The 2nd Rencontres du Vietnam on Exoplanetary Science
Quy Nhon, Vietnam 25th February to 2nd March, 2018

List of Abstracts

1. Talk by **Alain Lecavelier des Etangs** (Institut d'Astrophysique de Paris)
Title : Exocomets
Extrasolar comets, or exocomets, are detected using transit spectroscopy in young planetary systems. In particular, Beta Pictoris observations revealed a high rate of transits, allowing statistical analysis of exocomets populations in this system. With the study of more than 1,000 archive spectra, we obtained a sample of several hundred exocomets signatures in transit in front of Beta Pictoris. The statistical analysis showed the existence of two populations with different physical and dynamic properties. A first family consists of exocomets, which can be attributed to ancient comets trapped in a mean motion resonance with a massive planet, possibly β Pic b. The second family consists of exocomets, which may be the result of the recent fragmentation of one massive parent body.

Recently, our observations obtained with the Hubble telescope led to the first detection of exocomets in the far ultraviolet. Several atomic elements have been detected for the first time in these exocometes, in particular atomic hydrogen, oxygen and neutral nitrogen. The measurement of the abundance of these species in the exocomets is crucial to understand the processes of condensation and evaporation present in the last stages of the planetary formation. Preliminary results will be presented.

Finally, we will present analysis of Kepler light curves, that can be interpreted by exocomets transits. Peculiar attention will be given to the case of KIC8462852.

2. Talk by **Eiji Akiyama** (National Astronomical Observatory of Japan)
Title : Observations of protoplanetary discs: pathway to planet formation
Protoplanetary disks are the sites of planet formation but how these disks evolve into planetary systems is a long-standing mystery. In this talk, I will review our understanding of protoplanetary disks and show recent NIR and mm/sub-mm observational results of disk demographics, geometrical structures, dust properties and grain growth, gas to dust ratio, chemical composition including prebiotic organic materials, and polarization. In particular, the disks with holes or gaps that many researchers have posited as the signpost of planets will be stressed. I will conclude by showing future directions for our study of planet formation and new observational instruments and operations in the coming years that may provide the answer for the key questions.

3. Talk by Olja Panic (University of Leeds)
Title : Secrets of giant planet formation: Massive Herbig-Ae discs
Our recent survey of the gas and dust inventory in the discs of the Herbig Ae star population (1.5-3.5Msun, 5-10Myr) revealed overall high dust and gas masses. This is surprising considering that similar ALMA surveys of lower mass stars showed that protoplanetary discs are dispersed and giant planet formation halted by such advanced age of 5-10Myr. He hypothesize that the discs around the intermediate-mass stars follow a different evolution, in terms of their photoevaporation, temperature, and chemistry when compared to lower mass stars, causing

longer lifetime of the disc mass reservoir as suggested by our ALMA data. This may explain why intermediate mass stars have the highest frequency of detected giant exoplanets. We present an overview of the current knowledge of the intermediate-mass pre-main sequence population as a whole and discuss how the challenges in characterising their disc evolution may be overcome with existing and upcoming telescopes, testing the above hypothesis.

4. Talk by **Taichi Uyama** (University of Tokyo)
Title : Search for Accretion Signatures of Exoplanets within TW Hya Transitional Disk
We present near-infrared direct imaging search for accretion signatures onto possible protoplanets within protoplanetary disks. Paβ line (1.282 μm) is an indication of accretion onto a protoplanet, and its intensity is much higher than that of blackbody radiation from the protoplanet. We focused on the Paβ line and observed TW Hya, which has a multi-ring disk exhibiting evidence of planet formation, with Keck/OSIRIS.
Although no accretion signatures were detected using spectral differential imaging data reduction, the results of the present study allowed us to set 5σ detection limits for Paβ emission of 5.8×10^(-18) and 1.5×10^(-18) erg/s/cm^2 at 0.4" and 1.6", respectively. We considered the mass of potential planets using theoretical simulations of circumplanetary disks and hydrogen emission. The resulting masses were 1.45±0.04 Mj and 2.29±0.04 Mj at 25 and 95 AU, respectively, which agree with the detection limits obtained from previous broadband imaging. The detection limits should allow the identification of protoplanets as small as ~1 Mj, which may assist in direct imaging searches around faint YSOs for which extreme adaptive optics instruments are unavailable.

5. Talk by **Anne-Marie Lagrange** (Institut de Planétologie et d'Astrophysique de Grenoble)
Title : Results from directly imaged planets
"Few exoplanets have been imaged and characterized so far due to the technical challenges associated to high contrast direct imaging. Yet, they bring unique information on planetary systems formation and evolution, very complementary to indirect detections. After a brief review of the technical challenges, I will describe the results obtained, especially with the recent extreme adaptive optics, high contrast instruments SPHERE and GPI. I will then describe a plausible roadmap towards Earth-like planets imaging and characterization."

6. Talk by **Henriette Schwarz** (UC Santa Cruz)
Title : Spinning Worlds - The rotation of young gas giants and brown dwarf companions
I present the first rotation measurements of directly imaged planets and brown dwarf companions, measured from the Doppler broadening of the spectral lines. The rotation influences weather and climate, temperature distribution, chemical mixing, and the magnetic field. More than that, the planetary spin is the result of accretion of angular momentum during the formation, and observing planetary spin rates may promote our understanding of the accretion process or even help differentiate between opposing formation scenarios.

The observed targets span a range of masses, ages and orbital distances, providing the first opportunity to compare the spin parameters of young exoplanets and brown dwarf companions. Although the observed sample is small, we do see a correlation of spin velocity with age, which we interpret as due to the youngest objects still accreting angular momentum and spinning up through subsequent cooling and contraction.

7. Talk by **Ryan Garland** (University of Oxford)
Title : Bayesian Atmospheric Retrievals of Ultracool Late-T and Early-Y dwarfs
A significant number of ultracool (<600K) extrasolar objects have been unearthed in the past decade thanks to wide-field surveys such as WISE. These objects present a perfect testbed for examining the evolution of atmospheric structure as we transition from typically hot extrasolar temperatures to the temperatures found within our Solar System.

By examining these types of objects with a uniform retrieval method, we hope to elucidate any trends and (dis)similarities found in atmospheric parameters, such as chemical abundances, temperature-pressure profile, and cloud structure, for a sample of 7 ultracool brown dwarfs as we transition from hotter (~700K) to colder objects (~400K).

We perform atmospheric retrievals on two late-T and five early-Y dwarfs. We use the NEMESIS atmospheric retrieval code coupled to a Nested Sampling algorithm, along with a standard uniform model for all of our retrievals. The uniform model assumes the atmosphere is described by a gray radiative-convective temperature profile, (optionally) a self-consistent Mie scattering cloud, and a number of relevant gases. We first verify our methods by comparing it to a benchmark retrieval for Gliese 570D, which is found to be consistent. Furthermore, we present the retrieved gaseous composition, temperature structure, spectroscopic mass and radius, cloud structure and the trends associated with decreasing temperature found in this small sample of objects.

8. Talk by **Jonathan Gagné** (Carnegie DTM)
Title : Young Stars and Isolated Planetary-Mass Objects in the Solar Neighborhood
I will present new developments in the construction of a Bayesian classification tool to identify members of the 27 known young associations within 150 pc from partially complete kinematic data sets such as Gaia-DR1 and DR2. The new BANYAN-Sigma tool makes it possible to quickly analyze massive data sets and yields a better classification performance than all of its predecessors. This tool will allow to uncover many new stars for direct imaging of exoplanets and age-date exoplanet systems that are unrecognized members of young associations in the Solar neighborhood. I will also presents preliminary results of a search for T-type isolated planetary-mass objects in these young associations, based on BANYAN-Sigma and a cross-match between the AllWISE and 2MASS-Reject catalogs.

9. Talk by **Calire Moutou** (Canada-France-Hawaii Telescope)
Title : High precision radial velocities in optical and infrared
Since 1995, radial velocity (RV) measurements have been massively used for exoplanet searches with optimized high-resolution spectrographs. Several major issues have to be handled in order to carry out such measurements, such as: the light injection, the wavelength calibration, the spectrograph environment, and the data reduction. The RV precision was of the order of 100 m/s, 30 years ago, then 10 m/s with the first-generation velocimeters. The precision level of 1 m/s has been achieved in the optical in the early 2000s and is very close to being obtained in the near-infrared domain -while the new challenge of 10cm/s is now tackled by optical spectrographs. At each step in precision, and depending on the chosen wavelength of observations and targets of interest, the limiting factors are different. I will present a review of the challenges, highlights, and prospects of the optical and near-infrared RV instruments for exoplanet searches.

10. Talk by **Antoine Grandjean** (Institut de Planétologie et d'Astrophysique de Grenoble)
Title : HARPS survey result on close-by young star radial velocity
Young, close-by stars of a few Myr to a few hundreds Myr are the only sources offering the opportunity in the coming decade to fully explore their giant planet population. This will be achieved by the combination of complementary (in terms of achievable separations) approaches: the new generation of planet imagers on 10-meter class telescopes (like SPHERE at VLT) and high precision spectrographs, possibly completed by astrometric-precision surveys (Gaia). Given their ages, Young stars also represent unique laboratories to study the on-going planet formation processes, in particular the final stages of telluric planets formation, as well as the building-up of planetary systems architectures. We have completed a spectroscopic survey with HARPS and SOPHIE to search for short period (< 1000d) planets around more than 150 members of young, close-by associations. These stars are also targets of our on-going GTO SPHERE SHINE imaging survey to search for longer period planets. I will present the results of the HARPS survey, and for a subset of data, results of the SHINE survey as well.

11. Talk by **Richard Hall** (University of Cambridge)
Title : The Terra Hunting Experiment: demonstrating the feasibility of intense radial velocity surveys for Earth-twin discoveries
The detection of an Earth-mass planet in the habitable zone of a solar type star will be a ground breaking discovery. Current instruments are just shy of the precision needed to make these detections, and we are still confounded by the quasi-periodic stellar signals.

The HARPS3 instrument is designed to have the measurement precision required to make this discovery, and the Terra Hunting Experiment will have a unique and intense observation schedule to help combat the stellar signals.

In this talk I discuss an end to end simulation of HARPS3 radial velocity data and use a multi-nested Bayesian analysis package to find the planetary candidates within the data. We factor in the full 3D Keplerian system architecture, realistic stellar noise, a proposed observation schedule and location specific weather patterns for our entire 10 year survey.

I will discuss our promising results in the context of detecting long period earth planets and compare them to simulated results of a typical radial velocity survey. We also include the results of a continuous data series, representing the space-observatory case.

12. Talk by **Carole Haswell** (The Open University)
Title : Finding low mass planets orbiting bright, nearby stars: The Dispersed Matter Planet Project
A quarter of known short-period exoplanets orbit stars showing anomalously low stellar chromospheric emission. We attribute this to absorption by circumstellar gas replenished by mass loss from highly irradiated ablating planets, though for some more distant host stars interstellar absorption contributes. Among thousands of nearby bright stars, a few show depressed chromospheric emission indicative of undiscovered mass-losing planets. Because many nearby bright stars had already been observed by wide-field transit surveys and had radial velocity reconnaissance measurements performed, we suspected these undiscoveredlanets are most likely to be small and low mass. The Dispersed Matter Planet Project (DMPP) is conducting high cadence, high-precision radial velocity measurements and

finding these planets. Because DMPP targets are chosen by the signatures of circumstellar absorption in the stellar spectra, they are amenable to follow-up compositional analysis via transmission spectroscopy. This will allow empirical exogeology of sublimating rocky planets. The DMPP shrouded planetary systems are presumably a short-lived phase which may help explain the Neptunian desert: i.e. the dearth of intermediate-mass planets at short orbital periods.

13. Talk by **Ryan Cloutier** (University of Toronto)
Title : Discovering the Closest Habitable Worlds: Planet Detection Predictions for the SPIRou Legacy Survey-Planet Search
Small and cool M dwarfs outnumber Sun-like stars in the solar neighbourhood by nearly 4:1. Furthermore, M dwarfs are known to host numerous super-Earth-sized planets including one potentially habitable Earth-like planet for every four M dwarfs. To uncover this new population of planets around nearby M dwarfs---within ~ 10 pc---many ground-based hi-precision velocimeters will be optimized for operation at near-infrared wavelengths. One such instrument is SPIRou, whose first-light is scheduled on the 3.6m Canada-France-Hawaii Telescope in 2018. Shortly afterwards, the SPIRou science team will initiate the SPIRou Legacy Survey-Planet Search (SLSPS); a 3-5 year long planet survey around ~ 100 nearby M dwarfs in the Northern sky with an expected radial velocity precision of ~ 1 m/s. To access the expected planet yield in the SLSPS, we have conducted a detailed Monte-Carlo simulation of the full SLSPS. These simulations rely on our current understanding of the occurrence rate of M dwarf planetary systems and the intrinsic levels of stellar activity that these stars exhibit. Simultaneous modelling of planetary signals and activity allows us to estimate the number of planet detections in the SLSPS and their expected properties. I will present numerous highlights from the predicted SPIRou planet population including some prospects for the exciting observational follow-up opportunities that these planets present. Such highlights include the study of some of the closest habitable worlds which will be amenable to high-contrast imaging with ELTs in the coming decades.

14. Talk by **Heather Cegla** (University of Geneva)
Title : The Rossiter-McLaughlin effect reloaded: 3D orbital architectures and spatially-resolved stellar spectrums down to the coolest host stars
When a planet transits its host star, it obscures regions of the stellar surface and induces changes in the line-of-sight (LOS) Doppler velocities, known as the Rossiter-McLaughlin (RM) effect. Since the observed velocities depend on the stellar rotation and the trajectory of the planet across the stellar disk, this effect is sensitive to the star-planet alignment (which provides information on the system's dynamical history). Traditional RM analyses utilise some key assumptions: that the stellar surface is represented by homogenous Gaussian functions, and that rigid body stellar rotation is the sole contributor to the LOS velocities. However, these assumptions can be incorrect, and we have predicted that they may introduce systematic errors in sky-projected obliquities up to 20-30 degrees (Cegla et al. 2016a). To obviate these assumptions, we developed the 'reloaded RM' technique to directly measure the starlight behind the transiting planet and therefore spatially resolve the stellar spectrum along the transit chord. I will present this technique and show a successful proof-of-concept applied to the aligned HD 189733 system (Cegla et al. 2016b), as well an application to the highly-misaligned WASP-8 system (Bourrier et al. 2017a). For the WASP-8 system, we found a large variation in the local photospheric profile contrast, hitherto undetected in classical RM techniques; this resulted in the

system being 20 degrees more misaligned than that reported by Queloz et al. 2010. I will also present the first detection of an orbital architecture for a low-mass planet transiting a M dwarf star (Bourrier et al., accepted). This detection opens the way to the study of planetary dynamics around cool stars, which will be observed in their thousands by incoming transit (CHEOPS, TESS, TRAPPIST, SPECULOOS) and velocimetry (SPIRou, NIRPS) surveys. Hence, the reloaded RM provides a powerful tool to probe both stellar astrophysics and planetary evolution, whilst still being applicable to some of the coolest and slowest rotating systems.

15. Talk by **John Livingston** (University of Tokyo)
Title : New Planets from K2
The NASA K2 mission has continued to yield large numbers of new planet discoveries in its second year. We have carried out a systematic program of transit detection and ground-based follow-up, resulting in a sample of well-vetted planet candidates. The K2 photometry along with constraints from follow-up spectroscopy and high resolution imaging have enabled us to statistically validate a large fraction of these systems. Of particular interest are a number of planets with bright host stars which are amenable to detailed characterization via radial velocity mass measurement and transmission spectroscopy, multiplanet systems, and small planets receiving Earth-like insolation. By conducting follow-up transit photometry with Spitzer, we have also refined the ephemerides of many interesting systems, which helps to ensure the feasibility of future atmospheric studies (i.e. with JWST).

16. Talk by **Jiwei Xie** (Nanjing University)
Title : The scientific impact of the LAMOST on exoplanet research
Abstract: With the discoveries of thousands of planets, the Kepler mission has brought revolutions to the exoplanet researching field, which is advancing from studying individual exoplanets to characterizing planet populations. However, making any reliable statistical inference with a large Kepler planet sample is seriously limited by the lack of accurate stellar parameters for the majority of the targets. With 4000 fibers and 5 degrees of diameter field of view, the LAMOST is uniquely positioned to perform a systematic spectroscopic survey of Kepler target stars, forming a complete and unbiased sample to perform statistical inference on planet distribution and correlations with host properties, which provides new insights on planet formation and evolution. This talk will review several such statistical studies, showing how LAMOST can impact the study Kepler planets. In the future, LAMOST will continue to play such a crucial role in the TESS era.

17. Talk by **Amaury Triaud** (University of Birmingham)
Title : TRAPPIST-1 and other planetary systems around low-mass stars
The smaller the mass of a star, the more amplified the signal for putative exoplanets will be. A number of projects have benefitted from this effect. In addition to an ease of observation, low mass stars provide an opportunity to study the outcome of planet formation in settings that are different to those existing in the Solar system. They also speed up investigations into the atmospheric composition of terrestrial planets. In this review, I will describe the results obtained around low mass stars, and what we can expect them to teach us.

18. Talk by **Quentin Kral** (Institute of Astronomy in Cambridge)
Title : Effects of impacts on the TRAPPIST-1 planets
The TRAPPIST-1 system is unique in that it has a chain of seven terrestrial Earth-like planets located close to or in its habitable zone. In this talk, I will present the effect of potential cometary impacts on the TRAPPIST-1 planets and how they would affect the primordial atmospheres of these planets. We consider both atmospheric mass loss and volatile delivery with a view to assessing whether any sort of life has a chance to develop. We find that impacts happen at high velocities and can easily destroy the primordial atmospheres of all seven planets, even if the outer belt from which the comets are produced is very low mass similar to the Kuiper belt. However, we find that the atmospheres of the outermost planets can also easily be replenished with cometary volatiles, the bulk of which is water (> an Earth ocean mass could be delivered) and we thus predict that these planetary atmospheres should be more massive than those of the innermost planets. I will also discuss our results in the context of the most recent theories of abiogenesis, which involve impacts, UV irradiation and a hard planetary surface that may all be present in this system.

19. Talk by **Jason Dittmann** (MIT)
Title : LHS 1140b: A temperate super-Earth around a nearby M dwarf
Exoplanets around nearby small stars present the best opportunity for future atmospheric studies with the James Webb Space Telescope and the ground based ELTs under construction. MEarth has recently discovered LHS 1140b, a rocky super-Earth in the habitable zone of a nearby, quiet M dwarf. The long orbital period of this planet required MEarth to detect it via a single transit event aided through machine learning techniques to distinguish it from atmospheric noise. In this talk, I will discuss MEarth's discovery of LHS 1140b and its implications for single-transit detection in the TESS-era. I will also discuss recent Spitzer observations we have obtained of LHS 1140b and their implications for transit timing variations and the presence of other bodies in the system.

20. Talk by **Jack Lissaue**r (NASA Ames Research Center)
Title : Multi-planetary systems: Observations and models of dynamical interactions
More than 600 multi-planet systems are known. The vast majority of these systems have been discovered by NASA's Kepler spacecraft, but dozens were found using the Doppler technique, the first multi-exoplanet system was identified through pulsar timing, and the most massive system has been found using imaging.

More than one-third of the 4000+ planet candidates found by NASA's Kepler spacecraft are associated with target stars that have more than one planet candidate, and the large number of such Kepler "multis" tells us that flat multiplanet systems like our Solar System are common. Virtually all of Kepler's candidate multis are stable, as tested by numerical integrations that assume a physically motivated mass-radius relationship. Statistical studies performed on these candidate systems reveal a great deal about the architecture of planetary systems, including the typical spacing of orbits and flatness.

The characteristics of several of the most interesting confirmed multi-exoplanet systems will also be discussed. HR 8799's four massive planets orbit tens of AU from their host star and travel on nearly circular orbits. PSR B1257+12 has three much smaller planets orbiting close to a neutron star. Both represent extremes and show that planet formation is a robust process that produces a diversity of outcomes.

Although both exomoons and Trojan (triangle Lagrange point) planets have been searched for, neither has yet been found.

21. Talk by **Lea Hirsch** (University of California Berkeley)
Title : Planets in Binary Systems: Assessing the Impacts of Stellar Companions on Planet Formation and Evolution
Nearly half of all solar-type field stars have at least one stellar companion; separately, planets appear to be very common around G and K type stars. Yet the impacts of stellar multiplicity on planet formation and evolution is not well understood. To probe the effects of binary companions on planets, we are performing a dual survey for stellar and planetary companions around a volume-limited sample of sun-like stars out to 25 pc, using both high-resolution imaging (adaptive optics and speckle interferometry) and Doppler spectroscopy. I will describe the observational design and goals of the survey; I will also share new results on several interesting sample targets for which we have combined the imaging and radial velocity measurements to constrain the presence and orbit of companions.

22. Talk by **Leslie Rogers** (University of Chicago)
Title : Internal structures from terrestrial to giant planets: observations and models

23. Talk by **Jay Farihi** (University College London)
Title : Observations of planetary bulk compositions
We are now in a scientific era where the detection of an Earth-like planet is on the horizon. However, in order to determine whether a planet is truly Earth-like, knowledge of the surface is critical. This requires detailed information of planet compositions, which are poorly constrained from transit and radial velocity observations that yield planet radius and mass. The exact composition of planetary material, as derived from white dwarf pollution, provides the perfect tool to lift these degeneracies.

I will present the current state-of-the-art in polluted white dwarf studies, including recent results from Hubble ultraviolet spectroscopy. The data collected to date provide compelling evidence for distinctly terrestrial-like compositions, and chemical differentiation within large parent bodies. Intriguingly, there is now indirect evidence for water-rich (but otherwise rocky) planetesimals that may represent the building blocks of habitable exoplanets.

24. Talk by **Stéphane Mazevet** (Observatoire de Paris)
Title : Ab initio equation of states for planetary and exoplanetary modeling : the case of Jupiter
Using ab initio molecular dynamics simulations, we recently calculated the equations of state for the main constituents of planetary interiors: H, He, H_2O, $MgSiO_3$(MgO,SiO_2) and Fe. These equations of states are multi-phases, include liquid and solid states, and aim at building planetary and exoplanetary interior models solely based on ab initio predictions. This talk will concentrate on Jupiter. We will review how our current understanding of the behavior of these basic constituents at extreme density temperature conditions has modified our current understanding of Jupiter interior, not only for the envelop where metallization of hydrogen and hydrogen-helium demixing is the issue but also for the core where the high pressure melting properties of iron, water and silicates bring a new understanding on the nature of giant planet cores. This work is supported in part by the French Agence National de la Recherche under contract PLANETLAB ANR-12-BS04-0015 and the PSL IRIS project Origins and Conditions for the Emergence of Life

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25. Talk by **David Ehrenreich** (Geneva University)
Title : Observations and theories for atmospheres of transiting planets
Exoplanets transiting their parent stars offer the unique opportunity to measure transmission spectra of exoplanetary atmospheres. During the past 15 years, this technique has revealed the signatures of atomic and molecular species as well as scattering by (unknown) aerosols, allowing us to cast a first glance at the chemical and physical processes occuring in these remote and exotic worlds. These measurements are feeding theoretical models used to constrain the conditions in exoplanet atmospheres, while unveiling the dynamical processes impacting their evolution. One of the most dramatic processes is the escape of atmospheres for highly irradiated planets, which is now thought to have sculpted a large fraction of the irradiated exoplanet population. While the field of exoplanet atmospheric characterisation has been initially advanced by space-borne observations, spectacular progress has been achieved from the ground, especially with high-resolution spectroscopy. After a review of recent observational results and their interpretations, I will discuss what could be expected for the upcoming decade.

26. Talk by **Mau Wong** (NASA/JPL/CALTECH)
Title : Saturn's Upper Atmospheric Density Profile from Doppler Data During Cassini Proximal Orbits, with Exoplanet Pers
Interdisciplinary synergy between the giant planet research and the giant exoplanet research is beneficial to both fields. It leads to a deeper understanding of the origin and evolution of our solar system and extrasolar systems in a more global perspective. Given the currently available observations of extrasolar planets, Saturn and Jupiter are naturally the analogs of choice for similar sized exoplanets around sun-like stars, despite the differences in their orbital distances and temperatures. Comparing the atmospheres of planets from these two worlds is essential to paving the way for a more robust comparative study. Here we discuss the recent findings of Saturn's upper atmospheric density profile from Cassini. After thirteen years of surveying the Saturnian system and providing a multitude of ground-breaking science data, the Cassini spacecraft will perform its final act on September 15, 2017 when it plunges into Saturn's upper atmosphere. This 'close contact' with uncharted territory will deliver sets of data about Saturn that were not previously obtainable. In addition to new information obtained from various science instruments onboard, the doppler signal, primarily used for navigation purposes throughout the tour, will in this circumstance furnish a glimpse of the atmospheric density along Cassini's path through the upper atmosphere. In this talk we will discuss preliminary results from our analysis of the doppler data and its implication on the atmospheric density.

27. Talk by **Lorenzo Pino** (Observatoire de Genève)
Title : Combining low- to high-resolution transmission spectroscopy of hot Jupiters
Combining all transit spectroscopy data sets available from the optical to the near-infrared (NIR) for one of the most iconic exoplanets, the hot Jupiter HD189733b, reveals the dominance of

scattering by aerosols layers, above which a damped water band arise in the NIR and the sodium doublet reaches high altitudes in the thermosphere, as seen in the optical. Only high thermospheric temperatures (up to 10,000 K) or supersolar sodium abundance can explain the deep absorption in the cores of the sodium lines in the presence of aerosols. I will present the PyETA code for comparing synthetic transmission spectra to observations from different instruments (ground-based or space-borne, resolving powers from 10^2 to 10^5), which I employed to obtain these results. By using PyETA models, I will also illustrate a novel technique to characterize aerosols with simultaneous optical to near-infrared coverage of new generation, high-resolution spectrographs (GIARPS: HARPS-N + GIANO, CARMENES, ESPRESSO, …), which opens new perspectives for the characterization of exoplanetary atmospheres.

28. Talk by **Diana Powell** (University of California)
Title : Formation of Titanium and Silicate Clouds on Hot Jupiters
Over a large range of equilibrium temperatures, clouds shape the transmission spectrum of hot Jupiter atmospheres, yet their properties remain unknown. We present the first application of a one-dimensional microphysical and vertical transport model to predict the fully resolved size distribution of titanium and silicate cloud particles in the atmospheres of hot Jupiters. We use the resulting cloud particle size distributions to investigate how observed cloud properties depend on the atmospheric thermal structure and vertical mixing across a range of longitudes along a planet's equator. We uncover a distinct negative correlation between the total cloud mass and equilibrium temperature as well as a positive correlation between the total cloud mass and atmospheric mixing. We find the resultant cloud properties on the East and West limbs show distinct differences that increase with increasing equilibrium temperature. We calculate cloud opacities that are roughly constant across a broad wavelength range with the exception of a feature in the infrared. We suggest that cloud opacities in emission may serve as sensitive tracers of the thermal state of a planet's deep interior due to the existence or lack thereof of a cold trap in the deep atmosphere. We determine that a consideration of the fully resolved size distribution of cloud particles as opposed to a mean particle size has a distinct impact on the resultant cloud opacities. We further find that forward scattering is important across a broad wavelength range when titanium and silicate clouds are present and that the particle size thatcontributes the most to the cloud opacity depends strongly on the specific properties of the cloud particle size distribution. We also determine that it is unlikely that silicate clouds are responsible for the optical Rayleigh scattering slope seen in many hot Jupiters

29. Talk by **Leonardo A. Dos Santos** (Geneva Observatory)
Title : Observability of Earth's exosphere in an extrasolar system
Recent studies revealed that giant extra-solar planets with short orbital periods are surrounded by a neutral hydrogen-rich exosphere, which originates mainly from atmospheric erosion due to stellar radiation pressure. Rocky planets inside the habitability zones of their host stars may have a source of atmospheric hydrogen in the form of water, so it is only natural to ask if we can also detect such H-rich exospheres around them. In this project, we aim to assess if the exosphere of an Earth-like planet orbiting a Sun-like star or M dwarfs can be detected using the current instrumentation available. The hydrogen exosphere of Earth was modeled based on observations of the Ly-alpha; we modeled the transit of Earth's exosphere in front of a Sun-like star and nearby M dwarf stars, and analyzed the feasibility of observing the variation of the Ly-alpha emission line of the star during the transit. Our preliminary results show that the transit of an Earth analogue in the Ly-alpha emission line of a Sun-like star has a depth that is two orders of magnitude below the current detection capabilities of HST/STIS. However, the results seem

more promising for M dwarf stars, with depths of order ~1%, which requires a precision attainable by modern UV detectors.

30. Talk by **Jayne Birkby** (University of Amsterdam)
Title : MEASURE: the MMT Exoplanet Atmosphere SURvEy
High-resolution spectroscopy is a robust and powerful tool in exoplanet characterization. It uses changes in the Doppler shift of a planet to disentangle its spectrum from the glare of its host star. The technique is sensitive to the depth, shape, and position of a planet's spectral lines, and thus reveals information about the planet's composition, atmospheric structure, mass, global wind patterns, and rotation. I will present MEASURE: the MMT Exoplanet Atmosphere SURvEy. This 40 night survey with the ARIES spectrograph is the largest high-resolution study (R~30,000) of exoplanet atmospheres to date. It contains spectra of 11 exoplanets from hot Jupiters to warm Neptunes, both transiting and non-transiting, observing both their dayside and nightside thermal emission. I will describe the survey and present some of its preliminary results focused on thermal inversion layers. The survey not only enables a homogenous dataset to perform comparative exoplanetology, but provides complementary high-resolution spectra for exoplanets observed with HST and Spitzer. The combination of high- and low-resolution spectroscopy can provide stringent constraints on planet metallicity and thermal structure and is the next step in the detailed characterization of exoplanet atmospheres.

31. Talk by **Aurélien Wyttenbach** (Geneva Observatory)
Title : Ground-based observations of hot Jupiter thermospheres: first insight and challenges
Unveiling the characteristics of the numerous extrasolar planets discovered every year is one of the major goal of exoplanetology. Transiting exoplanets are among the best suitable targets for atmospheric studies, particularly with transmission spectroscopy. This technique studies the light filtered through the atmosphere of an exoplanet, as it passes in front of its star. These observations have experienced a rapid development in the last few years, allowing us to precisely probe the low part of atmospheres. Despite these progresses, we are still unable to understand the link between the low and the upper part of atmospheres, with the latter undergoing evaporation. Transit observations from the ground with stabilised high-resolution spectrograph, such as HARPS, have key roles to play in this context. Indeed, while taking care of multiple challenges linked to the stellar lines variability (Rossiter-McLaughlin effect, center-to-limb variation, activity), studies of sodium lines (via the Fraunhofer D doublet) deliver innovative measurements of atmospheres. The measured sodium absorptions in the atmospheres of the two hot Jupiters HD189733b and WASP-49b have revealed new informations about their thermospheres. The thermosphere is a very specific region of intermediate altitudes (very low pressure), where most of the stellar irradiation is absorbed by atoms and molecules, resulting in an upper atmospheric heating. This mechanism potentially lead to an hydrodynamical expansion of the atmosphere that may trigger the exoplanet evaporation. Henceforth, observations at high-resolution, particularly in the optical domain (e.g. with ESPRESSO), are a valuable and important resource in order to understand exoplanets atmospheres.

32. Talk by **Shigeru Ida** (Earth-Life Science Institute in Tokyo)
Title : Dependence of predicted exoplanet distributions on theoretical models
The exoplanet distributions obtained by radial velocity, transit and microlensing observations show a lot of implications for planet formation model. Comparison of the observationally obtained distributions with theoretical planet population synthesis (e.g., Ida & Lin 2008, Mordasini et al. 2009, Ida et al. 2013) strongly suggest that theoretically predicted migrations (both type I and type II migrations) are too efficient to be consistent with the observed

distributions. For type I migration, possible outward migration in viscously heated protoplanetary disks has been proposed (e.g., Paardekooper et al. 2010), while corotation torque saturation limits the outward migration. On the other hand, it has been pointed out that type II migration is not necessarily coupled to disk gas accretion (e.g., Duffell et al. 2014). Pebble accretion is also a new ingredient for planet formation process (e.g., Ormel & Klahr 2010, Lambrechts & Johansen 2012), while it is not clear how much pebble accretion contributes to planet accretion relative to the conventional planetesimal accretion. Note that all of type I & II migrations and pebble accretion are sensitively regulated by details of evolution and structure of protoplanetary disks. I will discuss these issues for better understanding what we have not known in planet formation.

33. Talk by **Vincent Van Eylen** (Leiden Observatory)
Title : Understanding planet formation through asteroseismology
Often, the lack of accurate stellar parameters hampers our understanding of planet formation. Here, I present results from a *gold sample* of planet host stars with parameters determined through asteroseismology, and show how this provides key progress in understanding planet formation and architectures.

For a sample of 117 planets, asteroseismology provided median uncertainties on the radius of 3.3%, enabling not only the detection, but also an interpretation of the radius valley. This valley is a bimodal distribution, with super-Earths ($\approx 1.5~R_\oplus$) and sub-Neptunes ($\approx 2.5~R_\oplus$) separated by a deficiency around $2~R_\oplus$. For the first time, this sample allowed a measurement of the slope of the valley as a function of orbital period, which is consistent with models of photo-evaporation, but not with the late formation of rocky planets in a gas-poor environment. The exact location of the gap further points to planet cores consisting of a significant fraction of rocky material.

Furthermore, I will interpret the so-called Kepler dichotomy, using eccentricity measurements of small planets. Accurate mean stellar densities allow the determination of orbital eccentricities of small planets through transit durations. I show that multi-planet systems are nearly circular, in full agreement with solar system eccentricities, but in contrast to the eccentricity distributions previously derived for exoplanets from radial velocity studies. However, the systems with a single transiting planet have significantly higher eccentricities. I relate these findings to obliquity measurements for multi- and single-planet systems. Finally, I link these findings to planet formation and evolution theory and argue that the eccentricity of systems with a single transiting planet may be related to the presence of non-transiting planets on inclined orbits, but not to the presence of stellar companions.

34. Talk by **Jérémy Leconte** (Laboratoire d'Astrophysique de Bordeaux)
Title : Habitable planets: properties, environment, and pathways to characterization
The universe is a vast place, and a blind search for life out there is short of impossible. Therefore, it is only natural to try and reduce the area to explore by putting in some additional assumptions based on a few educated guesses and a lot of "a priori" experience from what we know about life here on Earth. This appealing path led us to the definition of the so-called Traditional Habitable Zone (THZ). Because this concept has taken what seems to be an ever increasing significance in mission design and selection, I will thus start by briefly discussing its definition, limitations, and usefulness.

Then, I will review what we can learn from the latest 1D and 3D models concerning the processes constraining the possible presence of water on an exoplanet. I will especially focus on the case of planets orbiting ultra-cool stars which will be the first to be observable in the near future.

But what should we do once we have identified one or several golden targets? Indeed, the long awaited detections of some key molecules might very well be marginal at best, even with the new upcoming generation of instruments. So, in the near future, should we just try to stack up as much observations of these difficult targets as we can, hoping to beat the noise? Or are there other pathways to learn about habitability without directly observing a habitable planet?

35. Talk by **Akifumi Nakayama** (University of Tokyo)

Title : Dichotomy of Planetary Climate on Water-rich Terrestrial Planets in the Habitable Zone

Water-rich ocean terrestrial planets in the habitable zone are thought to have extremely hot climate because the high-pressure ice prevents weathering process in the carbon cycle. In this study, we explore the possibility that the high heat flow above the mid-ocean ridge melts the high-pressure ice and its effect on planetary climate. To that end, we develop an integrate climate model for Earth-sized ocean planets that includes melting of the HP ice and the carbon cycle. As a result, we have found that the high-pressure ice is entirely or partially molten, depending strongly on ocean mass. Consequently, seafloor weathering efficiently works, even if the HP ice is present. Moreover we have also found melting of the HP ice enhances the seafloor weathering because the seafloor temperature where the seafloor weathering can work is bounded at melting point regardless of the surface temperature. Thus, the carbon cycle has no negative feedback and planets lapse into snowball state. However, seafloor weathering might have the upper-limit. Therefore, excess water (> 60 Earth ocean mass) on Earth-like planets dichotomizes planetary climate into CO2-rich hot one and CO2-poor cold one. This study stress difficulty of clement climate, like the present Earth, and breakup of the conventional habitable zone in planets with excess amount of water.

36. Talk by **Benjamin Montet** (University of Chicago)

Title : Improving the Detection Efficiency of Small Planets in Transit and Radial Velocity Searches with Data-Driven Approa

Data from the Kepler telescope have shown that small planets are common, but the detection of true Earth analogues in radial velocity and transit observations remains elusive, in part because the amplitude of these signals is dwarfed in size by instrumental systematics. By developing new data-driven methods to better understand and model these instrumental effects, we can improve the sensitivity of these instruments and enhance the yield of both past and future missions. Here, I will discuss how modeling of data from the Kepler mission can be used to separate transiting planets from false positive eclipsing binaries, which can reduce ground-based follow-up work necessary for missions like TESS. I will also discuss methods to separate stellar spectral features from atmospheric telluric features to reduce the effects of unknown micro-tellurics in radial velocity surveys and to improve the precision of these observations to the sub-meter per second level.

37. Talk by **Shay Zucker** (Tel Aviv University)

Title : Shallow Transits - Deep Learning: Harnessing the Full Power of Artificial Intelligence to Detect Habitable Exoplanets

The current bottleneck in the detection of terrestrial planets is caused mainly by the presence of stellar-activity red noise. This structured noise renders the challenge to detect the very shallow transits in lightcurves from dedicated space missions (such as PLATO), extremely difficult. The talk will address the possibility to overcome this hurdle using deep learning. Deep learning is nothing less than a revolution in the field of Artificial Intelligence. Deep learning techniques have proven success in varied fields, such as image processing, speech recognition, autonomous vehicles, and even drug discovery. Specifically, it can provide new hope in needle-in-a-haystack problems, such as the detection of very faint signals in the presence of structured noise. The highly non-linear nature of deep learning renders it completely different from traditional techniques. The talk will give a very short tutorial of what deep learning is, and how it can be applied to detect and analyze transiting terrestrial planets. Results of a pilot study will also be presented.

38. Talk by **Sujan Sengupta** (Indian Institute of Astrophysics)

Title : Polarisation as a potential tool to detect exoplanets and exomoons

While scattering of light by atoms and molecules yields large amount of polarization at the B-band of both T- and L-dwarfs, scattering by dust grains in cloudy atmosphere of L-dwarfs gives rise to significant polarization at the far-optical and infra-red wavelengths where these objects are much brighter. However, the observable disk averaged polarization should be zero if the clouds are uniformly distributed and the object is spherically symmetric. Therefore, in order to explain the observed large polarization of several L-dwarfs, rotation-induced oblateness or horizontally inhomogeneous cloud distribution in the atmosphere is invoked. In this talk I'll show that when an extra-solar planet of Earth-size or larger transits the brown dwarf along the line of sight, the asymmetry induced during the transit gives rise to a net non-zero, time dependent polarization. Hence, I shall convey the message that time resolved imaging polarization should be a potential technique to detect transiting exoplanets around L-dwarfs. Applying the same principal I shall also show that time resolved image polarimetry may help in detecting exomoons around self-luminous directly imaged exoplanets.

39. Talk by **René Doyon** (Université de Montréal)

Title : Future instruments for exoplanets detection and characterization

Exoplanet detection and their characterization have been possible thanks to a wide variety of instruments and telescope facilities, small and big, on the ground and in space. Next year will see the deployment of the James Webb Space Telescope that will provide unique capabilities with unprecedented sensitivity and wavelength coverage for probing the atmosphere of exoplanets through medium resolution spectroscopy, from hot Jupiters to small temperate rocky planets orbiting nearby low-mass stars. In parallel, on the ground, several high-resolution infrared spectrographs are being deployed and will enable detailed studies of transiting and non-transiting systems. WFIRST will soon open a new chapter on high-contrast imaging by enabling the detection and characterization of exoplanets in reflected light. Finally, new instruments, specialized for exoplanet characterization, are already being designed for future extremely large ground-based telescopes and space-based flagship facilities such as LUVOIR. This talk will provide an overview of upcoming instrumental capabilities, present new promising techniques for exoplanet detection and characterization and discuss the various technological challenges associated with these future instruments.

40. Talk by **Diana Dragomir** (MIT)
Title : Maximizing the TESS Mission's Yield of Long-Period Planets
The upcoming TESS mission will discover thousands of transiting planets around bright stars. However, during its 2-year mission the satellite will observe most of the sky for just 27 days. The traditional requirement of at least three transits in order to establish a signal as a planet candidate will limit the orbital periods of TESS planets in most of the sky to 13.5 days. By also pursuing single- and double-transit events, we have the potential to double the number of planets with periods longer than ~13 days that TESS will discover. These additions will facilitate the search for trends between planet properties and their orbital period, and extend the period range over which such studies can be undertaken. Further, this strategy offers the only way for TESS to discover transiting planets in the habitable zones of dwarf stars earlier than M5 throughout most of the sky. I will show how careful prioritization, strategic planning and the judicious use of follow-up observations can confirm these planets and refine their ephemerides.

Through this program, we will generate a sample of long-period planets transiting bright stars that are ripe for mass measurements and atmospheric observations. In turn, these studies will provide constraints on the composition and formation of long-period exoplanets.

41. Talk by **Christian Veillet** (Large Binocular Telescrope Observatory)
Title : Instrumental Developments and Exoplanetary Science at LBTO
With its pair of 8.4m mirrors on a single mount, the Large Binocular Telescope (LBT) offers the gathering power of an 11.8m telescope and the angular resolution of a 22.8m telescope. With its pair of deformable secondary mirrors, it offers excellent adaptive optics (AO) performance, as demonstrated by the imaging of extrasolar planets in the early days of its AO operations.

Since then, various programs in Exoplanetary Science were launched, including the NASA HOSTS mission using the LBT Interferometer (LBTI). We will describe the main scientific objectives of the currently ongoing programs, which also include high spectral resolution transit observations.

We will close the presentation with an overview of the new instruments in development, such as visible and near-IR extreme-AO imagers and a near-IR AO-fed high-resolution and high-stability spectrograph, or in their infancy (interferometry in the visible). They all have exoplanets are targets of choice! Extrasolar Science will contribute to establish LBT as a forerunner of the ELTs, which are still a decade or more away from their full operation.

42. Talk by **Jens Hoeijmakers** (Geneva Observatory)
Title : Molecule mapping with SINFONI and the future of exoplanet characterization in the ELT era
To directly detect an Earth-like planet in the habitable zone of a Sun-like star, a contrast of 1E-10 needs to be achieved. We have proposed to combine high-contrast direct-imaging and high-dispersion spectroscopy to reach this contrast on an ELT (Snellen et. al, 2015). This needs a high-dispersion, AO assisted integral-field spectrograph. The planet is separated from the stellar PSF by spatially resolving it, and by simultaneously cross-correlating with a model spectrum. We show that with existing instruments this technique already provides significant potential: In archival SINFONI (VLT) K-band IFU spectra of β-Pic b we detect H2O and CO at high significance, while ruling out methane and ammonia. We call this method Molecule Mapping, and show that it is able to simultaneously discover a companion and perform a spectroscopic

characterization using a spatial map of the cross-correlation function. Our work gives a new impulse to the development of METIS and HARMONI at the E-ELT, which will be perfectly suited for these kinds of studies.

43. Talk by **Norio Narita** (University of Tokyo)
Title : MuSCAT and MuSCAT2 for detection and characterization of transiting exoplanets
We introduce development and scientific results of 2 multi-color simultaneous cameras, named MuSCAT and MuSCAT2. MuSCAT (Multi-color Simultaneous Camera for studying Atmospheres of Transiting exoplanets) is a 3-color simultaneous camera installed on the 1.88m telescope at Okayama Astrophysical Observatory in Japan. MuSCAT2 is a 4-color simultaneous camera on the TCS 1.52m telescope in Teide Observatory, Canaries, Spain. We will talk about specifications of those instruments, latest results, and future plans.

The 2nd Rencontres du Vietnam on Exoplanetary Science
Quy Nhon, Vietnam 25th February to 2nd March, 2018

List of Posters

1. **Shweta Dalal** (Institut d'astrophysique de Paris): *Giant planets survey with SOPHIE at OHP*.
   Giant planets survey with SOPHIE at OHP
   The SOPHIE spectrograph was installed at Haute Provence Observatory in 2006 in particular to perform various radial velocity surveys to study exoplanets. The goal of one of the SOPHIE surveys, SP2 program, is to improve the statistics on giant extrasolar planets. The current version of the SP2 catalog includes stars at a distance < 60 pc and B − V between 0.35 and 1. The statistical survey of these giant planets allows us to distinguish between exoplanet population like super-Earths, giant planets, and brown dwarfs and also to obtain correlation between the different parameters of these exoplanets and their host stars. It gives us an opportunity to follow-up multi-planet systems and study their characteristics. Thus, detecting and characterizing new giant planets under SP2 program not only allow us to explore the diversity of planetary systems but also put constraints on the models of their formation.
2. **Sebastian Danielache** (Sophia University):
   PATMO a photochemical model for the implementation of chemical networks and its application to exo-atmospheres.
   An important implication of the observation of rocky exoplanet's atmospheres is the possibility to discern weather the observed planet host living systems. The key factor in this search is finding molecules that cannot be created by geochemical mechanisms. Numerous molecules that are present in current Earth atmosphere are of biological origin, yet they can also be produced by specific geochemical processes therefore there is a need to distinguish "biohints" from biomolecules. Part of the methodology to distinguish between a biohint and a biomolecule will depend on whether planetary models are capable of creating a realistic picture of the chemical composition of the atmosphere with very limited planetary information. From a purely atmospheric

modeling point of view the logic by witch a molecule is from biological or geochemical origin is stablished by contrasting a non-biological planet and a planet under the influence of living systems. Non-biological planets are lifeless or with living systems incapable of significantly affect the surface or the atmosphere. By a planet under the influence of living systems the definition is purely limited by the information gathered from observational data. The boundary conditions for a geochemical model require the solar flux from the parent star, gravitational constant, an estimate of the albedo of the surface, and the flux of material into the atmosphere. Based on this information the model computes transport, deposition, chemistry, radiative transfer and the optical opacity of the planet. The ability to reproduce the chemical composition of a given planet resides on the resolution of large networks of chemical reactions coupled to transport and deposition. The extent of the chemistry included in an Earth like planet can be limited to hydrogen and the Carbon, Nitrogen, Oxygen and Sulfur cycles. Regardless of the reducing or oxidizing conditions of an atmosphere the chemical combinations of these elements are vast and each reaction requires specific kinetic data. Furthermore, the photochemistry associated to the incoming UV solar flux requires molecule specific absorption cross sections.

The PATMO model is a 1D photochemical model capable to account for most of the above boundary conditions and in its current state is being used to estimate chemical networks of the main element cycles (C, N, O, H and S). We present a series of results showing that the current chemical networks lack of a significant number of sink reactions that produce unrealistic concentrations of high reactivity radicals incompatible with planetary atmospheres.

3. **Nguyen-Thanh Dat** (Viet Nam National University Ho Chi Minh City):
A search for debris disks around nearby late-M dwarfs using the James Clerk Maxwell Telescope.
Debris disks are indirect evidence for planet formation around stars. While debris disks have been found around A- to K-type stars and some early-M dwarfs, no debris disks have been detected around late-M dwarfs and brown dwarfs so far. Therefore, we first searched for debris disks around three nearby late-M dwarfs by conducting observations at 850 µm with the SCUBA-2 bolometer array at the James Clerk Maxwell Telescope. We did not detect any debris disks around these targets. We estimated upper limits to the dust mass of their debris disks. Further search for debris disks around very close young brown dwarfs is needed to understand the formation of rocky planets around brown dwarfs.

4. **Jerome De Leon** (University of Tokyo):
Detection of Rayleigh scattering feature in the atmospheres of low density exoplanets.
The detection of the signature of Rayleigh scattering in the transmission spectrum of an exoplanet is increasingly becoming the target of observational campaigns because the spectral slope of the Rayleigh continuum enables one to determine the atmospheric scale height and mean molecular weight. This feature is also useful to break the degeneracy between a high-mean-molecular-weight atmosphere and/or high-altitude clouds or hazes to explain several featureless transmission spectra. Here, we present a subset of exoplanets with large scale-heights expected to demonstrate Rayleigh scattering feature in the optical observed using the MuSCAT multi-band instrument. Following a Bayesian framework for simultaneous, multi-band modeling of the transit and systematics enabled the marginalization of the wavelength-dependent radius

variation and careful treatment of their uncertainties. Our tentative results reveal that Rayleigh scattering slope feature can be robustly detected in some low density exoplanets. Our growing catalog of low density planets with well-known Rayleigh scattering feature in the optical offers constraints useful for future atmospheric characterization.

5. **Vedad Hodzic** (University of Birmingham):
   Amelie: Tool for fitting photometry and RVs of transiting planets and eclipsing binary systems.
   We present a flexible code for light curve and radial velocity fitting that can be applied to transiting planets and eclipsing binary systems alike. amelie performs a separate or joint fit on multi-band data with simultaneous detrending. The code uses ellc to generate model light curves and radial velocity curves, and the emcee package to obtain the posterior distribution of the parameters using a Markov chain Monte Carlo algorithm. amelie is currently being applied to the analysis of various systems, with papers being prepared for publication (Triaud et al.; North et al., Hall et al.). In the future, the code will be extended to include Rossiter-McLaughlin analysis, and likely circumbinary planets.

6. **Ko Hosokawa** (SOKENDAI/NAOJ):
   High resolution spectrometer for approaching the atmosphere of exoplanets.
   As of today more than 3500 exoplanets have been discovered, and some planets have been detected the molecule of its atmosphere. High dispersion spectrograph is becoming demanded to obtain the feature of molecule in the atmosphere, but the spectrographs currently in operation have a disadvantage of low throughput. We propose a concept of high wavelength resolution spectrometer with some spatial resolution, based on the Static Fourier Transform (StFT) spectroscopy. It will potentially have High throughput and its compactness comparing to the existing spectrograph. By applying StFT method, we constructed the low resolution prototype of spectrometer, and now my effort has dedicated to upgrading for higher resolution(R~20000) in visible wavelength region. This prototype is planned to finally to have a spatial resolution in near future.

7. **Yuichi Ito** (The University of Tokyo):
   Hydrodynamic escape of mineral atmosphere from hot rocky exoplanet.
   Until today, over 1000 exoplanets whose radii are less than 2 Earth radii have been discovered. About 50% of those planets have substellar equilibrium temperatures high enough to melt and vaporize rock. Thus, if rocky like CoRoT-7b, they likely have atmospheres composed of rocky materials such as Na, O, Si and Mg. We call such an atmosphere a mineral atmosphere in this study. Although a hot rocky exoplanet would evolve greatly through loss of planetary mass and atmospheric species if the mineral atmospheric escapes, there have been no theoretical studies that investigate the escape of the mineral atmosphere in detail.
   In this study, we construct a 1-D hydrodynamic model of the highly UV-irradiated, mineral atmosphere, including detailed photo- and thermo-chemistry. Using it, we determine the escape rate and outflow structure of the atmosphere. We find that the escape is massive enough to be a hydrodynamic/transonic wind, and its flux notably depends on the planetary size. From those results, we discuss the evolution of hot rocky exoplanets through loss of mass and Na.

8. **Yui Kawashima** (The University of Tokyo):

Possible origin of diverse transmission spectra of warm transiting exoplanets: Growth and settling of hydrocarbon haze produced via UV irradiation.

Recently, properties of exoplanet atmospheres have been constrained via multi-wavelength transit observation, which measures an apparent decrease in stellar brightness during planetary transit in front of its host star (called transit depth). Sets of transit depths so far measured at different wavelengths (called transmission spectra) are somewhat diverse: Some show steep spectral slope features in the visible, some contain featureless spectra in the near-infrared, some show distinct features from radiative absorption by gaseous species. These facts infer the existence of haze in the atmospheres especially of warm, relatively low-density super-Earths and mini-Neptunes. Previous studies that addressed theoretical modeling of transmission spectra of hydrogen-dominated atmospheres with haze used some assumed distribution and size of haze particles. In this study, we model the atmospheric chemistry, derive the spatial and size distributions of haze particles by simulating the creation, growth and settling of hydrocarbon haze particles directly, and develop transmission spectrum models of UV-irradiated, solar-abundance atmospheres of close-in warm (~ 500 K) exoplanets. We find that the haze is distributed in the atmosphere much more broadly than previously assumed and consists of particles of various sizes. We also demonstrate that the observed diversity of transmission spectra can be explained by the difference in the production rate of haze monomers, which is related to the UV irradiation intensity from host stars.

9. **Roxana Lupu** (BAER Institute/NASA Ames):
Model atmospheres for volatile-rich hot rocky planets.
We are building a versatile set of self-consistent atmospheric models to calculate the structure, composition, and spectra of hot rocky exoplanets in short period orbits. To date, more than 100 such hot rocky exoplanets have been confirmed, and they will form the majority of small planets in close-in orbits to be discovered by the TESS and Kepler K2 missions. These hot worlds offer the best opportunity to characterize rocky exoplanets with current and future instruments. We are using a fully non-grey radiative-convective atmospheric structure code with cloud formation combined with a self-consistent treatment of gas chemistry above the magma ocean. Being in equilibrium with the surface, the vaporized rock material can be a good tracer of the bulk composition of the planet. We are investigating both volatile-poor and volatile-rich compositions, with the volatile poor ranging from completely depleted, to water-free (Venus-like), to containing only sulfur and halogens (Io-like). To properly account for these exotic compositions and thermodynamic regimes, we are working on a self-consistent treatment of vertical mixing, condensation, and non-ideal gas behavior. We present our preliminary results for the atmospheric structure of hot, volatile-rich rocky planets. Our models will inform follow-up observations with JWST and ground-based instruments, aid the interpretation of transit and eclipse spectra, and provide a better understanding of volatile behavior in these atmospheres.

10. **Valerio Nascimbeni** (Università di Padova):
SCOLOPENDRA pipeline: unveiling exoplanetary atmospheres through differential spectro-photometry.
Transiting exoplanets offer many great opportunities. Among them, we can characterize their atmospheres by measuring the planetary radius as a function of wavelength (so called "transmission spectrum"), because the light from the host star is selectively

absorbed or scattered by the planetary limb depending on the chemical composition of the atmosphere, its physical state and vertical structure. Many relevant processes, including Rayleigh scattering, affect the optical slope of the transmission spectrum and cannot be investigated through "classical" spectroscopy, because its observables are normalized w. r. t. the continuum. Rather, ground-based MOS spectrographs such as FORS2@VLT and MODS@LBT are able to simultaneously gather spectra of both target and reference stars through oversized slits, correcting systematic errors and telluric features while preserving the continuum. Here we present SCOLOPENDRA, a publicly-available software pipeline specifically developed to perform high-accuracy differential spectrophotometry. We show the first results of SCOLOPENDRA on both unpublished and archival data, suggesting how it could be exploited as a flexible and accurate tool to homogeneously analyze and merge data sets from different instruments and setups.

11. **Julia Victoria Seidel** (University of Geneva):
Revealing thermospheres of exoplanets from observations.
The sodium doublet in the optical is the most reliable probe of exoplanet atmospheric properties. Recent high-spectral resolution observations of this doublet in hot gas giants have allowed to resolved the line shape, opening the way for extracting the parameters of the atmospheric region where the sodium line originates from using line-profile fitting.
Based on previous work by Ehrenreich (2006) and Pino (2017) a model of the sodium line cores is presented. The refined sodium transmission spectra aim at providing a better understanding of the processes involved in expanding thermospheres taking into account the high temperatures observed in hot gas giants.

12. **Noriharu Watanabe** (SOKENDAI-GUAS):
*Doppler tomographic measurement for the planetary orbital precession of WASP-33*b.
The projected-angle between the stellar spin axis and the planetary orbital axis, which is so-called the spin-orbit obliquity, is important to understand the planetary orbital evolution. The recently emerging method to measure this parameter is Doppler tomography, which is a method to obtain the moving shadow in the stellar line profile during a planetary transit.
We tried to measure the spin-orbit obliquity of WASP-33b by Doppler tomography from the Subaru/HDS data. WASP-33b is the first confirmed Hot Jupiter around rapid rotational star by Doppler tomography, and known that it orbits in a retrograde way (Brown et al., 2012). Moreover, its planetary orbital precession in 6 years was reported (Johnson et al. 2015). In our work, we could confirm its retrograde orbit via HDS like as these results of previous studies. We will show more detailed precession comparing these previous studies.