EXOCLIMES POSTER ABSTRACT GUIDE
SESSION 1

Eva-Maria Ahrer: Combining optical ground-based low- and high-resolution transmission spectroscopy data of WASP-94Ab. In this talk I will present evidence for sodium absorption and a steep scattering slope, using both high- and low-resolution optical transmission spectra of the hot Jupiter WASP-94Ab. On its own, our low-resolution transmission spectrum in the wavelength range of 3800-7140 Å has revealed a clear atmosphere with a 4.9σ sodium absorption and a scattering slope through the LRG-BEASTS survey. It was measured with the EFOSC2 spectrograph on the ESO New Technology Telescope — the first time this instrument has been used for transmission spectroscopy. The high resolution spectrum is from HARPS (taken as part of the HEARTS survey), probing the Doppler shifts of the sodium line doublet. In this talk I will present a detailed study of the atmosphere of this exoplanet, a highly-inflated hot Jupiter with a radius of 1.7 Jupiter radii and a mass of 0.5 Jupiter masses and an estimated equilibrium temperature of 1500 K. I will discuss the analysis of both low- and high-resolution observations and its independent results, as well as an additional combined analysis. In future, more combined observations will provide high precision abundances for such species, particularly when signals may be weak or when high altitude clouds and hazes are present.

Lili Alderson: Examining exo-climates across planetary transitions with JWST NIRSpec. JWST presents the opportunity to study the atmospheres of many planets, with the exquisite noise properties of the instruments allowing lower-mass planets to be well-studied for the first time. As we start to transition away from puffy, inflated objects, we can begin to examine how factors such as the reduction in the H/He envelope influence the chemistry of atmospheres, and where boundaries between different classifications of planets lie, if they exist at all. In this talk, I will showcase how NIRSpec is the premier instrument to explore these frontiers, with observations through the mass-space of a hot Jupiter, warm Saturn and sub-Neptune. These planets already tease the diversity of atmospheres JWST will study, with evidence of aerosol formation and dynamics, photochemistry, and the influence of carbon-based species. Together, these worlds will build a foundation for the population studies upon which exoplanet atmospheres will begin to be truly understood.

Natalie Allen: HST SHEL: Comparative Exoplanetology with HST/STIS With the wealth of exoplanetary atmospheres observed with HST in the past two decades, we are well on our way to unraveling the mysteries of solar systems other than our own. However, the analysis of such data is so dependent on the data reduction techniques and assumed system parameters that comparisons between random datasets is very difficult and even potentially misleading. To enable meaningful comparative exoplanetology studies, a uniform methodology with the data reduction and analysis is key. Thus enters the SHEL (Sculpting Hubble's Exoplanet Legacy) archival project, in which we will uniformly analyze the entirety of HST's exoplanet catalog using a set of consistent data reduction frameworks and with a uniformly derived set of system parameters. In this work, we present the data reduction pipeline for the STIS instrument, along with the first of the analyzed data for WASP-39 b and WASP-69 b. These datasets will not only enable comparisons between themselves, but be perfectly suited for use in combination with new JWST observations, as the analysis of WASP-39 b illustrates.

Jacob Bean: The metallicities and carbon-to-oxygen ratios of giant exoplanets I will present results from a large JWST GTO program focused on measuring atmospheric metallicities and C/O ratios for a sample of canonical hot Jupiters. Ultra-precise spectra have already been obtained for four planets, and a fifth will be observed in February. Our first result is the inference of a highly metal-enriched atmosphere for HD149026b. This planet is the most metal-rich giant planet known, with an estimated bulk metal fraction of 65% by mass. We find that the atmospheric metallicity for this Saturn-mass planet is highly inconsistent with the prediction of the mass-metallicity relationship defined by the solar system planets. Instead, the data match a new relationship between bulk and atmospheric metallicities that may be more fundamental. We also tightly constrain the C/O ratio for HD149026b to be slightly super solar. Our continuing analysis of the data from this program will ultimately provide the first look at population-level trends for giant planets in the JWST era.

Linn Boldt-Christmas: Optimising Exoplanet Transit Spectroscopy Observations Transiting exoplanets provide opportunities for us to observe their atmospheres and to analyse them using spectroscopy. As the characterisation of exoplanet atmospheres relies on the detection of spectrally resolved features, analysis can be improved with high signal-to-noise ratios (SNR) that are possible to obtain today with modern spectrographs. However, obtaining high SNR through adjusting exposure times comes with a trade-off. A higher cadence of several, shorter exposures minimises the spectral feature smearing that arises due to the continuously changing radial velocity of the planet; but a lower cadence of fewer, longer exposures collects more photons with reduced overheads and readout noise, enhancing the SNR of each observation. As such, there is a need to establish what the optimal compromise is between the SNR and time resolution for a given target. I will present a new method that will aid observational astronomers in establishing the optimal parameters for observing transiting exoplanets with spectroscopic instruments. This method is demonstrated using simulated spectra, cross-correlation, and other statistical techniques. This will be particularly relevant for planning ground-based observational studies to characterise atmospheres for objects around cooler stars with more complex stellar spectra.

Anne Boucher: The 2D Atmospheric Temperature Structure of a Hot Jupiter Revealed at High Spectral Resolution We report the first detection of the diurnal cycle made at high-resolution and for the ultra-hot Jupiter KELT-20b, with CFHT/SPIRou. We measure the variation of the temperature structure for the two hemispheres from H_2O features, but also (although less clearly) from CO. H_2O and CO are detected at more than 3 sigma, on both day and night hemispheres. As expected, the H_2O signal is consistent with an inverted temperature profile (warming with altitude) on the dayside and with a non-inverted profile (cooling with altitude) on the nightside. However, the CO signal is consistent with an inverted profile on both hemispheres, which could be an indication that the nightside CO signal originates from the evening (trailing) limb of the terminator. The radial velocity shifts retrieved for both molecules on each hemisphere, suggest a complex 3D picture of KELT-20b: a CO dominated day-side, with H_2O dissociation around the offset hotspot region, and a H_2O dominated nightside, both of which are subject to advection from eastward jets.

Beatriz Campos Estrada: A self-consistent model of cloudy substellar atmospheres The understanding of substellar objects is largely hampered by clouds obscuring their atmospheres. We combine low-temperature atmospheric modelling by MARCS (Gustafsson et al., 2008), with equilibrium chemistry (Woitke et al., 2018) and microphysical cloud formation (e.g. Helling et al., 2016) to self-consistently model substellar atmospheres. Our model can be used to study the clouds of present and future JWST targets, helping understand the evolution path of substellar objects and interpret JWST data.

Antoine Darveau-Bernier: A Hell of a Duo: Combining Low- and High-Resolution Spectroscopy to Study the Dayside of Ultra Hot Jupiters. Dayside atmospheres of ultra-hot Jupiters have now puzzled astronomers for the better part of a decade due to their smooth spectroscopic features in the Wide Field Camera 3 of the Hubble Space Telescope. This increases the level of difficulty in differentiating between different chemical species which prevents to put good constraints on the temperature profiles and abundances without relying significantly on model assumptions. High resolution spectroscopy constitutes a promising alternative due to its sensitivity to individual lines. In this work, I will present observations of the dayside of the UHJ WASP-33b with the echelle spectrograph SPIRou (SpectroPolarimetre InfraRouge) at the Canada-France-Hawaii Telescope. We were able to detect carbon monoxide in both WASP-33b's eastern and western dayside hemispheres. We were also able to perform two different retrieval analysis, one using only the SPIRou data and one adding the low resolution observations (WFC3 and Spitzer). This allowed us to put a good constraints on the CO abundance and improve those on the Temperature-Pressure profile as well as the H_2O and H^- abundances. This work emphasizes the potential of combining low- and high-resolution data to narrow our understanding of exoplanet's atmospheres.

Spandan Dash: Looking above the cloud deck of GJ 3470b Characterisation of cooler atmospheres of super-Earths and Neptune sized objects is often thwarted by the presence of clouds, hazes and aerosols which effectively flatten the transmission spectra. High-Resolution Spectroscopy (HRS) presents an opportunity to overcome this limitation by having the ability to detect molecular species whose spectral line cores extend above the level of clouds in these atmospheres. We analyse High-Resolution infrared observations of the warm Neptune GJ 3470b taken over two transits using CARMENES (R $\sim$ 80400) and look for signatures of H_2O in these transits with a custom pipeline fully accounting for the effects of data cleaning on a potential exoplanet signal. We find that our data is able to weakly detect an injected signal equivalent to the best-fit model from previous HST WFC3+Spitzer observations. However, we do not measure any significant detection using the actual observations. Using a Bayesian retrieval tool on the two observed transits to put simultaneous constraints on the abundance of H_2O and the cloud top-deck pressure selects for a family of degenerate models, which spans from very high abundance ($\log_{10}(H_2O)$ = -0.5) and cloud-free models (highly compressed heavy atmospheres), to super-solar abundances (-2.5<$\log_{10}(H_2O)\leq$-1) at high cloud deck models (-2.5>$\log_{10}(P)\geq$-4.5), and then to slightly super-solar and sub-solar abundances (-4.5<$\log_{10}(H_2O)\leq$-2.5) with moderately high cloud deck models (-1.5>$\log_{10}(P)\geq$-2.5). This is a broader range compared to, but is also compatible with published results from low resolution at a 1σ level.

Ernst de Mooij: Searching for Day-Night variations in the Fe I emission from WASP-33b The ultra-hot Jupiter WASP-33b shows evidence for a thermal inversion in the form of emission lines of atoms and molecules, including OH and Fe. Phase-curve measurements at optical wavelengths with TESS show a westward phase-offset while observations in the infrared with the Spitzer Space Telescope show an Eastward offset. We obtained phase-curve observations at high-spectral resolution at optical wavelengths with Subaru/HDS as well as CFHT/ESPaDOnS.

Using log-likelihood mapping and integrating a simple phase-curve model we demonstrate that it is possible to measure phase-curve variations, although unequal pre/post eclipse sampling can result in biases. For the Fe I emission, we show evidence that the peak is after eclipse at $+22 \pm 12$ degrees, consistent with the optical phase-curve. We also constrain the day-night contrast to be > 0.9, indicating that, in the case of Fe I, the night-side contributes less than 10% of the day-side flux in our simple model.

Trent Dupuy: High-Precision Measurements of Atmospheric Transitions' Influence on Substellar Evolution Spectroscopy plays a vital role in illuminating the atmospheric properties of brown dwarfs and giant planets. Over their lifetimes, these self-luminous objects cool and fade, and with this comes changes to their atmospheres. Understanding the influence that changing atmospheres have on the evolution of substellar objects requires measurements of the fundamental parameters of mass and/or age. In recent years there has been major progress in using high-precision mass benchmarks to measure the influence of the L/T transition on substellar cooling rates. I will review the state of testing evolutionary models using binary brown dwarfs with individual dynamical mass measurements as "mini-clusters" to probe luminosity/temperature evolution. This includes new results for epsilon Indi Bab, which now has the highest-precision masses of any brown dwarfs (0.5% uncertainties), confirming previous evidence that cooling slows during the L/T transition, for the first time in a system with a post-L/T-transition component. I will discuss future prospects for tests of substellar evolution at colder temperatures and lower masses, using dynamical masses in cooler binaries, younger binaries, and companions that induce astrometric accelerations on their host stars measurable in Gaia data.

Mark Fortune: Hazy or Noisy? How Reliable are Ground-Based Detections of Hazes? Ground-based multi-object spectrographs such as VLT/FORS2 and Magellan/IMACS have been used to identify hazes in exoplanets such as with WASP-88b and HATS-8b. These instruments are known to have large "common-mode" systematics which can often be similar in amplitude to the transit signal and have to be corrected for. A new approach to accounting for these systematics is presented and a reanalysis of two FORS2 observations of WASP-31b was performed using it. Although this planet was originally identified to have a flat spectrum, this new approach found that there was a much larger uncertainty in the slope of the transmission spectrum than in the initial analysis. This new method suggests that previous methods of accounting for large amplitude common-mode systematics may lead to significant overfitting of the slope of transmission spectra, casting some doubt on previous detections of hazes while also implying exoplanets believed to have flat spectra may in fact have hazy atmospheres. More generally our new approach can extract the covariance matrix of the transmission spectrum directly, and fully account for the impact of correlated noise in atmospheric retrievals.

Carlos Gascón: The Hubble HUSTLE program: UV-Visible Transmission Spectra of the Hot Jupiters KELT-7b and HAT-P-32b While past transmission spectroscopy studies have generally been carried out in the near-infrared wavelength range, fully understanding the complex physical and chemical processes that shape exoplanet atmospheres requires observations covering additional portions of the spectrum. The ultraviolet-visible has proven to be a key piece of this puzzle, providing valuable information regarding the presence of UV absorbers or scatterers, atmospheric escape, and enhanced scattering due to aerosol opacities. In this regard, the Hubble Ultraviolet-optical Survey of Transiting Legacy Exoplanets (HUSTLE) treasury program is currently characterising the atmosphere of fourteen exoplanets from 200 to 800 nm, aiming to study and compare the hidden features entangled in the UV-visible spectrum of a large population of exoplanets covering a broad range of temperature and masses. In this work, we present the first observations of the HUSTLE program for the two Hot Jupiters KELT-7 b and HAT-P-32 b, obtained with HST's WFC3/UVIS G280 Grism. In particular, we describe the extraction and reductions methods applied to the observations, and present the resulting UV-visible transmission spectra. In addition to this, we perform atmospheric retrievals on the extracted spectra and discuss the implications that these results have when constraining key atmospheric parameters such as the cloud opacity and the equilibrium temperature of both exoplanets.

Gloria Guilluy: A Helium Survey in Exoplanetary Atmospheres Exoplanets orbiting very close to their parent stars are strongly irradiated. This can lead the upper atmospheric layers to expand and to evaporate into space. Atmospheric mass-loss can significantly influence the evolution of close-in planets, and produce features in their population: one of the most prominent is the dearth of Neptunes on very short orbit (Period $<$ 4 days). Direct observations of mass-losses are essential to link the atmospheric escape to the desert formation and thus to comprehend its role in the evolution of close-in planets.

Giannina Guzman Caloca: Grid-trievals? A Comparative Study of Atmospheric Retrieval Techniques Exoplanetary atmospheric retrievals are effectively the bridge between observational data and theoretical modeling. They are the statistical means by which we identify a set of best-fit parameters and associated error bars for a given exoplanet spectrum. A number of different approaches exist for performing atmospheric retrievals. Traditional retrieval algorithms typically run tens of thousands of simplified fast forward models of an exoplanet spectrum in order to fully sample the relevant parameter space. In contrast, a less broadly utilized approach is to perform grid-based retrievals, in which the retrieval algorithm interpolates among a grid of pre-calculated forward models, rather than calculating these models in real time. A potential advantage of the grid-based approach is that it enables the use of more complex and physically motivated forward models that would otherwise be too slow to run "on the fly" in a traditional retrieval framework. We present a comparative study of the two retrieval approaches. Using the publicly available PLATON retrieval code we have made a modified version which utilizes a built-from-scratch grid-based algorithm instead of its traditional design. The goal of this work is to produce a quantitative comparison between traditional and grid retrievals through studying the performance of each version of PLATON. We specifically compare the precision, accuracy, and run-time between the two methods to evaluate the validity and applicability of the grid-based approach. Specifically, for each retrieval method (traditional and grid-based) we run a total of 8 retrievals for two nominal planets: HD 189733b and GJ 436b, a canonical Hot Jupiter and Sub Neptune, respectively, exploring a relevant range of atmospheric parameters and properties. We present the results from the PLATON retrievals in this presentation. Based on preliminary results, the average run time per model is significantly faster for the grid method (0.02 s vs. 0.09 s). In contrast, reaching convergence takes more forward model calls for the grid-based method, making it slower in total. We believe this effect is due to interpolation errors in the grid-based method causing convergence to take longer. This can be solved by utilizing a finer grid and we present the trade-offs and benefits of formatting a model grid for performance and accuracy.

Joseph Harrington: MCMC Stopping and Machine-Learning Acceleration in Free Atmospheric Retrievals The longer a Bayesian analysis runs, the more accurate its posterior and results based on it are.

These results include parameter uncertainties. In developing the Bayesian Atmospheric Radiative Transfer retrieval tool (Harrington et al. 2022, Cubillos et al. 2022, Blecic et al. 2022, PSJ), we derived a new Bayesian stopping criterion. The criterion determines the number of independent steps required to achieve parameter credible-region boundaries and uncertainties with a given accuracy. Combined with an assessment of the correlation length of the chains, the criterion says when to stop generating steps. The criterion applies to ALL Bayesian analyses. The Gelman-Rubin convergence criterion is frequently misunderstood to be when to stop a chain, but rather indicates when the chain has converged to the posterior and is thus ready to START producing steps useful for assessment of parameter uncertainties. Given the longer chain lengths our criterion calls for, and the advent of 3D retrievals, we investigated machine-learning acceleration of retrievals. Our toolkit for generating ML-accelerated surrogate modelsf for retrieval and other analyses (Himes et al. 2022, PSJ) allows for multimillion-step retrievals to run in a few hours. Finally, we will present the latest developments in the open-source BART family of retrieval tools.

Soichiro Hattori: A Robust and Efficient Approach to Simultaneously Fit Multiple Spectroscopic Light Curves from JWST Transmission spectroscopy has already produced key results from JWST Early Release Science (ERS) observations such as the detection of carbon dioxide and evidence for photochemistry in the atmosphere of WASP-39b. However, the favorable observing conditions the ERS targets were selected for are unlikely to be shared for future targets and robust scientific results from future JWST observations will require a careful disentangling of contaminating signals. We have therefore built a method to robustly and efficiently construct transmission spectra from JWST data. By using JAX and NumPyro, Python packages that when used in tandem allow for inference using efficient gradient-based methods such as Hamiltonian Monte Carlo (HMC), we are able to significantly reduce the computational time while maintaining a high level of rigor in our analysis. With the reduced computational time, our method simultaneously fits multiple spectroscopic light curves without an initial fit to the broadband light curve, allowing us to capture covariances between all of the parameters. We are currently able to simultaneously fit 50 spectroscopic light curves from the NIRSpec data of WASP-39b with a 300+ parameter model. We compare our transmission spectra to the previously published result and discuss the differences and their potential sources.

Thea Hood: Characterisation of the atmosphere of WASP-76b using SPIRou. The near-infrared spectropolarimeter SPIRou located at the Canada-France-Hawaii Telescope (CFHT) is one of if not the best for atmospheric characterisation of exoplanets from the ground, due to its properties and location. It observed the exoplanet WASP-76b following a reported and confirmed asymmetry in the limbs of the atmosphere of this ultra hot Jupiter, detected through observations in the visible (Ehrenreich et al. 2020, Kesseli & Snellen 2021). This has led to extensive theoretical and observational work around this planet to understand its peculiarity. In acquiring infrared data of this atmosphere, different species and pressure layers are expected to be probed, which could reveal a different temperature and dynamical profile of the atmosphere. I will detail my study of the characterisation of the atmosphere of WASP-76b using SPIRou infrared data and how it led to the first detection of H_2O and CO in high-resolution infrared data of this planet. Such detections open a new window into the understanding of the dynamics, physics and chemistry of WASP-76b, and new insight on ultra-hot planetary atmospheres.

Kathryn Jones: The stable climate of KELT-9b Even among the most irradiated gas giants, so-called ultra-hot Jupiters (UHJs), KELT-9b stands out as the hottest exoplanet thus far discovered with a dayside temperature of over 4500K. UHJs are a newly-emerging class of short-period exoplanets with temperatures above 2500K and chemically unique atmospheres. In this talk, I will present my recent work where I simultaneously analysed 4 high-precision phase curves from CHEOPS, as well as phase curves from TESS and Spitzer to infer joint constraints on the phase curve variation, gravity-darkened transits, and heat redistribution of KELT-9b. My results provide insights into the climate and atmospheric variability of KELT-9b and continue the work of investigating the properties and chemistry of ultra-hot Jupiters.

Thomas Kennedy: Examining feedback between magnetic effects and clouds in Hot Jupiter GCMs Hot Jupiters are a diverse population, and we expect to see trends across their parameter-space as different processes become important in their atmospheres. Previous work has identified magnetic effects and cloud formation as two processes that should be important in Hot Jupiter atmospheres, but they have only been modeled in isolation. The RM-GCM is capable of modeling both magnetic effects and radiatively active clouds in 3D Hot Jupiter atmospheres with moderate complexity, making it well-suited to investigating the ways in which the two processes interact. To capitalize on this, we are running a grid of GCMs across a broad range of irradiation temperatures with and without these effects. We will present the set-up for our grid of models, currently underway, and share preliminary results.

Thaddeus Komacek: The effect of interior heat flux on the atmospheric circulation of hot and ultra-hot Jupiters Many hot and ultra-hot Jupiters have radii larger than expected from standard evolutionary models. This implies that these planets retain significant heat from formation, which has been shown to be due to deposited heat in the interior of the planet offsetting cooling. As a result, it is expected that hot and ultra-hot Jupiters have relatively hot interiors compared to previous expectations, which similarly increases the predicted upward heat flux into the deep atmosphere. In this work, we study the effect of the internal heat flux on the atmospheric circulation of hot and ultra-hot Jupiters. Specifically, we utilize extant predictions for the internal heat flux from population-level evolutionary models to drive 3D General Circulation Model simulations of the atmospheric circulation of hot and ultra-hot Jupiters with varying semi-major axis and surface gravity. We find that including a consistent interior heat flux can lead to significant local differences in temperature and wind speeds. We also find that the effect of the interior heat flux can have significant observable consequences in phase curves in cases with a sufficiently high surface gravity. Using a consistent internal heat flux may be required to make robust predictions for the atmospheric circulation of hot Jupiters.

Maura Lally: Eclipse Mapping with MIRI: 2D Map of HD 189733b from 8 micron JWST MIRI LRS observations Observations and models of transiting exoplanets teach us to expect that atmospheric circulation features, such as east-west jets and polar vortexes, may cause large spatial flux contrasts across the dayside of hot Jupiters. In order to gain insights into these atmospheric circulation patterns, previous studies have mapped spatial flux variations through inversion of secondary eclipse data. Though eclipse mapping requires high signal-to-noise data, the first successful use of the technique to map the planet HD 189733b using 8 micron Spitzer IRAC data showed the promise of the method. JWST eclipse observations provide the requisite data quality to access the unique advantages of eclipse mapping over other methods, including sensitivity to latitudinal flux distribution, and lower sensitivity to other forms of variability throughout the planet's orbit. In order to take advantage of the new eclipse mapping opportunities offered by JWST, we measured the thermal emission from the previously mapped planet HD 189733b using JWST MIRI LRS. Here I present a preliminary two-dimensional map of the dayside atmosphere of HD 189733b derived from our observations at 8 microns, and compare my results with those produced from Spitzer data, bridging past and future eclipse mapping efforts.

Adam Langeveld: A high spectral resolution survey of sodium absorption in transiting exoplanets The alkali metal sodium (Na) is one of the most commonly detected chemical species in the upper atmospheres of giant exoplanets. The prevalence and strength of these detections presents an opportunity to search for trends and attempt to answer population-level questions on exoplanetary atmospheres. We report on a homogeneous survey of Na in a diverse sample of transiting exoplanets using high-resolution transmission spectroscopy. We use uniformly measured Na doublet line depths to constrain the atmospheric heights probed by Na observations across the sample. We report an empirical relationship describing the Na line properties as a function of the planetary bulk properties. We also present initial results from the ongoing Exoplanets with Gemini Spectroscopy (ExoGemS) survey, which has acquired high-resolution transmission spectra of over 20 exoplanets using GRACES at the Gemini North Observatory. Surveys of this type highlight a promising avenue for using high-resolution transmission spectroscopy to further our understanding of how atmospheric characteristics vary over a diverse sample of exoplanets.

Fabio Lesjak: Atmospheric retrieval of the dayside of WASP-43b with CRIRES+ Accurately estimating the C/O-ratio of hot Jupiter atmospheres is a promising pathway towards understanding planet formation and migration. In addition, it is closely linked to the formation of clouds and the overall atmospheric composition. The atmosphere of the hot Jupiter WASP-43b has been extensively analyzed using low-resolution observations with HST and Spitzer.

However, the K band, which hosts prominent spectral features of major carbon-bearing species such as CO and CH_4 was not covered by these observations, thus limiting the ability to place tight constraints on the C/O-ratio. Moreover, the planet had not been studied at high resolution, which can be used to probe the dynamics of the atmosphere. Here we show the first high-resolution dayside spectra of WASP-43b with the new CRIRES+ spectrograph. We observed the planet in the K band and are able to confirm the presence of CO and H_2O using the cross-correlation method. Furthermore, we applied a Bayesian retrieval framework to the data and retrieved the temperature-pressure profile, C/O ratio and other atmospheric parameters. We compare our results to the multitude of predictions from previous forward models and low-resolution atmospheric retrievals for this planets.

David Lewis: Cloud regimes on gas-giant exoplanets The diverse population of exoplanet systems spans a wide range of thermodynamic and chemistry regimes. We use 1D profiles extracted from 3D general circulation models of exoplanets orbiting M, K, G, and F stars as input for our kinetic, non-equilibrium model to study the formation of mixed composition cloud particles. We explore the host star's effect on the thermodynamic structure of Jupiter-sized gas-giant planets and the resulting impact on cloud formation. We identify trends in the nucleation rate and average cloud particle size across a range of exoplanet effective temperatures ($T_{\rm eff} = 400 - 2600\,{\rm K}$). Cloud particles have a highly mixed composition of silicates, metal oxides, and higher temperature condensates across the whole grid, and this composition varies with pressure. Finally, we find that gas giant exoplanets can be broadly classified, based on effective temperature, into three regimes of cloud formation and chemistry; cool ($T_{\rm eff} < 1200\,{\rm K}$), transition ($T_{\rm eff} = 1400 - 1800\,{\rm K}$), or hot planets ($T_{\rm eff} \geq 2000\,{\rm K}$). These trends become ever more important as the field moves towards population studies of a large number of gas-giant planet atmospheres.

Dion Linssen: New spectral windows into the escaping atmospheres of exoplanets Atmospheric escape is expected to have important consequences for the evolution of planets and has been suggested to create the observed radius valley and hot Neptune desert. To date, escaping exoplanet atmospheres have typically been probed with a handful of spectral lines, such as Lyman alpha, the metastable helium triplet and UV lines of metals. Inferring important characteristics such as the outflow geometry and mass-loss rate from these observations has been difficult due to differing theoretical predictions and model degeneracies. Expanding on the suite of tracers used to probe escaping atmospheres would help to mitigate these challenges. We post-process hydrodynamic outflow models with NLTE photoionization code Cloudy to predict the transit spectrum of typical gas giant planets and we find new spectral lines in the UV and optical that can potentially be used to study their upper atmospheres. By indicating the atmospheric altitude each of these lines probe, we can identify complementary lines which will allow us to better constrain the outflow properties.

Matt Lodge: Optical Properties of Fractal Aggregate Aerosols Representing the optical properties of aggregates quickly and accurately is becoming an increasingly important aspect of the theoretical models used to predict and analyse atmosphere compositions. There are several significant parameters to consider, for example the quantity, chemical composition, and geometry of particles that might interact with light. Complexity of analysis beyond this point varies depending on the overall function of the model, but the optical properties are often simplified to reduce the number of free parameters, and to reduce the number of calculations required. In many cases, fractal aggregates are modelled as spherical Mie scatterers; however studies on Earth-based aerosols have shown that real particles exhibit more complicated structures, with intricate branching features. Using detailed 3D tunnelling electron microscope images of real soot particles that were captured from the Earth's atmosphere, we analyse the scattering and absorption cross-sections of these fractal structures using discrete dipole approximation (DDA), and compare them to their spherical Mie equivalents. Through this analysis, we ask "How might the physical shape of aerosols affect observables?

Joshua Lothringer: Uncovering the Origins of Giant Planets with New Observations of Ultra-hot Jupiters To understand the formation and evolution of planets light-years away, we must look for clues in their atmospheres. I will first explore how the measurement of elemental abundances in exoplanets through panchromatic atmospheric characterization is revealing the story of planetary birth and migration. In particular, the population of ultra-hot Jupiters are irradiated enough to vaporize refractory material, opening a new window into giant planet formation through the first measurements of rock-to-ice ratios. Combined with the C/O ratio, a detailed understanding of the origin of giant planets can begin to be revealed. I will highlight results from some of the first JWST observations of these ultra-hot planets, including the measurement of WASP-178b's refractory-to-volatile and C/O ratios. I will also highlight how other important atmospheric processes, like cloud formation, can be understood through ultra-hot Jupiters.

Dana Louie: A First Look at the WASP-17 b JWST NIRISS Transmission and Emission Spectra The JWST Near Infrared Imager and Slitless Spectrograph (NIRISS) Single Object Slitless Spectroscopy (SOSS) mode is optimized for medium resolution (R 700) time-series observations (TSOs) of transiting exoplanets. Its wavelength coverage of 0.6 – 2.8 microns includes multiple water spectral bands as well as the potassium resonance doublet. Here, we present a first look of the JWST Telescope Scientist Team's WASP-17 b NIRISS SOSS transmission and emission spectra. The Hot Jupiter WASP-17 b (1.99 Jupiter radius, 0.486 Jupiter mass, 1770 K equilibrium temperature) has been previously observed from 0.3 – 5.0 microns using the Hubble Space Telescope, Spitzer, the Transiting Exoplanet Survey Satellite, and various ground-based facilities. A recent comprehensive analysis (Alderson et al., 2021) of WASP-17 b's transmission spectrum indicates $> 7\sigma$ water absorption, but inconclusive evidence for potassium absorption features. In contrast, Sedaghati et al. (2016) detected the wing of the potassium absorption line at 3-sigma confidence using ESO's Very Large Telescope FORS2 instrument. We present the WASP-17 b dayside thermal emission spectrum for the first time, which provides insights into the thermal structure of the planet's atmosphere.

Mei Ting Mak: Haze Archean in 3D The first evidence for life on Earth dates back to the Archean (2.5-3.8 billion years ago) with its reducing atmosphere, suggesting a low likelihood of oxygen-based metabolisms but a prevalence of methanogens instead. Since the Earth's atmosphere has spent most of its time in the Archean, it is reasonable to expect that other potentially habitable Earth-like planets to possess an Archean-like atmosphere, characterised by high concentration of the greenhouse gas CH_4. But laboratory data have shown that when CH_4/CO_2 exceeds approximately 0.1, hydrocarbon haze would start forming which would cool down the planet. We therefore need a comprehensive study of haze when modelling CH_4 in the Archean or exoplanets. By varying the CH_4/CO_2 ratio, we prescribe different profiles of haze into the Archean atmosphere within a 3D general circulation model (GCM) - the Met Office Unified Model. We find that the temperature profile is very sensitive to the prescribed haze profile. When CH_4/CO_2 is approximately 0.1, the haze layer has no radiative impact on the atmosphere. When increasing CH_4/CO_2, the global mean surface temperature drops rapidly. When CH_4/CO_2 goes beyond 0.2, the haze layer becomes saturated and the atmospheric structure does not vary much. We therefore conclude that the ratio of CH_4/CO_2 would be small for a temperate Archean climate. This study has important implications for the habitability of exoplanets, particularly for M-dwarf hosted planets where atmospheric methane absorption of the stellar radiation is larger.

Caroline Morley: Sonora Diamondback: A New Grid of Cloudy Atmosphere and Evolution Models We present a new generation of atmosphere and evolution models which include the effects of clouds. We show how silicate (+ iron and corundum) clouds change the spectra of exoplanets and brown dwarfs in objects from 900–2400 K at a range of surface gravities. We include, for the first time in our cloudy modeling framework, metallicities including super-solar (+0.5, similar to Jupiter) and sub-solar (-0.5). We show how the emergence and disappearance of clouds affects the evolution of planets, creating a new set of "hybrid" evolution models applicable for giant planets and brown dwarfs. Our models have key upgrades from prior generations, including updated chemistry and opacities, and we present medium-resolution spectra (applicable for JWST, and other, applications) and high-resolution spectra appropriate for echelle spectroscopy from the ground.

Sagnick Mukherjee: PICASO: An Unified Atmospheric Model of Exoplanetary Atmospheres with Photochemistry and Vertical Mixing JWST observations of exoplanetary atmospheres have already shown that atmospheric mixing and photochemistry are extremely important. Apart from being poorly understood, they are identified as important probes of exoplanetary interiors. However, to probe exoplanetary interiors using these processes in the JWST era, they need to be physically understood first, which requires more sophisticated atmospheric models than what is available today. PICASO is an open-sourced atmospheric model which can capture mixing-induced quenching of gases self-consistently. However, PICASO used to ignore photochemistry and molecular diffusion, which are known to have large effects on atmospheric chemistry. We have upgraded PICASO by coupling it with the VULCAN chemical network, which has allowed us to model the effects of vertical mixing, photochemistry, and molecular diffusion in atmospheres self-consistently. Using this state-of-the-art model, we have explored the impact of these processes on the thermal structure and spectra of exoplanet atmospheres across a large range of the mixing parameter (Kzz), interior temperature, metallicity, and carbon-to-oxygen ratio. Our results will be compared to emerging gaseous abundance trends from the MANATEE program that is observing several warm giant planets with JWST. As PICASO is open-sourced, it also serves as an important resource for the community for modeling JWST observations.

Lisa Nortmann: Dynamics of exoplanet atmospheres revealed with near infrared spectroscopy Investigating the spectral signatures of exoplanets allows us to constrain their physical and chemical properties and shed light on their formation histories. Particularly, studies at high-resolution offer opportunities to probe the atmospheres of cloudy exoplanets whose features remain obscured at lower resolution. Moreover, dynamics within the atmospheres can be investigated by resolving the Doppler shifts and line profiles of the absorbing and emitting material. Measuring these features independently for each atmospheric species and at different phases of the orbit can reveal the planets' 3D structures in the form of wind patterns, hot spots, and day-to-night side contrasts. In this talk I will show some of our latest results obtained with the CRIRES+ spectrograph and delve into some of the dynamic processes that can be uncovered though near infrared observations with state-of-the art high resolution spectrographs.

Stevanus Kristianto Nugroho: Unlocking the Day-side of Ultra Hot Jupiters: A NIR High-Resolution Emission Spectroscopy Study of WASP-33b High-resolution cross-correlation spectroscopy has been used widely in characterising the atmosphere of exoplanets. It relies on resolving the Doppler-shifted atomic/molecular bands in the spectrum of an exoplanet into individual absorption lines and combining them through cross-correlation to identify the atomic/molecular signatures unambiguously. Using this technique, we analysed high-resolution emission spectra of the day-side of an ultra-hot Jupiter, WASP-33b, taken using the InfraRed Doppler instrument on the Subaru telescope. As a result, we confirmed our previous detection of OH emission at $> 9\sigma$ only after the secondary eclipse. We also confirmed previous detection of Fe I, Si I, and Ti I, and found evidence of the emission of Mg I and Mn I after combining all data sets, which, if confirmed, add more chemical species that are detected on the day-side of an exoplanet. The non-detection of OH before the eclipse is likely due to astrophysical phenomena indicating a different spatial distribution of each chemical species. This highlights the 3-D properties of an exoplanet that needs to be taken into account in characterising its atmosphere.

Kazumasa Ohno: Radiative-chemical-microphysical modeling of cloud and haze formation on eccentric exoplanets Giant exoplanets with large orbital eccentricities are intriguing targets for upcoming atmospheric characterization. Such planets may have a formation and migration history that is distinct from some or all planets on circular orbits. Eccentric giant planets also provide diverse opportunities to study atmospheric physics and chemistry, as eccentric orbits yield both hot and cold environments under the same atmospheric composition and planetary gravity. These planets are natural laboratories to understand the relative timescales of chemical reactions, atmospheric mixing, aerosol formation and loss, and time-variable stellar forcing. Despite the crucial importance of eccentric exoplanets, there have been no comprehensive studies on the chemical and microphysical processes of cloud and haze formation on these eccentric worlds. Here, we provide the first microphysical model of cloud and haze formation on eccentric giant planets that hierarchically combines radiative transfer, disequilibrium chemistry, and aerosol microphysical models. We present several intriguing results of our radiative-chemical-microphysical model. These include the drastic orbital variation of the CH4 abundance at highly eccentric planets, a weak seasonality of photochemical haze throughout the entire orbit, a drastic seasonality of mineral clouds, and strong dependence of those aerosol properties on the strength of atmospheric circulation. The seasonality difference between photochemical hazes and mineral clouds may provide a unique opportunity to assess which hazes and clouds are predominant in a specific exoplanet from phase curve observations. Compute transmission and emission spectra of highly eccentric planets, we also find that the cloudiness/haziness of observable spectra strongly depend on the eddy diffusion strength, the most uncertain parameters in the atmospheric modeling. Thus, atmospheric observations of eccentric planets enable us not only to probe the atmospheric compositions but also to test the current understanding of vertical transport in exoplanetary atmospheres. Our modeling framework provides a powerful tool to thoroughly understand the upcoming observations of eccentric giant planets in the era of the James Webb Space Telescope.

Anusha Pai Asnodkar: Striking the iron while its hot: a deep dive into understanding the variability of KELT-9 b's atmospheric dynamics Recent modelling of ultra-hot Jupiter (UHJ) atmospheres emphasize the 3D nature of these extreme systems and the relevance of second-order effects such as magnetic drag, molecular dissociation, and cloud formation in shaping their thermal structure. These effects play a critical role in interpreting these systems with high-resolution spectroscopy, the most promising technique for building a comprehensive vertical and longitudinal picture of UHJ atmospheres. We conduct a case study of the observationally favorable and phenomenologically intriguing system KELT-9 b to build a map of the planet's atmospheric dynamics as a function of altitude and longitude. We distinguish tracers of the escape regime from those of global circulation patterns and extend our previous exploration of the system's time-variable signatures. Finally, we posit interactions with anisotropic stellar winds as a potential explanation of the observed multi-epoch planetary wind variability.

Luke Parker: Prospects for Observing Outgassed Silicate Atmospheres Rocky ultra-short period planets (USPs) are among the most extreme extrasolar worlds discovered to date, with orbital periods less than one day and dayside temperatures hot enough to vaporise rock. Surface magma oceans and silicate vapour atmospheres have been extensively modelled to describe these lava worlds, and their direct characterisation is now possible using the next generation of instrumentation. I will discuss two approaches we are taking to explore these extreme worlds, using emission spectroscopy at both high and low resolution. Extending high resolution spectroscopy (HRS) to its reddest limits in the M band we are searching for SiO, a key signature of an outgassed atmosphere on rocky worlds, and paving the way for HRS with METIS/ELT. At low resolution we have submitted proposals to use MIRI/JWST to observe evaporating lava worlds in eclipse. These measurements offer the opportunity to constrain the composition of a magma ocean and the interior of a rocky exoplanet. When linked with 3D Global Circulation Models and mantle dynamics models to constrain the atmospheric and mantle cycling of silicate material around these USPs, these studies offer the chance to study the climate cycle of a rocky exoplanet in the near future.

Stefan Pelletier: Refractory-to-volatile abundance ratios on the ultra-hot Jupiter WASP-121b measured from CRIRES+ and ESPRESSO Over the last decade, we have been measuring the metallicity and C/O ratio of giant planet atmospheres to probe their formation histories. However, while these can provide useful constraints on potential formation pathways, carbon and oxygen abundances alone cannot determine how or where a given giant planet originated. Breaking these degeneracies requires also measuring rock forming elements to constrain refractory-to-volatile abundance ratios. Unfortunately, measuring these crucial ratios (e.g., Fe/H, O/Fe, C/Fe) can only be done on planets hot enough for rock forming species to vaporize, but cold enough for water not to be fully dissociated. Luckily, some planets are right in the sweet spot - including the ultra-hot Jupiter WASP-121b, one of the most amenable exoplanets for atmospheric characterization. Here we present an extensive optical + infrared, eastern + western hemisphere, high-resolution view of WASP-121b's dayside atmosphere. We use CRIRES+ to probe molecules in the infrared, and ESPRESSO to probe atomic species in the optical. For both instruments we retrieve abundances and temperature profiles and compare differences between the eastern and western dayside hemispheres. Finally, we combine these to obtain refractory-to-volatile abundance ratios and explore implications for how and where in the protoplanetary disk WASP-121b may have formed.

Whitney Powers: Impacts of rotation on the Rainy-Bénard moist convection model Condensation is a critical process in the dynamics of planetary atmospheres. Water is a common condensate and is found here on earth, in Jupiter's weather layer, and water clouds have been detected in the atmospheres of Hot Jupiters. Other species can be condensates as well, such as methane in Titan's atmosphere. Condensation is coupled to atmospheric dynamics as it provides a buoyancy source which can then drive atmospheric convection. This coupling produces complex dynamics and warrants study at a fundamental level. The 'Rainy-Bénard' model, first presented in Vallis et al. (2019), uses a simplified equation set to study the fundamental interaction between buoyancy driven flows and condensation. It considers an incompressible ideal fluid with an active condensate which obeys a simplified Clausius–Clapeyron relation.

We extend this work by simulating Rainy-Bénard convection with rotation. Planets are rotating systems and have a wide range of rotation rates, so it is important to understand how rotation affects this system. Rotation constrains convection to long narrow columns, limits heat transport, and introduces an additional fundamental timescale to the system. We discuss how condensation in a rotating system affects dynamics, pattern formation, as well as vertical structure and transport scaling.

Michael Radica: Awesome SOSS: Transmission Spectroscopy of WASP-96b with NIRISS/SOSS The future is now — after its long-awaited launch in December 2021, JWST began science operations in July 2022 and is already revolutionizing exoplanet astronomy. The Early Release Observations (ERO) program was designed to provide the first images and spectra of JWST, covering a multitude of science cases and using multiple modes of each on-board instrument. Here, we present transmission spectroscopy observations of the hot Jupiter WASP-96b with the Single Object Slitless Spectroscopy (SOSS) mode of the Near Infrared Imager and Slitless Spectrograph, observed as part of the ERO program. As the SOSS mode presents some unique data reduction challenges, we provide an in-depth walk-through of the major steps necessary for the reduction of SOSS data: including background subtraction, correction of 1/f noise, and treatment of the trace order

Felix Sainsbury-Martinez: The impact of cometary 'impacts' on the chemistry, climate, and observable features of hot Jupiter atmospheres There is significant evidence, from our own solar-system, that 'impacts' can shape the compositions of planetary bodies, with evidence both close to home (e.g. the Earth-Moon system) and throughout the solar-system (e.g. the impact of comet Shoemaker-Levy on Jupiter in 1994). We are interested in exploring if such changes extend to extra-solar planets, exploring how icy cometary 'impacts', specifically their mass deposition, impact the atmospheric chemistry, climate, and observable features, such as transmission spectra, of hot Jupiters. To that end, we introduce a simplified cometary impact model, which includes both thermal ablation and pressure-driven breakup, and which we couple to the state-of-the-art 1D radiative-convective, and non-equilibrium, atmospheric model ATMO. Here, we focus on the effect that the incoming comets composition (and hence C/O ratio and metallicity) has on both the time-dependent, and steady-state, atmospheric chemistry, exploring changes in key (JWST and Ariel) observable molecules, the atmospheres pressure-temperature profile (which may have implications for radius inflation at high enough 'impact' frequency), and the resulting transmission spectra, including observability calculations for JWST. We finish by exploring both the expected frequency of 'impacts' as well as the time-scale over which 'impact' driven-effects occur, in order to characterise the overall observability of these features.

Arjun Savel: Peering into the black box: understanding uncertainty, significance, and detection in high-resolution cross-correlation spectroscopy of exoplanet atmospheres Ground-based high-resolution cross-correlation spectroscopy (HRCCS; $R \gtrapprox 15,000$) is a powerful complement to space-based studies of exoplanet atmospheres. By resolving individual spectral lines, HRCCS has the potential to precisely measure chemical abundance ratios, directly constrain atmospheric dynamics, and robustly probe atmospheric multidimensionality. But the subtleties of HRCCS — e.g., the lack of a visible exoplanetary spectrum in the data and the opaque process of telluric removal — can make interpreting its results difficult. In this work, we seek to clarify the uncertainty budget of HRCCS with a forward-modeling approach. We present a HRCCS observation simulator that includes spectral contributions from the exoplanet, star, tellurics, and various instrumental sources. Simulating a fiducial hot Jupiter dataset (WASP-77Ab emission with IGRINS on Gemini-South), we confirm that the commonly used principal components analysis does not "eat away" at the planetary signal, as the planet accelerates too rapidly in its orbit and competes with the noise term. Furthermore, we demonstrate that time-variable tellurics and moderate wavelength solution errors induce only moderate decreases in HRCCS detection significance. Our understanding of the underlying significance of HRCCS measurements paves the way for thorough exploration of higher-order physics, such as three-dimensionality and differential velocities of atmospheric gases.

Victor See: The impact of a host star's metallicity on exoplanet atmosphere evolution It is thought that magnetic activity, such as X-ray or extreme ultraviolet radiation (usually called XUV radiation), can erode exoplanet atmospheres through photoevaporation. This has important consequences for the evolution and habitability of exoplanets. While a lot of research has been conducted into what what determines the magnetic activity level of low-mass stars, there still remain some open questions. One active avenue of research is the role that a star's metallicity plays. In the past few years, it has become apparent that more metal-rich stars are more magnetically active. In this talk, I will present recent work investigating how a star's metallicity affects its XUV output over evolutionary time-scales. I will then show how this can affect the evolution of exoplanet atmospheres. In general, exoplanets in the habitable zones of more metal-rich stars, receive a higher XUV flux over the course of their lifetimes resulting in higher levels of atmospheric photoevaporation.

Maria Steinrueck: The effect of heating and cooling by photochemical hazes on the phase curve of sub-Neptune GJ 1214b Previous work shows that the day-night temperature contrast of sub-Neptunes strongly depends on the mean molecular weight of the atmosphere. However, heating and cooling from hazes may also affect the day-night contrast. In July 2022, JWST observed the first thermal phase curve of a sub-Neptune, GJ 1214b. Based on previous transit observations, this planet is known to be covered in a thick layer of aerosols. Understanding the effect of hazes on the thermal emission phase curve is crucial for interpreting the observations and determining the composition of the atmosphere based on the phase curve. We conducted simulations of sub-Neptune GJ 1214b with a general simulation model (GCM) that included the radiative effects of photochemical hazes. A horizontally uniform haze profile based on a 1D microphysics model was assumed. Our study spans a wide range of atmospheric metallicities and haze production rates as well as different assumptions for the haze refractive index. We find that temperature structure and phase curves strongly depend on the assumed haze refractive index. The observed JWST MIRI phase curve is best matched by a combination of a high metallicity atmosphere and highly reflective hazes.

Gabrielle Suissa: Photochemically Consistent Simulations of TOI-700 d TOI-700d, the first Earth-sized ($1.2\,\mathrm{R}_\oplus$) planet in the habitable zone discovered by TESS, orbits an M2V dwarf 21 parsecs away. Previous simulations using general circulation models (GCMs) have suggested that TOI-700d can maintain an ocean and reasonable surface temperatures under a variety of climates, although characterizing the atmosphere using transmission spectroscopy or phase curves would be difficult with current instrumentation due to low spectral signals (Suissa et al. 2020). However, photochemistry, which was not included in previous modeling efforts, can have a large effect on spectral features. For example, the simultaneous presence of oxygen (O_2) and methane (CH_4) is typically considered a robust indicator of life. However, the photochemistry of a Sun-Earth analog system efficiently destroys methane in oxygenated atmospheres, possibly rendering CH_4 difficult to detect. Methane's longer photochemical lifetime around an M dwarfs like TOI-700d can increase its abundance by 2-3 orders of magnitude, with major climatic and spectral impacts. We will model TOI 700d as an analog of modern and early Earth to study climates and detectability of biosignatures for these atmospheres. We present preliminary results of photochemical simulations of potential TOI-700d atmospheres using the actual TOI-700d stellar spectrum obtained by the Hubble Space Telescope. The atmospheres produced in the photochemical model will later be incorporated into GCMs and spectral models and thus will result in the first photochemically and climatically self-consistent model atmospheres and spectra for TOI-700d. We will be able to put this new analysis into the context of previous works considering climatically and photochemically self-consistent atmospheres and spectra of potentially habitable M dwarf planets.

Jake Taylor: Atmospheric Characterisation of WASP-96b using the Early Release Observations The newly operational JWST offers the potential to study the atmospheres of distant worlds with precision that has not been achieved before. One of the first exoplanets observed by JWST in the summer of 2022 was WASP-96 b, a hot Saturn orbiting a G8 star. As part of the Early Release Observations program, one transit of WASP-96 b was observed with NIRISS/SOSS to capture its transmission spectrum from 0.6–2.85 μm. In this work, we utilise four retrieval frameworks to report precise and robust measurements of WASP-96 b's atmospheric composition. We constrain the logarithmic volume mixing ratios of multiple chemical species in its atmosphere, including: $H_2O = -3.59^{+0.35}_{-0.35}$, $CO_2 = -4.38^{+0.47}_{-0.57}$ and $K = -8.04^{+1.22}_{-1.71}$. Notably, our results offer a first abundance constraint for potassium in WASP-96 b's atmosphere, and important inferences on carbon-bearing species such as CO_2 and CO. Our short wavelength NIRISS/SOSS data are best explained by the presence of scattering hazes, despite previous inferences of a clear atmosphere. Finally, we explore the data resolution required to appropriately interpret observations using NIRISS/SOSS. We find that our inferences are robust against different binning schemes. That is, from low $R = 125$ to the native resolution of the instrument, the bulk atmospheric properties of the planet are consistent. Our WASP-96 b systematic analysis of these exquisite observations demonstrates the power of NIRISS/SOSS to detect and constrain multiple molecular and atomic species in the atmospheres of hot giant planets.

Lucas Teinturier: The impact of radiative clouds on atmospheric dynamics and observables of Hot Jupiters We set out to use the generic Planetary Climate Model, a 3D Global Climate Model developed for Solar System planets and temperate exoplanets studies to simulate the atmosphere of Hot Jupiter. We modeled a set of iconic Hot Jupiters with different surface gravity, equilibrium temperature, radius , orbital period and irradiation temperature. In our simulations the gravity ranges one order of magnitude and the orbital period almost one order of magnitude. The modeling of those hot giant exoplanets is a good illustration of possible atmospheric regimes and of the impact of clouds in these exotic atmospheres. We post-processed our simulations to produce observables and compared them to publicly available observations. We will discuss these results during our talk. Moreover, we developed and incorporated into the model a scheme to simulate the formation of clouds and to take into account their radiative feedback on the atmospheric structure. Our cloud forming scheme is local, meaning that clouds will or will not form depending on the local temperature-pressure conditions. Probing different temperature regimes therefore makes it possible to study the formation of different condensates and their impact on the atmosphere. We tested our scheme using different possible condensates and different particle sizes. We will present our results on cloud dynamics for the parameter space probed in this study. We will also discuss our findings on the impact of cloud feedback on atmospheric dynamics and observables.

Daniel Valentine: Thermal Emission Spectrum of the Puffy Hot Jupiter WASP-17b Hot Jupiters provide the most exemplary conditions for characterising the atmospheres of exoplanets. Planetary systems oriented edge-on relative to our viewpoint give us access to atmospheric information on their nightside whilst in transit and on their dayside as they are eclipsed by their host star. By observing a system in secondary eclipse at infrared wavelengths, the emission spectrum of the planet can be disentangled from that of the host star. As part of the Space Telescope GTO programme (PI: N.K. Lewis), we present the dayside emission spectrum of the hot Jupiter WASP-17b, constructed using eclipse data obtained by the MIRI LRS instrument on-board JWST. WASP-17b has a highly puffed-up atmosphere (the planet is half the mass of Jupiter but twice the radius), resulting in a large scale height which promotes strong signals and allows for robust atmospheric characterisation. It is also in a retrograde orbit, which contradicts current planet formation theories – this research aims to contribute to bridging such gaps in our understanding of planet formation. This work will be followed by the construction of one-, two-, and three-dimensional eclipse maps of the dayside hemisphere, from which we aim to resolve dynamical, compositional, and thermal information on the planet.

Roméo Veillet: A new extensivly validated C/H/O/N/S chemical scheme for hot exoplanets disequilibrium chemistry Due to vertical mixing and photolysis, the chemical composition of warm exoplanet atmospheres is expected to be out of equilibrium and thus to deviate strongly from thermodynamic equilibrium. Evidence of this disequilibrium chemistry was recently observed by JWST with the detection of a photochemically produced sulfur species, SO_2 (Tsai et al. 2023). Thus, to study these warm exoplanet atmospheres, we need to simulate the chemical kinetics using networks of reactions, valid in this warm temperatures regime. To develop these networks, we can rely on combustion studies that provide C/H/O/N and C/H/O/S mechanisms validated by experimental data thanks to the extensive research that has been done on hydrocarbon combustion, NOx formation in combustion engines and sour gas combustion. Based on these models, we built a detailed mechanism to study the C/H/O/N/S disequilibrium chemistry of warm and hot exoplanet atmospheres that relies on extensively validated and recent state-of-the-art combustion mechanisms for hydrocarbon, oxygen, nitrogen and sulfur chemistry. We will present this new chemical model, and the first results we obtained for the study of several warm Neptunes and hot Jupiters (1D abundances profiles, synthetic spectra).

Jeehyun Yang: Automated chemical reaction network generation and its application to exoplanet atmospheres With the advent of JWST and spectroscopic characterization of exoplanet atmospheres with unprecedented detail, there is a demand for a more complete picture of chemical reactions and their impact on atmospheric composition. A traditional way of building chemical reaction networks for planetary atmospheres is adopting reaction rate information manually from various references. For this reason, a model's applicability is restricted to the typically limited conditions that the model is designed for (e.g., chemical networks for hot Jupiters cannot be used for Venus-like exoplanets). Here we utilize a computer-aided chemical reaction network generator to construct the reaction network and couple it with a kinetic-transport and photochemical model. This new approach has two major benefits over the traditional way: (i) reaction rates are chosen based on a rate-based iterative algorithm as well as multiple self-refinement steps, and thus it is less likely that the model will miss important reactions and becomes more reliable; and (ii) since the approach is automatic, it enables us to describe various chemical systems that are larger and more complex (e.g., from water world to hot Jupiter) in a very efficient and solid way. We use WASP-39 b as a test case to demonstrate improvements over a previous model.