion in Formation"

Greaves, J., Richards, A., Rice, K., & Muxlow, T.

We have observed one of the brightest T Tauri disks with the VLA. A compact secondary source is seen at $\sim$50 AU from the star, which is best explained as the dusty envelope to a proto-brown dwarf or proto-planet. To our knowledge, this is the first image of a companion forming within the host disk.

"Distinguishing Giant Planets and Brown Dwarfs"

Luhman, K.L.

I will describe possible observational criteria for distinguishing giant planets and brown dwarfs. I will then apply these criteria to examples of well-known substellar objects that have been found in isolation and as companions.

"Mapping the Atmospheres of Hot Jupiters"

Knutson, H.

We present the results of two sets of Spitzer observations designed to characterize the atmospheres of hot Jupiters, and discuss the prospects for more such observations in the upcoming Spitzer observing cycle. First, we monitored HD 189733b continuously at 8 micron for slightly more than half of the planet's orbit, beginning before the transit and ending after the secondary eclipse. We detect the increase in flux as the day side of the planet rotates into view, and fit the shape of the observed phase variation to derive a map of the brightness distribution on the surface of the planet as a function of longitude. Second, we present new secondary eclipse depths for HD 189733b at 3.6, 4.5, 5.8, 8.0, and 24 microns, and compare to the predictions of atmosphere models for this planet.

"Spitzer Spectroscopy of Hot Jupiters"

Deming, D.

Two independent scientific groups have recently reported the first spectroscopy of extrasolar planets, using the Spitzer Space Telescope. The planets (HD 209458b and HD 189733b) are transiting hot Jupiters with orbital periods of 3.5 and 2.2 days. The Spitzer spectra were constructed by measuring the wavelength dependence of the planet's secondary eclipse. Theorists expected that absorption by hot water vapor would dominate the spectra of these planets in the 7- 14-micron wavelength region. However, neither planet exhibited this expected signature, indicating that some process is masking the water absorption. One possibility is the dynamics-induced flattening of the atmospheric temperature gradient. Another possibility is the presence of high clouds. One planet (HD 209458b) shows spectral features appearing in emission above a hot thermal continuum, indicating the likely presence of silicate clouds, and possibly more exotic compounds, at high altitudes in the planet's! atmosphere.

The future launch of the James Webb Space Telescope will allow us to extend these measurements to spectra of transiting terrestrial planets in the habitable zones around lower main sequence stars.

"Detecting and Characterizing the Atmospheres of Transiting Hot Jupiters"

Sing, D.

We discuss the detection of atmospheric features in Hot Jupiters utilizing the transit technique. Thus far, all identified transit atmospheric signatures have been detected utilizing HST/STIS observations of HD209458, with the bulk of the features arising from the planets escaping atmosphere. These features allow, among other things, insight into the temperature profile of the planet as well as the complex atmospheric escape process. We present the recent detection of H II, and discuss how this and other features constrain the atmospheres of hot Jupiters.

"Atmospheric Properties of Extrasolar Planets"

Barman, T.

In this talk, observations of the handful of nearby transiting planets (from Spitzer and Hubble) will be discussed. The emphasis will be on the agreement and disagreement between these observations and theoretical models, in particular regarding the basic atmospheric chemical composition and temperature structure. I will discuss some recent results related to the atmospheric properties of HD 209458b and HD 189733b and describe a few predictions for some of the most recently discovered transiting planets.

"A Ground-Based Search for Absorption Features in Transmission Spectra of Transiting Extrasolar Planets"

Redfield, S., Endl, M., Cochran, W.D., & Koesterke, L.

We present details of a ground-based program designed to make extremely precise measurements of optical transmission absorption spectrum through a transiting extrasolar planetary atmosphere or extended exosphere. We combine multiple in-transit observations taken by the 9.2m Hobby-Eberly Telescope (HET) and compare directly with out-of-transit observations. Without high resolution space-based optical or UV spectrographs, ground-based facilities provide the only opportunity to probe the extrasolar atmospheric signatures in the visible waveband. We discuss the challenges of such ground-based observations, the sensitivity of our observations to date, and evidence for a transmission absorption detection. Measurements, and even upper limits, of atmospheric lines should provide important constraints on models of giant exoplanet atmospheres, including for example, cloud cover altitudes, atomic and molecular composition, and temperature profiles.

"Transmission Spectra of Giant and Terrestrial Exoplanets"

Tinetti, G.

We present here simulations of transmission spectra in the IR of extrasolar giant planets, HD209458b and HD189733b, during their transit in front of their parent star (Tinetti et al., 2007). If H2O and CO are abundant as estimated by our photochemical model (Liang et al., 2004), we expect they can be detected with the IRAC and MIPS cameras on board the Spitzer Space Telescope. According to our simulations, transmission spectra of EGPs in the IR are very sensitive to molecular abundances and less to temperature. Temperature influences the spectra above all by way of its effects on the atmospheric scale height and absorption coefficients. These considerations make transmission spectroscopy, linked with primary transit, an approach worth considering. The next generation of space telescopes (James Webb Space Telescope, JWST, 2013) will have the capability of acquiring spectra of smaller extrasolar worlds. To understand our ability to characterize neptune- and earth-size transiting exoplanets, we have generated synthetic transmission spectra of these exotic environments, using a set of chemistry, climate and radiative transfer models. In this presentation we will focus on the detectability of spectral signatures of crucial atmospheric molecules with future observations.

"The Impact of Transit Observations on Planetary Physics"

Fortney, J.J.

The nearly 20 known transiting planets have allowed access to exoplanetary interior, atmospheric, and exospheric physics. This talk will predominantly be focused on two areas: 1) What we are learning about hot Jupiter atmospheres from transit and secondary eclipse observations, and 2) Insights gained into the structure of hot Jupiters, and mass-radius relations for these objects, from transit observations. The first transiting hot Neptune, GJ 436b, will receive special attention.

"Atmospheric Circulation of Hot Jupiters"

Menou, K.

Hot Jupiters are exciting new planetary science laboratories. Thanks to a series of observational breakthroughs with the Spitzer Space Telescope, we now have data to constrain the unusual atmospheric conditions and the unique circulation regime present on a few extrasolar hot Jupiters. I will discuss efforts to understand the circulation regime of these planets and associated challenges.

"Atmospheric Dynamics of Hot Jupiters"

Showman, A.

This talk will provide an overview of plausible atmospheric circulation patterns on hot Jupiters and discuss implications for existing and future observations. I will begin with basic theoretical arguments that constrain the circulation regime and progress to a discussion of the various 2D and 3D modeling approaches that have been published, culminating in a presentation of our latest 3D numerical simulations that include radiative transfer. I will emphasize the implications of existing observations (lightcurves, secondary-eclipse depths, transit spectra) for the circulation and the extent to which current models can explain these observations.

"Cloud Formation in Giant Planets"

Helling, C.

Clouds are a common feature in gas giant and brown dwarf atmospheres, and observation start to directly infer their existence spectroscopically. Cloud formation due to the condensation of solids/liquids reduces the remaining gas phase element abundances and their gravitational settling introduces an additional dynamic process, both changing the atmospheres appearance considerably. I will discuss the physics and chemistry of the dust cloud layer based on a consistent treatment of seed formatiom, growth/evaporation and gravitational settling. I furthermore will present results of a comparative study of dust cloud modeling as result of a concerted effort of various groups to understand cloud formation in substellar objects.

"The Multi-object APO Radial-Velocity Exoplanet Large-area Survey (MARVELS)"

Ge, J.

The Multi-object APO Radial-Velocity Exoplanet Large-area Survey (MARVELS) will conduct the largest ground-based Doppler planet survey to date using the wide field Sloan Digital Sky Survey telescope and new generation multi-object Doppler instruments in 2008-2014. The baseline survey goal is to detect ∼200 giant planets orbiting 13,000 relatively bright stars (V¡12) (∼10,000 main sequence stars and ∼3000 giant stars) over ∼1000 square degrees of the sky with two optical survey instruments capable of 120 objects and ∼10 m/s Doppler precision (for V∼11 solar type stars). The survey will systematically assemble a well-defined sample of planets with a wide range of masses (0.2-15 Jupiter masses) and orbits (1 day-3 years); the planets will be drawn from a set of stars with a diverse set of compositions, ages, and rotational velocities. The survey.s main scientific objectives are to study the diversity of extrasolar planets; to investigate the correlations between planets and host star properties; to measure the distribution of planet masses and orbital parameters; to constrain theoretical models of planet formation, migration and evolution; to discover a dozen transiting planets around relatively bright stars for detailed studies of planet properties; to identify candidates for multiple planet systems or additional lower mass planet companions; and to detect rare planets or rare objects. Early scientific results from the on-going pilot survey will be presented.

The MARVELS survey also plans to accommodate more optical survey instruments with a total of ∼400 object capability, one red-sensitive multi-object Doppler survey instrument, called Red ET, with ∼15-object capability and 3-10m/s Doppler precision and one optical extremely high precision Doppler instrument, called EXPERT, with ∼20-object capability and 0.5-1 m/s Doppler precision. Red ET will enable a survey of ∼1500 M dwarfs (I¡13) with the goal of identifying short-period super-Earth mass planets, possibly including some in the habitable zones around these low mass stars. EXPERT will search ∼2000 bright solar type stars (V¡ 10) to detect and characterize short-period super-Earth mass planets.

“Limits to RV Surveys”

Fischer, D., & Laughlin, G.

Radial velocity precision has asymptotically improved over the past several decades. Pressing down from precisions quoted in units of kilometers per second, the state of the art in Doppler surveys is now meters per second precision. With an eye on centimeter per second precision, how low can we go? What are the obstacles to achieving extreme precision? What type of planets can we hope to detect with radial velocity surveys in the next decade? This presentation highlights new strategies for the detection of extrasolar planets with the lowest amplitude velocity signals.

"Pushing Down the Limits of RV Precision with HARPS"

Lovis, C., Mayor, M., Pepe, F., Queloz, D., & Udry, S.

The HARPS instrument has led to the discovery of several hot Neptunes and/or super-Earths thanks to its RV precision below 1 m/s. In this talk we briefly review the various instrumental and stellar limitations that have to be overcome to detect these low RV amplitudes. We also discuss the prospects for measuring the mass of transiting super-Earths detected by space missions.

"Kepler and Follow-Up Science"

Latham, D.

Kepler will be capable of detecting transits of Earth-sized planets in front of Sun-sized stars, extending out to planets in Earth-like orbits. The challenge will be to determine spectroscopic orbits accurately enough so that the masses and radii can be used to study planetary structure and composition, for example to distinguish rocky planets from water worlds. I will outline the plans for this follow-up work and the prospects for progress beyond Kepler.

"Optimizing Coronagraphic Surveys for Planets"

Agol, E.

Recent laboratory experiments have demonstrated extremely high contrast imaging near a bright point source (Trauger & Traub 2007), a pre-requisite for coronagraphic surveys for extrasolar planets with TPF and precursor telescopes. As the technology is now maturing, the question of which stars to target and how to optimize a direct imaging planet search needs to be addressed, so I will discuss scaling relations and analytic estimates for how to optimize the number of planets detected (not necessarily in the habitable zone), taking into account noise from zodiacal light, exo-zodiacal light, and speckle noise, as well as the diversity among stellar and planetary systems.

"Terrestrial-Planet Transits of M Stars"

Traub, W., & Cutri, R.

We discuss the benefit of extending the Kepler survey to include about 1000 M-dwarf stars. Assuming that eta-sub-Earth (in the habitable zone) is unity, we expect to detect about 11 transiting Earth-size planets. The transit depths are large, ranging from about 200 to 200,000 ppm. Transit times are about 0.5-3 hours, well matched to the Kepler temporal resolution. Stellar signals are on the faint end of the Kepler range, but the red bias of M stars will produce stronger signals than are indicated by the V magnitudes of these stars. Given that M-dwarf stars may have Earth-like analogs, and that Kepler is well-suited to observe these stars, we believe that such an investigation could yield very important results.

In addition, and as a secondary goal, Kepler could search for inner giant planets (hot Jupiters) using the photometric variation of signal, although this aspect requires that the noise spectrum be close to the photon-counting value.

"Astrometry from the Ground and from Space"

Segransan, D.

TBD

"Microlensing Searches for Extrasolar Planets: Results and Future Prospects"

Gaudi, S.

Microlensing is unique among planet detection methods in that it is potentially sensitive to analogs of all the solar system planets except Mercury, as well as to free floating planets. I review the landscape of microlensing searches for extrasolar planets, beginning with an outline of the method itself, and continuing with a review of the results that have been obtained to date. Four planets have been detected with microlensing so far; I discuss what these detections have taught us about the frequency of terrestrial and giant planets. I then speculate on the expected returns of next-generation microlensing experiments both from the ground and from space. When combined with the results from other complementary surveys, next generation microlensing surveys can yield an accurate and complete census of the frequency and properties of planets, and in particular cool, low-mass terrestrial planets.

"How Extreme Can Planetary Systems Be?"

Lissauer, J.

The first system of extrasolar planets was found in orbit about a pulsar. The next was a giant planet in a 4 day orbit, and following that a more massive giant in an eccentric orbit. These types of planetary systems were not expected prior to being found. What else is out there, in our galaxy? Dynamical stability (for a large number of orbits) is a requirement, but beyond that what restrictions are there? For instance, a nearly coplanar system analogous to our solar system but with planets alternating between prograde and retrograde orbits with increasing distance from star would be stable but not plausible. A pure lead planet could survive, but how could such a planet form? These and other speculations will be discussed, including some 'predictions' that are likely to be observationally testable within the next decade or two.

"Warm Planets around Cool Stars: Searches for Habitable Zone Planets around Late M Dwarfs"

Ramsey, L.

The low mass of M stars, less than 0.5 solar masses, combined with close in orbits yield radial velocity amplitudes for planets in the habitable zone around these stars that are well within current limits of 1-2 m/sec acheived with visible light instruments. These same instruments become significantly challenged when looking at M5 dwarfs and cooler. However, if one takes advantage of the fact that M-stars emit most of their energy in the near infrared (NIR) hundreds of targets become accessible to 8-meter class telescope. We will discuss the potential NIR radial velocity surveys of M-star using the proposed Precision Radial Velocity Spectrometer (PRVS) for Gemini and the Habitable Zone Pathfinder (HZP) instruments for the Hobby Eberly telescope. We also present some preliminary laboratory results that demonstrate the viability and challenges of precision radial velocity work in the NIR.

"Searching for Cool-Star Exo-Planets in the Near Infrared"

Edelstein, J.

Most known exo-planets have been discovered using visible-band Radial Velocity (RV) measurements that have concentrated on solar-type stars. The overwhelming majority of the Suns neighbors, however, are cool, lower-mass M dwarf stars. M-stars present the best opportunity for the RV detection of near Earth-mass planets in the habitable zone because of the stars low mass and energy output. The peak flux for M-stars occurs in the near infrared (NIR = $\sim$1-2 um) band-pass where precision RV instruments do not yet exist and where telluric absorption, OH emission, and velocity calibrants are problematic.

We describe a program designed specifically for the near infrared RV survey of planets about cool-stars, the Triplespec Exo-planet Discovery Instrument (TEDI), to be fielded later this year. Detailed studies show that the NIR observing challenges can be overcome and that the planet population statistics, rotational velocity, and photospheric activity of M-stars are amenable to the discovery of companions. TEDI is a Berkeley externally dispersed interferometer that augments the new Cornell near infrared (0.82.4 ?m) spectrograph TripleSpec to be mounted on the Palomar 5-m Hale telescope. The science program, instrumental approach, and anticipated performance are described.

"Habitability of Super-Earths"

Schneider, J.

TBD

"Super Earths Evolution: Towards Habitability"

Valencia, D.

In the last two years, five super-Earths (planets with masses between 1-10 $M_{\oplus}$) have been discovered and many more will follow with CoRoT and Kepler. Some super-Earths may conveniently orbit in the ?habitable? zone but only their thermo-chemical evolution will determine if, in fact, they are habitable. The tectonic and thermal evolution will determine the planets? surface conditions. In turn, their thermal evolution is highly influenced by the mode of convection. Earth is the only planet in the Solar System with plate tectonics and this mode of convection, due to its connection to geochemical cycles, has been associated with the existence of life on our planet. We show that super-Earths will also exhibit plate tectonics, even if dry. Using our detailed internal structure models and parametric convection analysis, we show that, with increasing planetary mass, lithospheric subduction is more likely to occur. Massive terrestrial planets will have larger convective driving forces that can overcome lithospheric resistance to deformation, and thinner lithospheres that are therefore weaker. These effects contribute favorably to the subduction of the lithosphere, an essential component of plate tectonics. Super-Earths are good candidates in the search for habitable worlds.

"Habitability of Planets in Binaries"

Haghighipour, N.

A survey of all currently known extrasolar planets indicates that close to 25% of their hosting stars are members of binary systems. While the majority of these binaries are wide (i.e., with separations between 250 and 6500 AU), the detection of Jovian-type planets in the two binaries ? Cephei (separation of 18.5 AU) and GJ 86 (separation of 21 AU) have brought to the forefront questions on the formation of giant planets and the possibility of the existence of smaller bodies in moderately close binary star systems. Given that more than half of main sequence stars are members of binaries/multiples and the frequency of planets in binary/multiple systems is comparable to those around single stars, such questions have now found realistic grounds. In this paper, I will discuss habitability in binary systems and the effects of the companion on the formation of Earth-like planets in the system's habitable zone. I will present the results of a large survey of the parameter-space of binary-planetary systems in search of regions where habitable planets can form and have long-term stable orbits. I will also discuss the effect of the companion on mechanisms of the delivery of water to such planets.

"Terrestrial Planet Formation in Hot-Jupiter Systems"

Fogg, M.

About a fifth of the exoplanetary systems that have been discovered contain a so-called hot-Jupiter - a giant planet orbiting within 0.1 AU of the central star. Since these stars are typically of the F/G spectral type, the orbits of any terrestrial planets in their habitable zones at ~ 1 AU should be dynamically stable. However, because hot-Jupiters are thought to have formed in the outer regions of a protoplanetary disk, and to have then migrated through the terrestrial planet zone to their final location, it is uncertain whether terrestrial planets can actually grow and be retained in these systems. Initial speculations, based on the assumption that migrating giant planets will clear planet-forming material from their swept zone, all concluded that hot-Jupiter systems should lack terrestrial planets. I show that this assumption may be incorrect, for when terrestrial planet formation and giant planet migration are simulated simultaneously, abundant solid material is predicted to remain from which terrestrial planet growth can resume. The outcome of such renewed growth is a set of volatile-rich terrestrial planets, positioned from $\sim$ 0.4 AU outwards, with typically at least one member sited in the system's habitable zone.

"Inflated Planets and their Low-Mass Companions"

Mardling, R.A.

Of the fourteen transiting extrasolar planetary systems for which radii have been measured, at least three appear to be considerably larger than theoretical estimates suggest. It has been proposed by Bodenheimer, Lin & Mardling that undetected companions acting to excite the orbital eccentricity are responsible for these oversized planets, as they find new equilibrium radii in response to being tidally heated. In the case of HD 209458, this hypothesis has been rejected by some authors because there is no sign of such a companion at the 5 m/s level, and because it is difficult to say conclusively that the eccentricity is non-zero. Transit timing analysis as well as a direct transit search have further constrained the existence of very short-period companions, especially in resonant orbits.

The eccentricity of a short-period planet will only be excited as long as its (non-resonant) companion's eccentricity is non-zero. Here we show that the latter decays on a timescale which depends on the structure of the interior planet, a timescale which is often shorter than the lifetime of the system. *This includes Earth-mass planets in the habitable zones of some stars.* We determine which configurations are capable of sustaining significant eccentricity in the observed planet for at least the age of the system, and show that these include systems with companion masses as low as a fraction of an Earth mass. The orbital parameters of such companions are consistent with recent calculations which show that the migration process can induce the formation of low mass planets external to the orbits of hot Jupiters. Systems with inflated planets are therefore good targets in the search for terrestrial planets.

“Planetary Systems around the Coolest Stars: Formation, Properties, and Habitability”

Apai, D.

M-dwarfs are the most common stars in the Solar neighborhood and are the most typical planet host stars. These extremely long-living yet dim stars provide a circumstellar environment radically different from those around Sun-like stars. I will briefly highlight our current picture of planet formation around cool stars and report on our recent Spitzer studies of protoplanetary disks around cool stars and brown dwarfs. I will also present results from an ongoing direct imaging survey exploring giant planets on the yet uncharted 3-30 AU orbital radii around cool stars using a novel high-contrast imaging technique. I will discuss these results in the frame of planetary habitability and future extrasolar planet missions.

"Earth-like Planets: Frequency of Occurrence, Predictions, Speculations"

Lin, D.

TBD

Poster Abstracts

1.1 “Search for Massive Earths around SARG Astereosismology Targets”

Benatti, S., Bonavita, M., Claudi, R.U., Desidera, S., Endl, M., & Barbieri, M.

The extension of the domain of radial velocity planet searches toward planets of masses significantly lower than Saturn is one of the most relevant results of the past years. The greatest difficulty is to strive for smaller radial velocity amplitude against the imposed limits by the star itself, especially for sun-like stars. However it was shown that averaging consecutives radial velocity measurements it is possible to limit the effect of granulation and pulsation of the stars. In the search for solar-like oscillations the target is continuously monitored for several contiguous nights. The data acquired in these campaigns are then very suited to reach the limits of radial velocities, and indeed the low mass planet around μ Arae was discovered because the star was a target of an asteroseismological campaign. In this work, we describe the intrinsic radial velocity limits obtained by data from two different asteroseismological campaigns performed with SARG, the high resolution spectrograph of the TNG (Telescopio Nazionale Galileo). The nightly averages show rms dispersion of just 0.2 m/s over one week. This allows us to exclude short period planets of a few Earth masses around these stars.

1.2 “PRL Advanced Radial-velocity All-sky Search (PARAS)”

Chakraborty, A., Mahadevan, S., & Richardson, H.

We are building a new high resolution (R$\sim$ 60,000) seeing limited ($\sim$ 2arcsecs) Echelle Spectrograph that will be used to search for extra-solar planets down to the precision of 5 to 3m/s. The project is being supported by the Physical Research Laboratory (PRL) and hence is known as PRL Advanced Radial-velocity All-sky Search (PARAS). PARAS is an optical fiber-fed Echelle Spectrograph that will work at R = 60000 with a slit width of 150microns between 3700A and 8100A wavelengths. The optical design is such that with an instrument beam size of 100mm (4inch) it should suit the existing 1 to 2m class of telescopes available in India and the spectral region between 4000A and 6800A should be used for extra-solar planets survey (at 3 to 5m/s RV accuracy) using the simultaneous ThAr referencing Method. PARAS will be installed with a 1.2m telescope which is situated at Mt. Abu (5800feet, some 150miles north from the main PRL Campus at Ahmedabad, India). The spectrograph should see the first light by the spring of 2009. We are guaranteed at least 120nights per year, more nights are possible.

Since thermal stability is absolutely necessary to achieve ¡5m/s RV accuracies, PARAS is planned to be kept inside a vibration free isolated tank under low vacuum (10^{-3} mbar) in a thermally isolated room at 29C +/- 0.01. The Echelle grating considered is that of a single 420mm x 210mm x 76mm from Master MR160 (from Richardson Gratings-Newport which has 31.6g/mm and blazing angle of 76degrees). Further, we aim to achieve efficiency of 30% from the slit to the CCD detector, and up to 12% to15% including sky, telescope, fiber-fed optics etc. We expect to reach the S/N ratio of 70 on a 10mag star for an integration time of 40mins. We aim to achieve at least 5m/s RV accuracies on such a star. The Spectrograph design is complete and will be presented.

1.3 “Modeling the Resonant Planetary Systems with the RV Observations”

Gozdziewski, K., & Musielinski, A.

We discuss the dynamical modeling of radial velocity observations of stars hosting resonant planet systems. The phase space of a multi-planet system has, in general, a non-continuous and very complex structure with respect to any stability criterion. Hence, the search for statistically optimal initial conditions has to take into account also the dynamical character of a putative planetary configuration.

Moreover, due to relatively small data sets, significant measurement errors, stellar jitter and other uncertainties, such fits appear often very unstable. To find optimal and stable configurations, we apply a self-consistent approach that relies on the elimination of unstable configurations during the fitting process, through penalizing unstable solutions with a suitably large value of Ch-squarei function, rms or other measure of the fit quality.

In particular, we consider a case, when the model of the radial velocity observations can be not unique. That concerns, for instance, two-planet configurations involved in 2:1 or 1:1 mean motion resonances. The reflex signal of two Jovian Trojan planets can be also interpreted as a signal of one planet in quasi-circular orbit. That possibility is very attractive, as stable Trojan companions to the stars may be quite common. It is indicated both by a number of Trojan configurations in the Solar system as well as by the theoretical studies predicting that they can be a frequent by-product of planet formation and evolution. We explore how such ambiguity influence the creation and stability of Earth-like planets interior to the orbits of the Jovian Trojans.

1.4 “A Bayesian Re-analysis of HD 11964: Evidence for Three Planets”

Gregory, P.C.

Astronomers searching for the small signals induced by planets inevitably face significant statistical challenges. Bayesian inference has the potential of improving the interpretation of existing observations, the planning of future observations and ultimately inferences concerning the overall population of planets. This paper illustrates how a re-analysis of published radial velocity data sets with a Bayesian multi-planet Kepler periodogram is providing strong evidence for additional planetary candidates.

The periodogram (Gregory, ApJ 631, 1198, 2005 & MNRAS 374, 1321, 2007) employs a parallel tempering Markov chain Monte Carlo algorithm. The HD 11964 data (Butler et al. ApJ, 646, 505, 2006) has been re-analyzed using 1, 2, 3 and 4 planet models. Each model incorporate an extra noise parameter which can allow for additional independent Gaussian noise beyond the known measurement uncertainties. The most probable model exhibits three periods of $38.02^{+0.06}_{-0.05}$, 360^{+4}_{-4} and 1924^{+44}_{-43} d, and eccentricities of $0.22^{+0.11}_{-0.22}$, $0.63^{+0.34}_{-0.17}$ and $0.05^{+0.03}_{-0.05}$, respectively (Butler et al. 2006 reported a single planet with a period of 2110 ± 270 d). Assuming the three signals (each one consistent with a Keplerian orbit) are caused by planets, the corresponding limits on planetary mass ($M \sin i$) and semi-major axis are $(0.090^{+0.15}_{-0.14} M_J, 0.253^{0.009}_{0.009}\mathrm{au}), (0.21^{+0.05}_{-0.02}\mathrm{M_J}, 1.13^{0.04}_{0.04}\mathrm{au}), (0.77^{+0.08}_{-0.08}\mathrm{M_J}, 3.46^{0.13}_{0.13}\mathrm{au})$, respectively. The small difference (1.3σ) between the 360 day period and one year suggests that it might be worth investigating the barycentric correction for the HD 11964 data. This research was supported in part by a grant from the Canadian Natural Sciences and Engineering Research Council of Canada at the University of British Columbia.

1.5 “Detection of a Planet Orbiting the F-star which is also a Member of a Hierarchical Triple System”

Guenther, E.W., Hartmann, M., Hatzes, A.P., & Esposito, M.

Up to now most radial velocity planet search programs have concentrated on stars of one solar mass. Our knowledge on frequency of planets and brown dwarf companions of more massive stars thus is rather limited. In the case of solar-like stars, the frequency of short-period brown dwarf companions, and very massive planets and is very low. In here we present the discovery of an object with an msini of 8.4+/-1.0 Mjupiter. The object could thus be a planet or a very low-mass brown dwarf. The host star is an F-star, and is a member of a hierarchical triple star-system. With a spectral type of F4V, the host stars is one of the earliest spectral types on the main sequence that is know to host a substellar companion, either a very massive planet or brown dwarf. The companion was detected by means of precise radial velocity measurements using the 2-m-Alfred Jensch telescope in conjunction with its Echelle spectrograph and an iodine cell.

1.6 “Planet Search using a 1.8m Telescope”

Jeon, Y.-B., & Lee, B.-C.

About four years preiodic radial velocity (RV) observation of 55 K-giants has been carried out using BOES (Bohyunsan Observatory Echelle Spectrograph). As a result of the observation seven stars are showed regular RV variation with period of several hundreds days and at least two of them seem to have planets. BOES is a fiber-fed high resolution echelle spectrograph for the BOAO (Bohyunsan Optical Astronomy Observatory) 1.8m telescope. Using a 2k $\times$ 4k CCD, the wavelength coverage of BOES is 3600Å– 10500Å(86 spectral orders) in one exposure. The measured spectrograph resolving powers for 80, 200 and 300 μm fibers are 90,000, 45,000 and 30,000, respectively. The current RV measurement accuracy of BOES is about 9 m/s.

1.7 "Two Substellar Companions Orbiting Evolved Intermediate-mass Stars in the Open Clusters NGC 2423 and NGC 4349"

Lovis, C., & Mayor, M.

We present first results from a high-precision radial-velocity survey of red giants in a sample of intermediate-age open clusters. The aim of this research is to better characterize the properties of extrasolar planets around intermediate-mass stars ($2-4M_{Sun}$). We use the well-known cluster properties to determine accurate masses for the red giants. We present the discovery of a planet around the $2.4 - M_{Sun}$ star NGC2423No3, with an orbital period of 714 days and a minimum mass of $10.6M_{Jup}$. Moreover, we have discovered a brown dwarf with a minimum mass of 19.8 M_{Jup} and an orbital period of 678 days orbiting the $3.9-M_{Sun}$ star NGC4349No127, which is the most massive star around which a substellar companion has been detected to date. Combining the results of this survey with the whole sample of known planetary systems, we find that the frequency of massive planets is higher around intermediate-mass stars, and that the total mass of planetary systems scales with the mass of the central star.

1.8 "Laser Frequency Comb for High Precision RV Observations"

Osterman, S., Diddams, S., Beasley, M., Froning, C., Hoberg, L., Mbele, V., & Weiner, A.

High resolution spectroscopy is the foundation for many of the most challenging and productive of all astronomical observations, none more so than the search for extrasolar planets. A highly precise, repeatable and stable wavelength calibration is essential for long term radial velocity observations, where an incomplete or unreliable wavelength calibration will compromise the programs findings. The two wavelength references in wide use for visible wavelengths, iodine absorption cells and thorium/argon lamps, each have fundamental limitations which restrict their ultimate utility.

We are exploring the possibility of adapt emerging laser frequency comb technology in development at the National Center for Standards and Technology in Boulder, Colorado, to the needs of high resolution, high stability astronomical spectroscopy. This technology has the potential to extend the two current wavelength standards both in terms of wavelength coverage and in terms of long term precision, ultimately enabling cm/s astronomical radial velocity determination. We present an overview of laser frequency comb technology and discuss one proposed astronomical application.

1.9 “Effect of Intrinsic Stellar Noise on the Detection of Exoplanetary Radial Velocity Signals in Solar-like Stars”

Tingley, B., Grundahl, F., & Kjeldsen, H.

All stars exhibit an intrinsic radial velocity noise, yet no detailed analysis of the effects of intrinsic stellar noise on the detection of exoplanetary radial velocity signals has published to date. It is possible to create a model based on the SOHO/GOLF time series that describes the intrinsic radial velocity noise of Solar-like stars on the timescales of several hours and longer. These must be scaled to account for the stellar atmospheric effects: the sodium line observations of GOLF and the broad-spectrum observations typical of ground-based observations probe different parts of the stellar atmosphere. This scaling is, however, trivial. This model can be used to perform Monte Carlo simulations that demonstrate that the observations are strongly dominated not by measurement precision but by the intrinsic noise of the star. As a result, Earth-like radial velocity signals are in fact extremely difficult to detect around Solar-like stars due to the strength and peculiar natu re of the noise. Fortunately, theory suggests that later spectral types are less noisy and other observable phenomena exist (f.x. the Rossiter-McLaughlin effect) that might be able to classify transiting exoplanet candidates.

2.1 "Searching for Terrestrial Mass Trojan Planets"

Ford, E.B., Gaudi, B.S., & Holman, M.J.

We outline two novel methods for detecting Trojan companions to transiting extrasolar planets. The first method involves comparing the midtime of eclipse with the time of the stellar reflex velocity null. This method already rules out Trojan companions to HD 209458b and HD 149026b more massive than ∼13 and ∼25 Earth masses a 99.9% confidence level (Ford & Gaudi 2006). The second method uses only photometric observations to search for transit timing variants due to a Trojan companions to a transiting extrasolar planet (Ford & Holman 2007). While previous transit timing observations have achieved the required timing precision, many more such observations are needed to provide strong limits on the presence of Trojan planets via transit timing. Both methods have the sensitivity necessary to detect terrestrial-mass Trojan planets using existing ground-based observatories. Detecting Trojan planets with these or other methods would place significant constraints on theories of orbital migration and the formation of short-period planets.

2.2 "Search for Extra-solar Planets using LOAO 1.0m Telescope"

Kim, S.-L., & Lee, C.-U.

KASI has been operating a 1.0m telescope at Mt. Lemmon Optical Astronomy Observatory(LOAO) in Arizona, USA. Observation systems such as the telescope, a 2K×2K CCD camera, and a dome are controlled remotely at KASI headquarter in Daejeon, Korea via network connection. We have two long-term projects to search for extra-solar planets using the LOAO 1.0m telescope. One is to monitor nearby open clusters for detecting transit effects by extra-solar planets. Time-series data of six open clusters and for about 20 nights per a cluster have been obtained from January 2004. Another is to follow up micro-gravitational lensing phenomena for detecting any peculiar light variation by extra-solar planets. We have been participating in a multi-site network group for the follow-up observations, MicroFUN (Microlensing Follow-Up Network). We will present recent results of these two projects.

2.3 “Design Considerations for a Transit Search Targeting Habitable Planets around M Dwarfs”

Nutzman, P., & Charbonneau, D.

By targeting nearby M dwarfs, a transit search using even modest equipment is capable of discovering planets smaller than Neptune in the habitable zone of their host stars. A future transit search, the MEarth Project, aims to employ a network of humble robotic telescopes to monitor M dwarfs with sufficient precision and temporal coverage to detect habitable planets down to twice the radius of Earth. Here we investigate the design requirements for the MEarth Project. We evaluate the necessary field of view, telescope aperture, and telescope time allocation on a star-by-star basis, as is possible for the well characterized nearby M dwarfs. Through these considerations, 1670 late M dwarfs ($R < 0.33{\sim}R_{\odot}$) emerge as favorable targets for transit monitoring. Based on an observational cadence and total telescope time allocation tailored to recover at least 90 % of transit signals from planets in habitable zone orbits, we find that a network of ten 30 cm telescopes, each observing a 25 arcmin^2 field of view, could survey these 1670 M dwarfs in less than 3 years. A null result from this survey would set an upper limit (at 99 % confidence) of 20 % for the occurrence of planets larger than 2 R_{earth} out to the habitable zone of late M dwarfs. If the true occurrence rate is 10 %, the expected yield would be 2.5 planets.

2.4 "MAESTRO-1: A Planetary Transit in a Binary System"

Setiawan, J., Weldrake, D., Weise, P., Müller, A., Henning, Th., Afonso, C., & Launhardt, R.

In this poster we present the results of the radial velocity follow-up of a transit planet candidate MACHO.120.22303.5389 (MAESTRO-1). The photometric is consistent with a transiting object with an orbital period of R=2.43 days and a radius of $R => 1.8 R_j up$. Our preliminary results from the 2.2m MPG/ESO telescope and FEROS (R=48,000) in May and July 2006 displayed a radial velocity variation with amplitude ~650 m/s with the same period as the transit, and a solar-type primary (Weldrake et al. 2006, astro-ph/0612214). This is consistent with an orbiting companion of mass $\sim 4 M_j up$. Further observations in 2007 confirmed this finding and show an additional secondary long-period variation with amplitude of ~35 km/s, indicating the presence of a stellar companion with a semimajor axis smaller than 1.5 AU. The system is probably a binary system with a transiting planetary companion around one of the component of the binary. So far, this is the first detection of a planetary transit in a close binary system. The study of this interesting system is important to put constraints on planet formation and migration theories.

2.5 “High-time Polarimetry Measurements of the TrES-3 Host Star”

Slowikowska, A., Stefanescu, A., Ioannou, Z., & Kanbach, G.

We present our preliminary polarimetric results of the host star (GSC 03089-00929) of TrES-3 (O’Donovan et al. 2007). The aim of the project was to obtain polarization characteristics of the target with very high time resolution as a function of orbital phase of the planet. TrES-3 has one of the shortest orbital periods (31 hours) of the known transiting exoplanets that makes it an excellent target for orbital-dependent studies. We are looking for any changes of the position angle and/or polarization degree as a function of the orbital period. Our observations were performed with the high-speed photo-polarimeter OPTIMA (Optical Pulsar Timing Analyzer) mounted at the 1.3 m Skinakas telescope. Our target has been observed for about 14 hours distributed over three nights between 15 and 17 June this year.

2.6 "Planet Formation Models Meet Transit Timing Observations"

Steffen, J.H., Raymond, S., Agol, E., & Mandell, A.

Several planet formation models predict the presence of low-mass companion planets that are shepherded into mean-motion resonance with a gas giant as the giant migrates inward. Such systems, and hence the models that predict them, can be studied by observations of the timing of the transits of the giant. This is because transit timing variations (TTV), that are caused by planet-planet interactions, are largest near mean-motion resonance and have been shown to be sensitive to terrestrial-mass companions. We investigate the TTV signal that arises from several realizations of a core-accretion plus migration model of planet formation. In these systems a giant planet is migrated through a gas disk that is populated with many planetesimals. As the system evolves the planetesimals collide to form planets which are subsequently trapped near mean-motion resonance with the migrating giant. We present the TTV signal that results from these systems and discuss the feasibility of detecting the trapped planets via a TTV study.

3.1 “Radio Search for Water in Exo-Planetary Systems”

Cosmovici, C., Salerno, E., Montebugnoli, S., Pluchino, S., & Zoni, L.

In 1994 the world witnessed the much heralded collision of Comet Shoemaker-Levy 9 with Jupiter giving astronomers a unique opportunity to study the consequences of a catastrophic impact in a planetary atmosphere and the subsequent changes in the chemistry and in the excitation conditions of atomic and molecular species. One of the most important result from the ground based observations was the detection of water MASER emission at 22 GHz (Cosmovici et al., 1996, Planet.Space Sci.44.735) by using a new fast multichannel spectrometer coupled with the 32 m dish of the Medicina Radiotelescope, near Bologna, Italy. These observations were the first evidence that comets are able to deliver huge amounts of water (about 50 billion tons per comet) in planetary atmospheres thus rising the fascinating possibility of life development in an appropriate environment. Thus we decided to use this discovery as a powerful and unique diagnostic tool for water search in exoplanetary systems were cometary bombardments occur today as they occurred on our planet billion of years ago. Moreover calculations have shown that this MASER line can be observed also in water rich atmospheres where the necessary pumping can be delivered by photo-deposited energy which can affect the level populations. Up to now 32 exoplanetary systems have been observed: suspect transient emissions have been identified from 4 stellar systems, but the low S/N ratio needs confirmation from other powerful telescopes with different methods. In order to improve the detection limits a new multichannel spectrometer was developed. It is a modular system: parallelising several boards it is possible to increase the bandwidth and the number of channels . The system is able to operate realtime FFTs (over bands narrower than 100 MHz) in parallel to KLTs (no real time) or other transforms. This instrument could play a key role in ordinary spectral line observations and in future applications requiring very high processing/computing power, dramatically increasing the on-line analysis performances.

3.2 "Hot Nights on Extrasolar Planets"

Cowan, N.B., Agol, E., & Charbonneau, D.

We present results from Spitzer Space Telescope observations of the mid-infrared phase variations of three short-period extrasolar planetary systems: HD209458, HD179949 and 51Peg. We gathered Infrared Array Camera (IRAC) images in multiple wavebands (3.6 micron or 4.5 micron, and 8 micron) at eight phases of each planet's orbit. At 8 micron we detect a phase function for HD179949 which is in phase with the planet's orbit and with a relative peak-to-trough amplitude of 0.00141(33). Assuming that HD179949b has a radius $R_J < R_p < 1.2R_J$ and a small Bond albedo, it must recirculate less than 30% of incident stellar energy to its night side at the 1 sigma level and have a mass less than $3.6M_J$. We do not detect phase variations for the other two systems but we do place the following 2 sigma upper limits: 0.0007 for 51Peg, and 0.0015 for HD209458. Due to its edge-on configuration, the upper limit for HD209458 translates, with appropriate assumptions about Bond albedo, into a lower limit on the recirculation occuring in the planet's atmosphere. HD209458b must recirculate at least 32% of incident stellar energy to its night side, at the 1 sigma level, which is consistent with other constraints on recirculation from the depth of secondary eclipse depth at 8 micron and the low optical albedo. These data indicate that different Hot Jupiter planets may experience different recirculation efficiencies.

3.3 "Mid-IR Observations of Proplyds in Orion"

Huelamo, N., Pantin, E., & Sterzik, M.

We present mid-infrared imaging and spectroscopy of three protoplanetary disks (proplyds) in the Orion Star Forming Region. The observations have been obtained with VISIR, the mid-IR Imager and Spectrometer mounted at UT3 (Melipal) in the VLT (Paranal). We have analyzed diffraction-limited observations of the proplyds to study the silicate and PAH emission. The main goal is to characterize the dust at these early evolutionary stages.

3.4 “Refined Parameters and Spectroscopic Transit of the Super-massive Planet HAT-P-2b”

Loeillet, B., Shporer, A., Bouchy, F., Pont, F., Mazeh, T., Beuzit, J.L., Boisse, I., Bonfils, X., Dasilva, R., Delfosse, X., Desort, M., Forveille, T., Galland, F., Gallenne, A., Hébrard, G., Lagrange, A.-M., Lovis, C., Mayor, M., Moutou, C., Pepe, F., Perrier, C., Queloz, D., Segransan, D., Sivan, J.P., Santos, N.C., Udry, S., & Vidal-Madjar, A.

We performed follow-up radial-velocity spectroscopic observations of HD 147506, the parent star of the recently discovered transiting planet HAT-P-2b, in order to refine the orbital parameters of the system and to observe the Rossiter-McLaughlin (RM) effect. We used the SOPHIE spectrograph, mounted on the 1.93 m telescope at OHP. We obtained 42 new measurements, 34 of which on May 14th, at the night that the planet was transiting its star. The projected relative inclination we derived from the radial velocities during the transit, lambda=0+/-10, is consistent with zero. The planetary and stellar radius, R_s=1.43±0.05 $R_\odot$ and R_p=0.95±0.04 R_{Jup}, had been also re-determined and are somewhat smaller than the previously determined values. The refined values of HAT-P-2b radius and mass indicate a density of 13.7±4.0 g cm^{-3}, suggesting an object in between the known transiting planets, with typical density of the order of 1 g cm^{-3}, and the very low-mass stars, with density greater than 50 g cm^{-3}.

3.5 “Measuring the Spin-Orbit Alignments of Transiting Exoplanetary Systems: The Case for TrES-1”

Narita, N., Enya, K., Sato, B., Ohta, Y., Winn, J., Suto, Y., Taruya, A., Turner, E., Aoki, W., Tamura, M., Yamada, T., & Yoshii, Y.

It is commonly believed that close-in planets (hot Jupiters, hot Neptunes) originally formed at larger orbital distances and migrated inward during the planet formation epoch. In order to explain the process of planet migration, the proposed migration mechanisms involve gravitational interactions with the protoplanetary disk (disk-planet interaction), other giant planets (planet-planet interaction), and separated binary companion (the Kozai migration).

On the other hand, the alignment of the stellar spin axis and the planetary orbital axis (spin-orbit alignment) is known to be an useful diagnostic for discriminating planet migration mechanisms, because the disk-planet interaction models would predict small (negligible) misalignments for migrated planets, while the planet-planet interaction models may naturally produce significant misalignments. Thus one can test the planet migration models by measuring the spin-orbit alignment in exoplanetary systems, and actually one can measure the alignment by exploiting the Rossiter-McLaughlin effect in transiting exoplanetary systems.

Here we report that we recently succeeded in detecting the Rossiter-McLaughlin effect in the transiting exoplanetary system TrES-1 with the Subaru/HDS. It is the third case for which the Rossiter-McLaughlin effect has been detected in a transiting exoplanetary system, and the first demonstration that such measurements are possible for relatively faint ($V \sim 12$) host stars. We will review the backgrounds and our result for TrES-1, and present future prospects of the Subaru observations.

Reference: Narita et al. 2007, PASJ in press, astro-ph/0702707

3.6 “HD 10647: A Debris Disk Imaged around an RV Planet Host Star”

Stapelfeldt, K.R., Krist, J.E., Bryden, G., & Chen, C.

We present HST/ACS coronagraphic imaging and Spitzer spectrophotometry of HD 10647, an F9 star at d= 17 pc with an RV planet in a 2 AU orbit. A diffuse debris ring with radius 90 AU is detected - the first debris disk imaged in scattered light around a star hosting a confirmed extrasolar planet. Using the disk spatial distribution shown by the HST image, we model the spectral energy distribution and derive constraints on the dust properties and inner extent of the debris material.

4.1 “Eccentricity Perturbations via the Kozai Mechanism in the M4 Pulsar Planet System”

Moody, K., & Sigurdsson, S.

We use octupole level three-body secular perturbation equations to examine the evolution of the eccentricity of the orbit of the low mass white dwarf around the pulsar in the PSR 1620-26 system by varying several parameters around suspected values. Taking into account GR precession, and using the most current values for the size and eccentricity of the orbits wefind that for highly inclined orbits, i.e. $82 < i < 95$ degrees for a mass for the third body of at least 2 mJ, the eccentricity of the inner orbit can be made as high as the observed value (e1=0.025) with a change in inclination of about half a degree. This result can limit possible formation scenarios for this system. Jovian mass planetshaving highly eccentric orbits, such as 70 Vir b, may have had their orbits perturbed into that state by a captured body in an inclined wide orbit.

4.2 “Towards a Direct Detection of Planets around Neutron Stars”

Posselt, B., Neuhauser, & Haberl, F.

The current approach to find planets around neutron stars is by terms of the radio pulse timing technique. This indirect method however works only for the most stable pulsars. Young pulsars or radio-quiet neutron stars are not probed. Furthermore it is difficult to obtain more information about the substellar companions of pulsars without direct detections. We will present our direct Infrared imaging search for substellar companions around young isolated neutron stars, including radio-quiet neutron stars. First results of three objects from two observational epochs will be shown.

5.1 “Physical Properties of Two Brown Dwarfs Hosting Planetary Mass Objects”

Bayo, A., Barrado y Navascués, D., & Morales-Calderón, M.

We have derived some physical properties (age, $T_{\rm eff}$, gravity, accretion/activity) of 2M1207 (member of TWA) and Oph 162225-240515, both of them brown dwarfs harbouring planetary mass objects. The study has been carried out by analysing observations in the optical and IR and comparing them with templates, as well as with theoretical models.

5.2 "The DODO Survey: Imaging Substellar and Planetary-mass Companions to White Dwarfs - Results and Limits"

Burleigh, M., Hogan, E., & Clarke, F.

The Degenerate Objects around Degenerate Objects ("DODO") project searches for wide, spatially resolved very low mass companions to nearby white dwarfs through direct imaging. Our target list of $\approx$ 40 white dwarfs includes objects from 0.3 - 4Gyr in age within $\approx$ 20pc. Each target has a proper motion > 0.2 arcsec per year. We take pairs of deep (one hour) J-band images with the 8m Gemini and VLT telescopes, separated by one year or more, and search for common proper motion companions as faint as $J \approx 23.5$. We have found no such companions, but can place interesting limits in terms of mass and temperature. Using the evolutionary models of Baraffe and Burrows, we are in some cases sensitive to companions as low in mass as $3M_{\rm jup}$, although for most targets we are only sensitive to masses $> 5M_{\rm jup} - 10M_{\rm jup}$. However, such objects will be significantly lower in temperature than the currently coolest known substellar objects, and have spectral types later than T8.5. The lack of any detections is consistent with the known rarity of substellar companions $> 5M_{\rm jup}$ to main sequence stars in radial velocity and imaging surveys.

5.3 "Transit Characteristics for Substellar and Terrestrial Companions to White Dwarfs"

Faedi, F., Burleigh, M., Goad, M., West, R., & WASP Consortium

We consider the characteristics of and probabilities for transits of brown dwarfs, gas giants and terrestrial companions in close orbits around white dwarfs. Brown dwarf and gas giant companions will completely eclipse the white dwarf. One non-eclipsing, short-period white dwarf + brown dwarf system is already known, WD0137-349 (Maxted et al. 2006), but such objects remain difficult to identify as infra-red excesses or through radial velocity measurements. The detection of a significant number of eclipsing systems might help uncover the mooted population of "old" CVs in which the current accretion rate is extremely low and the companion has been reduced to a substellar mass. Short-period terrestrial companions to white dwarfs may seem unlikely, but the recent detection of silicate-rich dust disks around white dwarfs at orbital radii of a few R_{sun} suggests that asteroids and larger objects can migrate into such orbits during the final stages of solar system evolution. Due to the small radii of white dwarfs ($\sim R_{earth}$), terrestrial objects smaller than the Earth would be detectable as transits $>$ few % in depth. We are analysing the SuperWASP light curves of white dwarfs for such transits. Future wide field, high time resolution surveys such as Pan-Starrs and LSST will observe thousands of white dwarfs, significantly increasing the chances of detecting transiting companions from brown dwarfs to rocky bodies with very small radii.

5.4 “Spitzer IRAC Observations of White Dwarfs: Limits on the Presence of Planetary and Substellar Companions at Young and Old Degenerates”

Farihi, J., Becklin, E.E., & Zuckerman, B.

We present the results of original and archival Spitzer IRAC observations of three distinct populations of nearby white dwarfs; 1) open cluster white dwarfs, 2) high mass field white dwarfs, and 3) metal-rich white dwarfs. No targets are found to have excess flux consistent with unresolved substellar or massive planetary companions. We calculate conservative (3 sigma) photometric upper limits at 4.5 microns in order to place constraints on such objects. Combined with known or estimated ages and distances for the targets, these yield upper mass limits on closely orbiting planets and cold brown dwarfs. While the lack of very low mass substellar objects within a few AU is naturally understood as a consequence of the preceding giant phases, their absence at several to tens of AU may require alternate explanations.

5.5 “Looking for Chemical Evidence for the Accretion of Planets onto Red Giant Stars”

Miller, J., Majewski, S., Smith, V., Rood, R., Cunha, K., Patterson, R., & Bizyaev, D.

The inner planets of some main sequence stars with planets (SWPs) will be within the radius of tidal orbital decay during their host star’s red giant phase and will thus be accreted during the star’s evolution. The orbital angular momentum gained from such an accretion process has been posited to explain the anomalously high rotational velocity of some giant stars, and the accretion of a planet should leave chemical signatures in the star’s atmosphere as well. We present preliminary results of a detailed chemical abundance analysis of a sample of rapidly rotating giant stars, their slow-rotation counterparts, and K giants with known planetary companions. Among several independent chemical signatures that have previously been proposed to be present in giant stars that have accreted planets, we focus on (1) a correlation of the abundance of different elements as a function of their condensation temperature, which would imply the accretion of chemically fractionated material (i.e., a planet), and (2) an increase in lithium abundance, which should be depleted by convection in standard giant star evolution but which could be replenished by planet accretion.

5.6 “The PSU/TCfA Search for Planets around Evolved Star. Accurate V sin(i) Measurements for Slow Rotating F-K Giants”

Nowak, G., & Niedzielski, A.

We present results of our projected rotational velocities (V sin(i)) measurements of F, G and K giants obtained from the cross-correlation function (CCF) constructed from the spectra used for radial velocity (RV) determination. This procedure has several advantages with respect to use of specially acquired spectra because (1) no additional observing time is required and (2) the Iodine cell provides most accurate wavelength calibration, removing uncertainties due to for example variations of pressure and light or slit illumination. For this reason we only use the part of spectra where strong Iodine lines appear. We compute CCF by cross-correlating the spectra cleaned from Iodine lines with the numerical mask constructed as a sum of delta-functions centered on the rest wavelengths of carefully selected lines.

We also present the calibration of the HET/HRS cross-correlation function to determine accurate projected rotational velocities V sin(i) for slow rotating F-K giant stars.

5.7 “The PSU/TCfA Search for Planets around Evolved Stars. Precision of Radial Velocity Determinations for Red Giants”

Nowak, G., & Niedzielski, A.

Searches for planets around evolved G-K subgiant and giant stars are essential for developing general understanding of planet formation and evolution of the planetary systems. Precise radial velocity (RV) measurements of giants have lead to the discovery of ten planets around such star. However, the long period radial velocity variations of red giants may also have other than planetary nature. Non-radial oscillations or rotational modulation due to star spots can also induce RV variations, thereby mimicking the gravitational influence of low-mass companions. It is therefore very important to eliminate such non-planetary interpretation of low amplitude periodicity in radial velocity curve of red giants.

In this work we present bisector analysis of the cross-correlation function (CCF) for a number of stars from our survey for which strong correlation between bisector velocity span (BVS) of the CCF and radial velocity suggests that rotational modulation is responsible for the observed RV variations. We will also discuss the effect of stellar activity on precision of RV determination in red giants.

5.8 “Differences in the Planet Populations around Main-Sequence Stars and Giant Stars”

Quirrenbach, A., Reffert, S., Hekker, S., Albrecht, S., Mitchell, D.S., Fischer, D.A., Marcy, G.W., & Butler, R.P.

In recent years, several substellar companions around evolved stars (mostly G and K giant stars) have been found via precise radial velocity searches. Our group has found seven such companions by monitoring about 150 giant stars for about 7 to 8 years. The population of sub-stellar companions around those evolved and slightly massive stars (masses typically range from 1 to 3 $M_{\odot}$) seems to be rather different from the population of planets known around main-sequence stars. Most notably, the semi-major axes of the companions around the evolved stars tend to be larger, the eccentricities smaller, and the masses larger than those of the companions discovered around main-sequence stars. We discuss several reasons for these differences in the two populations, including the effect of the primary mass on the mass of the companion, and the effect of mass loss and expansion in size of the primary star on its way to the tip of the red giant branch, which might lead to wider and less eccentric orbits of its companions.

5.9 “Two Brown Dwarfs in Resonance around a K3II Giant”

Reffert, S., Quirrenbach, A., Hekker, S., Albrecht, S., Mitchell, D.S., Fischer, D.A., Marcy, G.W., & Butler, R.P.

The K3II giant ι Aur (HD 31398, HIP 23015) was observed regularly for about 7 years as part of our on-going precise radial velocity survey of about 360 giant stars at Lick Observatory. The radial velocities show two periodicities, with periods of approximately 2 and 4 years, respectively. Although other mechanisms causing periodic RV patterns cannot fully be excluded at this stage of the analysis, the most likely explanation is that the periodic radial velocity pattern of ι Aur is caused by two brown dwarfs orbiting the star in a 2:1 resonance. We present the orbital fit and dicuss this interesting system.

5.10 “A Giant Planet Orbiting an Extreme Horizontal Branch Pulsating Star”

Silvotti, R.

In this poster I report the discovery of a planetary-mass body (M sin$i$ = 3.2 M_{JUP}) orbiting an extreme horizontal branch, core helium burning, pulsating star at a distance of about 1.7 AU, with a period of 3.2 yr. The maximum radius of the red giant precursor may have reached 0.7 AU, whereas the orbital distance of the planet during the main sequence is estimated to be about 1 AU. This detection of a planet around a post-red giant star proves that planets with orbital distances $<$ 2 AU can survive the red giant expansion.

5.11 “The Penn State/Torun Centre for Astronomy Search for Planets around Evolved Stars. Basic parameters of a sample of evolved stars.”

Zielinski, P., & Niedzielski, A.

The main objective of the Penn State/Torun Centre for Astronomy Search for Planets Around Evolved Stars is to study evolution of planetary systems in stellar evolution timescale. For such an analysis we need precise physical parameters for hosts of the evolved planetary systems. In this paper we present basic physical parameters for a sample of evolved stars observed within our survey with the High Resolution Spectrograph (R=60000) of the Hobby-Eberly Telescope. Effective temperatures, gravitational accelerations, microturbulence velocities and metalicities were determined using strictly spectroscopic methods based on analysis of equivalent widths of FeI and FeII lines. These data together with the catalog ones allow us to estimate stellar masses and ages and locate the stars on the HRD. The results were further discussed and results for set of well-known stars were compared with the literature ones. It is concluded that our strictly spectroscopic approach brings fairly reliable and consistent results.

6.1 “On the Evolution of Protoplanets in Circumbinary Disks”

Pierens, A., & Nelson, R.

About 60% of solar-type stars reside in binary or multiple star systems. So far about 30 planets have been discovered in such systems, most of them orbiting only one star. Thus, it is important to investigate how planet formation proceeds in binary systems. Here we focus on planet formation in circumbinary discs and investigate how low-mass planets evolve as a result of interaction with the gaseous disc. We begin by simulating the evolution of a binary-circumbinary disk system. These simulations are run until a quasi-stationary state is achieved, for which the disk structure and the binary eccentricity remain almost unchanged. We then use this equilibrium state as the initial conditions for simulations of protoplanets embedded in circumbinary disks. We find that the inward migration of a single low-mass protoplanet is stopped at the edge of the tidally truncated cavity formed by the binary. This effect is due to positive corotation torques, which counterbalance the net Lindblad torques at the cavity edge. Halting of migration occurs in a region of long-term stability, suggesting that low mass circumbinary planets may be common, and that gas giant circumbinary planets should be able to form in circumbinary disks. We also present some preliminary results showing the evolution of two protoplanets in circumbinary disks. These suggest that, depending on the planetary mass ratio, multiple planets systems may be stable in circumbinary disks.

7.1 “Disk-planet Tidal Interaction Including and Energy Equation”

Baruteau, C., & Masset, F.

Linear theory as well as numerical simulations of the tidal interaction between a circumstellar disk and a protoplanet embedded in predict the protoplanet undergoes an orbital decay that brings it to the vicinity of the central star. This is known as planetary migration. Its characteristic time is far less than the disk dissipation time, which implies, contrary to what is detected, that all planets would reach the inner edge of their disk. Hence the challenge to find a way to reduce or cancel the migration rate. In this communication, the rate of angular momentum exchanged between a rotating potential and a radiatively inefficient disk is estimated. We apply this study to the case of an embedded protoplanet using high resolution numerical simulations with the staggered-mesh polar hydrocode Fargo (Masset, 2000).

7.2 “Gas-Density Enhanced Regions: Favorable Places for the Formation of Planetesimals via Gravitational Instability”

Haghighipour, N.

To form planetesimals through gravitational instability, the density of solid particles in the central plane of the solar nebula has to reach a critical value. Youdin and Shu (2002) have suggested that the radial drift of small objects due to gas-drag may help the nebula to reach this critical density. However, numerical simulations by Weidenschilling (2003) have shown that turbulent stress may affect the collective motion of particles and inhibit their accumulation as needed by the gravitational stability model. During the evolution of a nebula, however, regions may appear where the density of the gas is locally enhanced. The locations of maximum gas-density are turbulence-free, making them suitable for the gravitational instability to act. In these regions, the combined effect of gas-drag and pressure gradient causes small objects, in the vicinity of such gas-density enhancements, to migrate towards and accumulate at the locations of the maximum gas density. Since the pressure gradient is non-existence at these locations, small particles accumulate at these regions and increase the local density of the disk's solids. In a gas- density enhanced region with a long lifetime, the accumulation of particles may reach the critical value necessary to trigger gravitational instability. I will present the results of the simulations of the formation of such solid-density enhancements, and discuss the conditions for which the local disk-density is massive enough to start gravitational instability.

7.3 “Orbital Distributions of Planets around Intermediate-mass (2-5 Msun) Stars”

Ida, S., & Sato, B.

Based on RV survey of intermediate-mass (2-5 M_{sun}) stars and planet formation model for various mass stars, we discuss orbital distributions of gas giants around the intermediate-mass stars. Burkert & Ida (2007, ApJ 660, 845-849) pointed out that the separation/period gap in the distribution of gas giants around F dwarfs can be accounted for by less efficient type II migration around these stars than around GK dwarfs, using Monte Carlo simulation developed by Ida & Lin (2005, ApJ 626, 1045-1060). The less efficient type II migration can be resulted in by more compact size of protoplanetary disks, more distant ice boundary, and more efficient photoevaporation around these stars. Extending this idea to more massive stars, we suggest that due to very inefficient type II migration, the orbital distribution of gas giants would be limited to $>\sim$ 1AU (i.e., short-period gas giants may be poorly populated) around the intermediate-mass stars. The data of ongoing RV survey for GK giants may be consistent with this theoretical prediction.

7.4 “Formation of Terrestrial Planets from Protoplanets: Statistics of Planetary Spin”

Kokubo, E., & Ida, S.

The final stage of terrestrial planet formation is known as the giant impact stage, where protoplanets collide with one another to form planets. The initial spin state of terrestrial planets is determined at this stage. We statistically investigate the spin parameters of terrestrial planets assembled from protoplanets using N-body simulations. As initial conditions, we adopt the oligarchic growth model of protoplanets. For the standard disk model, two Earth-sized planets typically form in the terrestrial planet region. We find that the spin angular velocity of the planets is well expressed by the Gaussian distribution and their obliquity is well expressed by the isotropic distribution. The typical spin angular velocity is given by the critical spin angular velocity for rotational instability under the assumption of perfect accretion in collisions. We show the dependences of the spin parameters on the initial protoplanet system parameters. The initial orbital separation and velocity anisotropy of protoplanets barely affect the spin parameters. The bulk density of protoplanets does not affect the obliquity distribution, while the spin angular velocity increases with the bulk density.

7.5 “Extrasolar Giant Planet Formation: Monte Carlo Simulations”

Mordasini, C., Alibert, Y., Benz, W., & Naef, D.

The characteristics of the now over 200 known extrasolar planets are a testbed for current planet formation theories. We use our core-accretion model that includes concurrent migration and disk evolution to generate populations of synthetic extrasolar planets by Monte Carlo simulations.

The probability distributions for the Monte Carlo calculations are derived as closely as possible from observations of protoplanetary disks, so that the resulting synthetic planet population should be an analogue of the real population in the solar neighborhood.

Using a synthetic observational bias we sort out the sub-population of synthetic planets that could actually be detected with current radial velocity surveys. The properties of this subset are compared in Kolmogorov Smirnov tests with the observed extrasolar planets. We find that we can reproduce with high statistical significance concurrently many important observed properties and correlations of the known extrasolar planets.

Moreover, having at hand the full synthetic population we can also made predictions for the properties of the vast group of planets undetectable today, like the low end of the planetary initial mass function.

7.6 "Collisions Between Small Dust Particles Reduce the Formation Time of Giant Planets"

Movshovitz, N., & Podolak, M.

One of the major open questions in the core accretion model is whether the gas envelope can be accreted in a sufficiently short time. Planetesimal accretion in the later stages provides a luminosity that keeps the planet from contracting and slows further gas accretion. Work by Hubickyj et al. (2005) has shown that if the assumed grain opacities are arbitrarily lowered in the outer radiative zone by a factor of 50, the formation time can be reduced to ~ 2 Myr.

We have studied the microphysics of grains in the radiative zone of a forming giant planet, and have determined the size distribution and resulting grain opacity. We find that in the lower half of the radiative zone the opacity is indeed lower by more than a factor of 50, but in the upper half it rises slowly to the full value assumed in earlier calculations. The optical depth in this high opacity region is between 1 and 10. It remains to be seen how much this more realistic opacity will affect the computed formation time for a giant planet.

Reference: O. Hubickyj, P. Bodenheimer, and J. J. Lissauer. Accretion of the gaseous envelope of Jupiter around a 510 earth-mass core. Icarus. 179:415431, 2005.

7.7 “Planet Formation in the Cluster Environment”

Pfalzner, S.

Most stars form not in isolation but in a cluster environment. These young stars are usually surrounded by a disc which contains the building blocs for planet formation. Especially in young dense clusters interactions between the young disc-surrounded stars are a common event. The result of these interactions is mass and/or angular momentum loss in the disc. Obviously this has direct consequences on the planet formation process.

Our results show that high mass stars function as gravitational foci for the other cluster members, which has the consequence that these stars loose their discs very quickly. Therefore planet formation around high-mass stars is very unlikely.

But the cluster environment might not only prevent planet formation, but trigger it as well. The angular momentum loss in the disc is usually connected with the appearance of spiral structures. If gravitational instabilities are the way to form giant planets, these triggered spiral arms could be the prerequisite to planet formation. It will be shown which regions of clusters are most likely to form planets via gravitational instabilities.

7.8 “Disc Fragmentation Forms Brown Dwarfs not Planets”

Stamatellos, D., & Whitworth, A.

Disc fragmentation has been proposed as a possible mechanism for the formation of planets around young stars. This mechanism works only if the disc can cool efficiently enough to allow for proto-condensations to grow. Disc simulations have produced contradictory results about whether this is feasible or not (e.g. Durisen et al., Boss et al.). We will present radiative-hydrodynamic (RT-SPH) simulations of discs, using a newly developed method that accounts for the radiative transfer within proto-condensations. The effects (i) of the rotational and vibrational degrees of freedom of H2, H2 dissociation, (ii) opacity changes due to e.g. the melting of dust ices and the sublimation of dust, and (iii) thermal inertia, can all be captured at minimal computational cost. Our simulations suggest that discs cannot fragment within $\sim$100 AU from the central star. However, massive discs can fragment at distances larger than $\sim$100 AU to produce brown dwarfs, and possibly planets and low-mass hydrogen-burning stars. This result agrees with recent analytic calculations (Whitworth & Stamatellos 2006).

7.9 “A Systematic Study of the Final Masses of Gas Giant Planets”

Tanigawa, T., & Ikoma, M.

We construct an analytic model for the rate of gas accretion onto a planet embedded in a protoplanetary disk as a function of planetary mass, disk viscosity, disk scale height, and unperturbed surface density in order to study the long-term accretion and final masses of gas giant planets. We first derive an analytical formula for surface density profile near the planetary orbit from considerations of the balance of force and the dynamical stability. Using it in the empirical formula linking surface density with gas accretion rate that is derived based on hydrodynamic simulations of Tanigawa and Watanabe (2002, ApJ 586, 506), we then simulate the mass evolution of gas giant planets in viscously-evolving disks. We finally determine the final mass as a function of semi-major axis of the planet. We find that the disk can be divided into three regions characterized by different processes by which the final mass is determined. In the inner region, the planet grows quickly and forms a deep gap to suppress the growth by itself before disk dissipation. The final mass of the planet in this region is found to increase with the semi-major axis in a similar way to the mass given by the viscous condition for gap opening, but the former is larger by a factor of approximately 10 than the latter. In the intermediate region, viscous diffusion of the disk gas limits the gas accretion before the planet form a deep gap. The final mass can be up to the disk mass, when disk viscous evolution occurs faster than disk evaporation. In the outer region, planets capture only tiny amounts of gas within the lifetime of the disk to form Neptune-like planets. We derive analytic formulae for the final masses in the different regions and the locations of the boundaries, which are helpful to gain a systematic understanding of the masses of gas giant planets.

8.1 “The Origin of the Short-Period Planets: The Jumping Jupiter Model with Tidal Circularization”

Nagasawa, M., Ida, S., & Bessho, T.

We studied the origin of short-period planets by numerical simulations. The discovered short-period planets have nearly circular orbits because of the tidal dissipation within their envelopes (Rasio et al. 1996). Such planets are considered to be formed at large distance from their host stars and migrated to shorter-period orbits. One proposed mechanism for migration is the tidal interaction with protoplanetary gas disk, but in multiple planetary systems, the “Jumping Jupiters model” (Weidenschilling & Marzari 1996) can be effective. The growth to the giant planet leads the system to gravitational instability. As a result, one planet is scattered into shorter orbit by close encounters of the planets. We performed numerical simulations to study the origin of short-period planets based on the Jumping Jupiter model. Although the planet cannot be scattered into the short-orbit directly, the “Kozai mechanism” effectively works on the scattered planet when the three planets are left in the system. By Kozai mechanism, the high inclination as a result of the scattering is changed to the eccentricity of the innermost planet. It leads the pericenter of the innermost planet to approach to the star periodically. At the closest approach, the planet experiences the strong tidal force and looses energy, and can migrate into the shorter orbit. In our simulation, the short-period planets are formed at about 30% cases after the planet-planet scatterings.

8.2 "Tidally Driven Inspiral of Hot Jupiters"

Ogilvie, G., & Lin, D.

We discuss the orbital decay timescales of short-period extrasolar planets based on new calculations of tides in rotating solar-type stars. Tidal dissipation is much less efficient than occurs in the circularization of solar-type binary stars because inertial waves are not excited unless the star spins rapidly. The survival of even the shortest-period planets can be plausibly explained provided that the Hough waves generated in the radiative zone reflect coherently from the centre of the star. As the star evolves, however, nonlinearity may set in at a critical age, resulting in a rapid inspiral of the planet.

9.1 “The Role of Resonance in Planet Migration”

Gibbon, M.E., & Mardling, R.A.

Recent studies have indicated that the observed semi major axes and eccentricites of extrasolar planets may be explained by appealing to post formation evolution of a number of protoplanets within a gas disk. With the ultimate goal of understanding the influence of the mutual gravitational attraction on the osculating elements of a pair of migrating protoplanets, we examine a spherical harmonic expansion of the disturbing function in the general three-body problem. This expansion accommodates arbitrary mass ratios, eccentricities and inclinations, and provides insight into the action of individual mean motion resonances on the overall dynamics of the three-body system. Using this expression together with Lagrange’s planetary equations, we have derived analytic expressions for the rates of change of the osculating elements of the protplanets. Here we present an evaluation of the numerical solution of these equations for the osculating elements as functions of time and compare this to values calculated from direct integration of the three-body equations of motion for coplanar three body systems.

9.2 “Formation of the Oort Cloud and New Comets due to the Galactic Tide”

Higuchi, A., Kokubo, E., Kinoshita, H., & Mukai, T.

We have investigated the orbital evolution of planetesimals due to the galactic tide. We considered the vertical component of the tidal force from the galactic disk. The galactic tide pulls up the perihelia and randomizes the inclination of planetesimals with large aphelion distances. We applied the analytical solutions to the orbital evolution of planetesimals to the Oort cloud formation the planetesimal disk. Due to the galactic tide, the eccentricity and inclination of some planetesimals with small angular momentum conversely oscillate a great deal. Also, some planetesimals show the libration of the argument of perihelion ω around $\omega = 90^\circ$ or 270° (the Lidov-Kozai mechanism). The planetesimals that gain perihelion distances great enough to leave the planetary region become members of the Oort cloud. We found that due to the galactic tide, planetesimals with semimajor axes $>\sim 1,000$ AU increase the perihelion distances outside the planetary region ($>\sim 100$ AU) and planetesimals with semimajor axes $>\sim 20,000$ AU spread the inclinations to the galactic plane (the galactic inclinations) over the range 0° to 90° in 5 Gyr. As perihelion distances oscillate, the planetesimals come back to the planetary region as new comets. We also discuss the distribution of inclination of new comets from the Oort cloud.

9.3 “The Blue Needle: Extreme Asymmetry in the HD 15115 Debris Disk”

Kalas, P., Graham, J., & Fitzgerald, M.

We have discovered an edge-on debris disk surrounding the nearby F5V star HD 15115, making it a prime candidate for exoplanet detection via radial velocity and transit techniques. Using the ACS coronagraph aboard the Hubble Space Telescope in the optical, the west disk ansa is detected to >550 AU radius, whereas the east ansa has ∼315 AU radius, giving the HD 15115 disk a needle-like morphology. With Keck adaptive optics, we detect the disk as close as 0.7” (31 AU) radius at near-infrared wavelengths, and in regions of overlap with the optical data we find a very blue V-H disk scattered light color relative to the stellar color. HD 15115 is now the fourth debris disk resolved in scattered light in the Beta Pic moving group, but the most asymmetric debris disk seen to date. Extreme asymmetries may be caused by dynamical perturbations from HIP 12545, another Beta Pic Moving Group member east of HD 15115. An alternative is that the dust source region at ∼30 AU radius has been recently perturbed by planetary dynamical instabilities.

9.4 "Regularization of the Caledonian Symmetrical Four Body Problem"

Sivasankaran, A., & Steves, B.

The number of quadruple stellar systems in the Galaxy is estimated to be of the order of 109. The four body problem is increasingly being used for explaining complex dynamical phenomena that appear in the solar system and exoplanetary systems. The Caledonian Astrodynamics Research Group has developed the Caledonian Symmetric Four Body Problem (CSFBP) which is a four body system with a symmetrically reduced phase and a five body extension to it called the Caledonian Symmetric Five Body Problem (CS5BP). The CSFBP can be applied to the study of the stability and evolution of symmetric quadruple stellar clusters and exoplanetary systems of two planets orbiting a binary pair of stars.

The main limitation of the CSFBP model is that, the potential function for the Hamiltonian equations of motion of the CSFBP contains singular terms. The potential function needs to be regularized in order to study the close encounters and collisional events occurring in the system. Regularization is a mathematical tool used to analyze the motions leading to collisions by transforming singular differential equations into regular equations. There are various regularization methods available, to accurately compute close encounters in gravitational few body problems. Here we will present a method to regularize the equations of motion of the CSFBP.

10.1 "The Young, Wide and Very Low Mass Visual Binary LOri167"

Barrado y Navascues, D., Bayo, A., Morales-Calderon, M., Huelamo, N., Stauffer, J.R., & Bouy, H.

We look for wide, faint companions around members of the 5 Myr Lambda Orionis open cluster. We used optical, near-infrared, and Spitzer/IRAC photometry. We report the discovery of a very wide very low mass visual binary, LOri167, formed by a brown dwarf and a planetary-mass candidate located at 5 arcsec, which seems to belong to the cluster. We derive Teff of 2125 and 1750 K. If they are members, comparisons with theoretical models indicate masses of 17 (20-15) Mjup and 8 (13-7) Mjup, with a projected separation of 2000 AU. Such a binary system would be difficult to explain in most models, particularly those where substellar objects form in the disks surrounding higher mass stars.

10.2 “NGC 1333 IRAS 4A: Twin Protostellar Disks with Vastly Dissimilar Characters”

Choi, M., Tatematsu, K., Park, G., & Kang, M.

NGC 1333 IRAS 4A is a Class 0 protobinary. We observed the IRAS 4A1/2 system in the ammonia (2, 2) and (3, 3) lines using the Very Large Array. IRAS 4A was found to contain two disks with surprisingly dissimilar properties, one gas-rich and the other dusty. We found that the A2 disk is brighter in the ammonia lines but dimmer in the dust continuum than its sibling disk, with the gas-to-dust ratios different by about an order of magnitude. The gas-rich A2 disk may be unusually active or hot, as indicated by its association with water vapor masers. The existence of two very dissimilar disks in a binary system suggests that the formation process of multiple systems can be very different from that of single stars and that stars belonging to a multiple system do not necessarily evolve in phase with each other. Furthermore, planetary systems made in such environments can have diverse characters: gas-rich disks may favor the growth of gas-giants while dusty disks may be more productive of rocky planets.

10.3 Ground-based Infrared Imaging Search for Sub-stellar Companions around Young Nearby Stars”

Eisenbeiss, T., Seifahrt, A., Schmidt, T., & Neuhauser, R.

We present earlier and recent results of our ongoing search for sub-stellar companions next to young nearby stars. The flux ratio between star and companion is smaller for younger objects due to ongoing contraction of the secondary, hence these are the targets of our choice since 2000. Indeed we were able to find and confirm as many as 4 sub-stellar companions, one of them possibly having a planetary mass.

10.4 “A Multiple Stellar System with Young Stars”

Lee, C.-U., Kim, S.-L., & Lee, J.W.

A multiple stellar system which consists of young stars is presented. To discriminate each component star from a composed spectrum, we use the spectrum disentangling method. It uses the synthetic code SPECTRUM which was developed by Richard O. Gray. This code computes LTE synthetic spectra using atomic and molecular line list for the optical spectral region 3000Åto 6800Å, and gives good fits on O, B, A type stars. Robert Kuruczs ODF (opacity distribution function) grids are also used for a stellar atmosphere model. Effective temperatures for synthetic spectra are determined from many times of spectral line fitting process. Membership of each component is confirmed by RV curve analysis. We will present their basic stellar parameters.

10.5 "Tidal Perturbations in Protoplanetary Disks"

Madlener, D., & Pfalzner, S.

Stars born in dense clusters often experience close encounters distorting their disks by tidal forces. The forming of planets might be induced by such an event. We implemented a simulation using tree methods and Smoothed Particle Hydrodynamics to model self-gravitation and fluid dynamics of the protoplanetary disk. The Nearest Neighbour search is based on a hashed octree to facilitate parallelization of the code. Different viscosity laws like the AV terms proposed by Monaghan, Hernquist & Katz and Balsara are used to resolve shock fronts and observe viscosity effects on the evolution of perturbations.

10.6 “Is Our Sun a Singleton?”

Malmberg, D., Davies, M.B., Chambers, J.E., Church, R.P., De Angeli, F., Mackey, D., & Wilkinson, M.I.

All stars are formed in some form of cluster or association. These environments can have a much higher number density of stars than the field of the Galaxy. Such crowded places are hostile environments: a large fraction of initially-single stars will undergo close encounters with other stars or exchange into binaries. We describe how such close encounters and exchange encounters will affect the properties of a planetary system around a single star. We define a singleton as a star which formed single, have never suffered a close encounters with another star or spent time within a binary system. It may be that planetary systems similar to our own solar system can only survive around singletons. Close encounters or the presence of a stellar companion will perturb the planetary system, often leaving planets on tighter and more eccentric orbits.

10.7 “The Lambda Orionis Star Forming Region: the Spitzer Perspective”

Morales-Calderon, M., Barrado y Navascues, D., Stauffer, J.R., & Bayo, A.

The Head of Orion is a complex star forming region which includes a young open cluster, Collinder 69 ($\sim$6 Myr), two dark clouds (Barnard 30 and Barnard 35, with younger populations, $\sim$3Myr) and other younger areas (LDN 1588 and LDN1603, $\sim$1Myr). We have observed one, or half a square degree in each of these regions in order to study the stellar and substellar population. These data have been complemented with optical and near infrared photometry and spectroscopy. Among the issues we are studying are the difrent types and properties of the circumstellar disks through the ages thought to be crucial to understanding disk dissipation and planetary system formation. We are also trying to explain all these properties in the context of the differences in the local environment and evolution.

10.8 "Bondi-Hoyle Accretion in Star Clusters: Implications for Stars, Disks, and Planets"

Throop, H., & Bally, J.

We investigate the Bondi-Hoyle accretion of gas from a parent molecular cloud onto young star-disk systems in a cluster. This post-formation accretionary phase can continue for several Myr after young stars are born, until the gas is dispersed from the cluster, or when low-mass stars are ejected from the cluster. We perform N-body simulations of stars orbiting in young model clusters using 30, 500, and 3000 stars. We include the gravitational effects of stars and gas, and include the dispersion of gas in response to stellar winds and high-mass star formation. A star-formation efficiency (SFE) of 33% is assumed. Initial conditions roughly simulate those in the Taurus, IC348, and Orion clusters after star formation has begun.

We find that for solar-mass stars, the total mass accreted is roughly 0.1 $M_\odot$, 0.05 $M_\odot$, and 0.02 $M_\odot$ in the three clusters. The average mass accretion rate dM/dt is roughly 3×10^{-9} $M_\odot$ yr^{-1} in all three clusters, and varies roughly as $M^{2.1}$. The 1σ spread in accretion rates for stars of the same mass varies by a factor of 500, due to variations in stars' position and velocity.

The mass accreted is insignificant compared to the star's mass, but it is comparable to or greater than the disk mass. For small clusters, the mass accreted onto a star over several Myr can be 10x that of the minimum-mass solar nebula (MMSN). SPH simulations Ruffert (1999) and others show that the accretion flow is likely to pass through the disk, where it may significantly affect the planetesimal and planet-formation process, by increasing the amount of raw material available, and providing a steady stream of this material over several Myr. We discuss a variety of implications of this process, including its effect on the formation of terrestrial and gas-giant planets, the migration of extrasolar planets, FU Ori outbursts, and metallicity variations between a star and its planets.

The accretion rates modeled here are consistent with observations showing $\dot{M} \sim M^2$ in young stars (*e.g.* Muzerolle et al 2005). Our rates are lower than those observed by a factor of 5-10, indicating that other processes also contribute to the accretion. Nevertheless, the Bondi-Hoyle accretion rate is high enough that it may have a substantial and unappreciated effect on the formation of planetary systems.

11.1 "Near Infrared Spectroscopic Detection of Close Orbiting Extrasolar Giant Planets"

Barnes, J.R., Jones, H.R.A., Leigh, C.J., Barman, T.S., Prato, L., Segransan, D., Collier Cameron, A., Pinfield, D.J., & Jenkins, J.S.

I will present prospects for the near infrared spectroscopic detection of close orbiting extrasolar giant planets. Because any absorption signature lies buried in the noise of a spectrum, a multiline deconvolution can be applied to the spectral lines available in order to boost the effective S/N ratio of the data. This method is similar to reflected light studies in the optical but offers a more favourable regime in which to search for a planetary signature since the planet/star flux ratio is predicted to be an order of magnitude greater. I will discuss the sensitivity of the method and estimate detection tolerances for mismatches between observed and model planetary atmospheres. Application of this technique to observations of HD 75289 and HD 189733 is presented for which ~ 2.2 μm planet/star contrast ratio upper limits are presented.

11.2 “Atmospheric Dynamics of Short-period Extra Solar Gas Giant Planets”

Dobbs-Dixon, I., & Lin, D.N.C.

More than two dozen short-period Jupiter-mass gas giant planets have been discovered around nearby solar-type stars in recent years, several of which undergo transits, making them ideal for the detection and characterization of their atmospheres. Here we adopt a three-dimensional radiative hydrodynamical numerical scheme to simulate atmospheric circulation on close-in gas giant planets. In contrast to the conventional GCM and shallow water algorithms, this method does not assume quasi hydrostatic equilibrium and it approximates radiation transfer from optically thin to thick regions with flux-limited diffusion. In the first paper of this series, we consider synchronously-spinning gas giants. We show that a full three-dimensional treatment, coupled with rotationally modified flows and an accurate treatment of radiation, yields a clear temperature transition at the terminator. Based on a series of numerical simulations with varying opacities, we show that the night-side temperature is a strong indicator of the opacity of the planetary atmosphere. Planetary atmospheres that maintain large, interstellar opacities will exhibit large day-night temperature differences, while planets with reduced atmospheric opacities due to extensive grain growth and sedimentation will exhibit much more uniform temperatures throughout their photospheres. In addition to numerical results, we present a four-zone analytic approximation to explain this dependence.

11.3 “A Spitzer Spectrum for HD 189733b”

Grillmair, C.J., Charbonneau, D., Burrows, A., Armus, L., Stauffer, J., Meadows, V., van Cleave, J., & Levine, D.

We report on the measurement of the 7.5-14.7 micron spectrum for the transiting extrasolar giant planet HD 189733b using the Infrared Spectrograph on the Spitzer Space Telescope. The continuum is well measured and has a flux ranging from 0.6 mJy to 1.8 mJy over the wavelength range, or $0.49 \pm 0.02\%$ of the flux of the parent star. The variation in the measured fractional flux is very nearly flat over the entire wavelength range and shows no indication of significant absorption by water or methane, in contrast with the predictions of most atmospheric models. Models with strong day/night differences appear to be disfavored by the data, in agreement with recent IRAC time series photometry, and suggests that heat redistribution to the night side of the planet is highly efficient.

11.4 "Internal Waves Driven by Stellar Irradiation in Hot Jupiters"

Gu, P.-G., & Ogilvie, G.I.

We investigate the dynamical response of a non-synchronized hot Jupiter to stellar irradiation. In our current model, the stellar radiation acts like a diurnal thermal forcing from the top of a radiative layer of a hot Jupiter and excites internal waves propagating into the planet's interior. When the spin is faster than the orbital motion, these waves carry negative angular momentum and are damped by radiative loss in the upper layer of the radiative zone. As a result, the upper layer gains the angular momentum from the lower layer of the radiative zone. Simple estimates of angular momentum flux are made for all transiting planets.

11.5 “The Consistent Modelling of Alkali Lines and Dust Formation in Extreme Exo-planets”

Johnas, C.-M.-S., Helling, Ch., Witte, S., Woitke, P., & Hauschildt, P.-H.

We present the first PHOENIX model atmosphere results for extreme exo–planets where we have coupled a detailed modeling of the alkali line profiles (Johnas et al. 2006) with a non-equilibrium treatment of the formation of chemically heterogeneous dust clouds (Helling & Woitke 2007). Our investigation of the Na I and K I line shows strong differences in shape and depth of the line profiles compared to commonly used impact approximated van der Waals profiles and an previous dust treatment in PHOENIX. The reason for this effect is that these previous attempts of treating dust in phase-equilibrium lead to a much stronger depletion of the remaining atmospheric gas phase. This shows that the modeling of dust formation processes does influence the spectral pseudo-continuum which is determined by the resonance absorption wings of the alkali lines.

11.6 “Determining the Rotational Period, and Inferring the Presence of Clouds, from Photometric Observations of Exoplanets”

Palle, E., Ford, E., Seager, S., Vazquez, M., & Montanes-Rodriguez, P.

Future observations will aim to determine the surface and atmospheric properties of extrasolar planets similar to the Earth. Here, we have modeled changes in the apparent brightness of the Earth (as a function of its phase angle, and in the direction of the observers) due to the rotation and orbital motion of the Earth, as well as to the temporal variability of clouds and ice (on daily and seasonal timescales). We apply reflectance models that have been previously validated with observations of the Earthshine that illuminates the dark side of the Moon. We use real cloud data from satellite observations to characterize the hourly, diurnal, and seasonal variability that we might observed in earth-like extrasolar planets. We find that measuring the rotation period of the Earth is non-trivial, even for high signal-to-noise observations, largely due to the temporal variability of cloud cover on timescales comparable to the rotation period. If the rotation period can be measured, then deviations from a periodic signal can be used to infer the presence of tracers (relatively short-living structures) in its atmosphere (i.e., clouds). This could provide a useful technique for recognizing exoplanets that have weather (i.e., cloud cover changing on a diurnal timescale). Such variability is likely to be related to the atmospheric temperature and pressure being near a phase transition. Thus, such observations would support the possibility of liquid water on an extrasolar planet.

11.7 “Planetary Atmospheres - the Search for Reflected Light”

Rodler, F., & Kurster, M.

To date, more than 200 exo planets have been found, but we still lack knowledge of their atmospheres. Here, we present an interesting approach to get information about the planetary athmospheres: the search for star light reflected from exo planets.

Previous high S/N spectroscopic campaigns on the search for reflected light ended up in establishing upper limits to the planet-star flux ratios of the order of 5×10^{-5} in the visual, indicating low reflectivity of these planets.

We present our studies on the search for reflected light and will discuss different approaches. In addition to that, we present a reanalysis of archive data in order to establish a new upper limit to the planetary reflectivity.

12.1 "ARTEMIS (Automated Robotic Terrestrial Exoplanet MIcrolensing Search) – A Possible Expert-system Based Cooperative Effort to Hunt for Planets of Earth Mass and Below"

Dominik, M., Horne, K., Allan, A., Rattenbury, N.J., Tsapras, Y., Snodgrass, C., Bode, M.F., Burgdorf, M.J., Fraser, S.N., Kerins, E., Mao, S., Mottram, C.J., Steele, I.A., Street, R.A., Wheatley, P., & Wyrzykowski, L.

The technique of gravitational microlensing is currently unique in its ability to provide a sample of terrestrial exoplanets around both Galactic disk and bulge stars, allowing to measure their abundance and determine their distribution with respect to mass and orbital separation. Thus, valuable information for testing models of planet formation and evolution is gathered, constituting an important piece in the puzzle for the existence of life forms throughout the Universe. However, in order to achieve these goals in reasonable time, a well-coordinated effort involving a network of 2m or 4 $\times$ 1m telescopes is required. Such effort could lead to the first detection of an Earth-mass planet outside the Solar system, and even planets less massive than Earth could be discovered. From April 2008, ARTEMIS (Automated Robotic Terrestrial Exoplanet MIcrolensing Search) shall provide a platform for a three-step strategy of survey, follow-up, and anomaly monitoring. As an expert system embedded in eSTAR, ARTEMIS will give advice for follow-up based on a priority algorithm that selects targets to be observed in order to maximize the expected number of planet detections, and will also alert on deviations from ordinary microlensing light curves by means of the SIGNALMEN anomaly detector. While the use of the VOEvent protocol allows a direct interaction with the telescopes that are part of the HTN (Heterogenous Telescope Networks) consortium, additional interfaces provide means of communication with all existing microlensing campaigns that rely on human observers. The success of discovering a planet by microlensing critically depends on the availability of a telescope in a suitable location at the right time, where the latter can mean within 10 minutes. To encourage follow-up observations, microlensing campaigns are therefore releasing photometric data in real time. On ongoing planetary anomalies, world-wide efforts are being undertaken to make sure that sufficient data are obtained, since there is no second chance. Real-time modelling offers the opportunity of live discovery of extra-solar planets, thereby providing "Science live to your home".

12.2 “Properties of Low Mass Planets Detected by Microlensing”

Donatowicz, J.

4 planets have been detected so far with the microlensing technique. We will show that follow up observations by the second generation of VLTI instrumentation will allow us to directly detect the lens and greatly improve our knowledge of the systems: By detecting the lens star, we will obtain accurate determination of the mass of the planet, and its orbital separation. We will use OGLE-2005-BLG-390Lb ($\sim$5.5 Earth mass orbiting a red dwarf at $\sim$2.8 AU) as an illustration.

12.3 “The Space Interferometry Mission PlanetQuest”

Kulkarni, S.

TBD

12.4 “ESPRI: Exoplanet Search with PRIMA“
Setiawan, J., & ESPRI consortium

Narrow-angle astrometry is a powerful tool for detecting and characterizing extrasolar planets, very complementary to the radial velocity technique. However, to play a significant role, an astrometric accuracy of order 10 mu-arcsec is needed, which is beyond the performance of current instrumentation. To achieve this accuracy and carry out an astrometric planet search program, a consortium with partners from Germany and Switzerland, in agreement with ESO, will enhance the PRIMA facility (Phase-Referenced Imaging and Micro-arcsecond Astrometry) at the VLTI with Differential Delay Lines and Astrometric Data Reduction Software. PRIMA will implement dual-star interferometry at the VLTI, thus enabling high-precision narrow-angle differential astrometry. The primary new discovery space opened by PRIMA will be Saturn down to Uranus-mass planets with orbital periods of a few years (a=1-5AU) around nearby (<15pc) late-type (M-F) main sequence stars as well as Jupiter-mass planets around young (and active) stars. When completed in late 2008, we will use the facility to carry out a large astrometric planet search program. The main goals of this program are: (i) the determination of masses and orbital parameters of known radial velocity planets; and (ii) the search for new planets around nearby stars of different spectral type and age (down to 10 Myr). This poster gives an overview of the ESPRI project, covering hardware and software developments as well as the anicitipated planet search program.

12.5 “Finding Planets around M Dwarfs from Space”

Tanner, A.

Radial velocity surveys have been the workhorse for planet finding over the past ten or so years. The inclination ambiguity inherent with these types of measurements, however, prevents definitive studies in the properties of the solar systems as a function of their mass. The necessity for stable photospheres and large signal to noise over multiple wavelengths eliminates both young and late type stars. Astrometry, on the other hand, provides an unambiguous mass estimate of the planet, is less susceptible to photospheric jitter and is ideal for planet searches around low-mass stars. While there are a hand-full of ground-based astrometric searches being conducted, the future of astrometric planet finding lies in space-based missions. Here, I will review the astrometic capabilities of future space missions including Kepler, GAIA and SIM PlanetQuest. Astrometric surveys are particularly suited to finding planets around low mass stars since the lighter stellar mass produces a larger astrometric signal for a given planet mass. Indeed, it will be missions like SIM PlanetQuest which will be able to detect terrestrial mass planets in the habitable zones of nearby solar-type stars.

12.6 "SPHERE/ZIMPOL: Simulating the Direct Detection of Exoplanets by Polarimetry"

Thalmann, C., Boccaletti, A., Mouillet, D., Dohlen, K., Carbillet, M., Schmid, H.M., Roelfsema, R., Beuzit, J.-L., & the SPHERE Consortium

The detection of reflected light from an old (> 1 Gyr) Jupiter-like extra-solar planet has not yet been achieved due to the very high intensity contrast ($\sim 10^{-8}$) and the small angular separation between the planet and its parent star. One goal of the ESO planet finder instrument SPHERE is to perform such a direct detection using a large telescope (VLT), an extreme AO system, a stellar coronagraph, and a sophisticated polarization imager.

Light scattered off a gas planet's atmosphere becomes polarized in the process. This property provides the possibility to detect a polarization signal from a planet among the unpolarized residual light halo of the coronagraphic, AO-corrected image of a bright star with a sufficiently powerful polarimeter. In SPHERE, polarimetry will be possible with the Zurich Imaging Polarimeter (ZIMPOL), an instrument concept based on fast (kHz) polarization modulation and demodulating CCD detectors. ZIMPOL has been proven to achieve polarimetric sensitivities of 10^{-5}.

In order to investigate the feasibility and the expected performance of this instrument, we provide simulations made with IDL-based AO, diffraction, photometry and reduction code, using up-to-date error estimations from the current SPHERE/ZIMPOL design study as input parameters. We conclude that direct detection of Jupiter-like planets in close orbit around the brightest nearby stars is achievable with three levels of differential methods: polarimetric imaging as basic differential technique; polarization switching to subtract static instrumental effects, and field rotation to average down any remaining spatial features.

12.7 “Results from the Keck ET Exoplanet Survey”

van Eyken, J.C., Ge, J., Lee, B., Kane, S.R., Mahadevan, S., Fleming, S.W., Guo, P., Wan, X., Zhao, B., Crepp, J., Cohen, R., Galvez, M.C., Groot, J., & Warner, C.

The W. M. Keck Exoplanet Tracker (Keck ET) is a precision Doppler radial velocity instrument based on dispersed fixed-delay interferometry, a new technique that allows for multi-object RV surveying for extrasolar planets. Installed at the 2.5m Sloan telescope at Apache Point Observatory, the combination of Michelson interferometer and medium resolution spectrograph is designed for simultaneous precision Doppler measurements of up to 60 targets. Using the same technique, the single-object prototype ET installed at the KPNO 2.1m telescope was previously used to discover a new 0.49MJup (m sin i) planet, HD 102195b (ET-1). The Keck Exoplanet Tracker now yields 59 usable simultaneous fringing stellar spectra, of a quality sufficient to attempt to detect short period hot-Jupiter type planets. Although systematic errors remain to be addressed, typical photon limits for stellar data are now around the 30m/s level for magnitude V around 10.5 (best 6.9m/s at V=7.6), and short-term RMS precisions approach this limit. Engineering upgrades are underway at APO at the time of writing to try and further improve this. A number of targets showing interesting RV variability are under investigation, and here we present an update on these and the current status of the ET project.

13.1 “Liquid Water on a Frozen Extrasolar Planet?”

Ehrenreich, D., Lecavelier des Etangs, A., Beaulieu, J.-P.m & Grasset, O.

The microlensing technique used to detect extrasolar planet is sensible to low-mass planets orbiting a few astronomical units away from their parent star. The detection of OGLE-2005-BLG-390Lb (Beaulieu et al. 2006) around an M star in the Galactic Bulge unveils the existence of cold (∼40K) Earth-mass planets. Such planets could nevertheless host liquid water beneath a frozen surface, because of a strong radiogenic heating of the ice shell. Heating and cooling of the ice shell depend on the ice-to-rock ratio (I/R) and the age of the planet planet. OGLE 390Lb now seems too old (∼10Gyr) to host a subsurface ocean, for any tested I/R value. However, the heat production rate was larger in the past so that liquid water did flow for several billions of years underneath the ice shell.

13.2 “Jupiter - Friend or Foe?”

Horner, J., & Jones, B.W.

It has long been assumed that the planet Jupiter acts as a giant shield, significantly lowering the impact rate on the Earth, and thus enabling the development and evolution of life in a collisional environment which is not overly hostile. However, in the past, little work has been carried out to examine the validity of this idea. In the first of a number of papers, we examine the degree to which the impact risk resulting from a population representative of objects evolving inward from the outer Solar System is enhanced or lessened by the presence of a giant planet, in an attempt to fully understand the impact regime under which life on Earth has developed. The results show that the situation is far less clear cut that has previously been assumed, for example, the presence of a giant planet can act to significantly enhance the impact rate at the Earth.

13.3 “Proposed Spectral Features for Earth-like Exobiopheres”

Montanes-Rodriguez, P., Palle, E., & Guerrero, E.M.

Since the discovery of the first planet outside the solar system, the number of planet detections is increasing exponentially. Although we have not been capable of detecting and exploring planets like our own yet, challenging space missions are already being planned for the next decades, and the discovery of earth-like planets is only a matter of time. When the time arrives, one of our main concerns will be to determine their degree of similarity with our own planet. This will necessarily include the search for life and meteorological patterns. We have considered the real distribution of clouds on Earth during an entire year, and our results show that terrestrial vegetation can be detected when Earth is observed as a distant planet, although its signal will be measurable only for small angular distances between the planet and the parent star. The combination of other spectral signals can provide evidence of planetary meteorology. Here we study these signals in several earthshine spectra.