Exoplanets IV

Atmospheric Escape and Evolution Splinter Session

Wednesday, May 4, 2022 (1-5 pm PT)

The M Resort, Milan room

List of participants:

Name	Affiliation	Pronouns
Leonardo dos Santos	Space Telescope Science Institute	he/him
James Kirk	Harvard CfA	He/him
Jessica Spake	Caltech	
Munazza Alam	Carnegie EPL	
Shreyas Vissapragada	Caltech	he/him
Michael Zhang	Caltech	
Kevin France	University of Colorado	He/His
James Owen	Imperial College London	He/Him
David Kasper	University of Chicago	
Lia Corrales	University of Michigan	she/her
Madelyn Broome	UC Santa Cruz	She/her/hers
Natalia Guerrero	University of Florida	she/her
Jessica Libby-Roberts	Penn State University	She/her/hers
Vigneshwaran Krishnamurthy	NAOJ, Japan	He
Chima McGruder	Harvard | CfA	he/him/his
Romain Allart	Université de Montréal	He/him/his

Name	Affiliation	Pronouns
Raissa Estrela	Jet Propulsion Laboratory, California Institute of Technology	She/Her/Hers
Dion Linssen	University of Amsterdam	he/him
Kevin Ortiz Ceballos	Center for Astrophysics | Harvard & Smithsonian	he/him/his
Allison Youngblood	NASA Goddard Space Flight Center	she/her/hers
Akash Gupta	University of California, Los Angeles	He/him/his
Juliana Garcia-Mejia	CfA | Harvard & Smithsonian	she/her
William Misener	University of California, Los Angeles	he/him
James Rogers	Imperial College London	He/His/Him
Antonija Oklopcic	University of Amsterdam	she/her/hers
George King	University of Michigan	he/him
Winter Parts	Penn State University	they/them
Aidan Gibbs	UCLA	He/him
Chenliang Huang	University of Arizona	
Gudmundur Stefansson	Princeton University	He/him/his
Ethan Schreyer	Imperial College	He/him/his
Ares Osborn	University of Warwick	they/them
R. O. Parke Loyd	Eureka Scientific, Inc.	He|Him|His
Keighley Rockcliffe	Dartmouth College	she/her/hers
Leslie Rogers	University of Chicago	She/Her/Hers
Collin Cherubim	Harvard University	
Marie-Luise Steinmeyer	University of Copenhagen	she/her
Beatriz Campos Estrada	University of Copenhagen	she/her
James Jackman	Arizona State University	He/him/his
Bibiana Prinoth	Lund Observatory	she/her/hers

Session program:

All times are PM and Pacific Time.

Welcome and introduction
1:00 – 1:05: Leonardo dos Santos

Invited reviews:
1:05 – 1:35: Allison Youngblood
1:35 – 2:05: Chenliang Huang

Contributed talks (observations):
2:05 – 2:15: Romain Allart
2:15 – 2:25: George King
2:25 – 2:35: Keighley Rockcliffe
2:35 – 2:45: R. O. Parke Loyd

2:45 – 3:10: Coffee-break

Contributed talks (demographics)
3:10 – 3:20: Raissa Estrela
3:20 – 3:30: Madelyn Broome
3:30 – 3:40: William Misener

3:40 – 3:50: Short break

Contributed talks (simulations):
3:50 – 4:00: James Owen (on behalf of Richard Booth)
4:00 – 4:10: Dion Linssen
4:10 – 4:20: Ethan Schreyer

4:20 – 5:00: Topical discussions

5:00: End

Topical discussions:

These discussion topics were compiled based on those suggested by the participants during registration. Our main interests include, but are not limited to:

- Lyman-alpha and metastable He observations: reproducibility, variability, strategies, retrievals
- Detailed hydrodynamic escape modeling: including magnetic fields, planetary/stellar wind interactions, radiative transfer, what properties of the host star drive escape, sources of uncertainties in escape rate estimates
- Going beyond: other escape traces besides H and He, non-H dominated planets, dusty outflows, isotopic fractionation, future instruments (ground- and space-based)

Coffee-break menu:

- M Signature Italian Roast Coffee (regular and decaf)
- Milk 2% & almond milk
- Assorted Freshly Baked Jumbo Gourmet Cookies
- Warm Mini Pretzel Bites with Cheese Sauce & Honey Mustard Dipping Sauce
- Sliced Fruit Spears in a Rock Glass

Abstracts

Topic: Observations (4 talks)

Romain Allart
Title: Search for the presence of helium in the atmosphere of ten exoplanets with SPIRou
Abstract: I will present a summary of the search for helium absorption in ten exoplanets observed with SPIRou. I will then show some preliminary correlations for this survey homogeneously analyzed.

George King
Title: The strongly irradiated planets in Praesepe
Abstract: We present an analysis of XMM-Newton observations of four stars in the young (670 Myr) open cluster Praesepe, all of which host planets close to the radius-period valley and/or the Neptunian desert. Although no longer in the saturated regime, we find that strong XUV irradiation is still ongoing. We also investigate possible futures for the planets with simulations of their atmospheric evolution, with outcomes dependant on their current masses.

Keighley Rockcliffe
Title: A Lyman-α transit left undetected: the environment and atmospheric behavior of K2-25b

Abstract: K2-25b is a young warm Neptune that was expected to be undergoing atmospheric escape. HST/STIS observations of K2-25b transits in Lyman-alpha show that there is no significant neutral hydrogen outflow. What could be causing this non-detection? Do we expect this from other young exoplanets?

R. O. Parke Loyd
Title: An Experiment to Distinguish Exoplanet Outflow Mechanisms by Measuring Lyα Tail Lengths with UV-SCOPE
Abstract: Two processes, core powered mass loss (CPML) and photoevaporation (PE), can explain the atmospheric escape that transforms sub-Neptunes into super-Earths. To resolve which process dominates, the mid-class explorer mission UV-SCOPE, proposed to NASA December 2021, would measure the Lyα tail length of approximately 40 active planetary outflows, determining whether their launch velocities match the predictions of CPML or PE.

Topic: Demographics (3 talks)

Raissa Estrela
Title: Terrestrial Worlds Atmospheres: Analysis of Multi dimensional Factors that Shape their Evolution
Abstract: Most of the planets detected are small, with a size that is unusual in our Solar System ranging from Earth to Neptune radii. To understand the processes that shape these planets, here we explore the relationships between their radius, insolation, and density. Also, we investigate the potential role of stellar irradiation in envelope removal by tracking the evolution of their envelope in the mass-radius diagram considering the escape due to photoevaporation.

Madelyn Broome
Title: Can Photoevaporative Mass Loss Reproduce Both the Period-radius Valley and Neptune Desert?
Abstract: Until now, no models have attempted to recreate the period-radius valley ("Fulton Gap") and "Neptune desert" in the same sample of planets. We use a new version of the soon-to-be-publicly-available Murray-Clay et al. (2009) 1D relaxation code (now with multispecies and multifrequency capabilities) to model photoevaporation as a Parker wind for a grid of planets. We also explore the impact of atmospheric metallicity and stellar type on mass loss, as well as generate predictive spectra to infer the observability of atmospheric escape using UV telescopes.

William Misener
Title: To cool is to keep: residual H/He atmospheres of super-Earths and sub-Neptunes
Abstract: After undergoing core-powered mass-loss, some super-Earths can retain small residual H/He envelopes, which can be have masses up to 10^-3 times the mass of the planet. This retention is possible because, for significantly depleted atmospheres, the density at the radiative–convective boundary drops sufficiently such that the cooling time-scale becomes shorter than the mass-loss time-scale. These residual hydrogen envelopes reduce the

atmosphere's mean molecular weight compared to a purely secondary atmosphere, a signature observable by current and future facilities.

Topic: Detailed modeling of escape (3 talks)

James Owen (on behalf of **Richard Booth**)
Title: Atmospheric escape from lava worlds
Abstract: Close in rocky planets are hot enough that the star can melt the day-side, forming a lava pool and rock vapour atmosphere. At low enough planet masses this rock vapour atmosphere can undergo atmospheric escape, condensing the atmosphere into observable dust particles as it expands and cools, as seen in the catastrophically evaporating rocky planets. I will present the first self-consistent simulations of this process, allowing us to understand how to link observations of these outflows to planetary interiors

Dion Linssen
Title: Constraining mass-loss rates by simulating Parker wind profiles with Cloudy
Abstract: Attempts to constrain mass-loss rates by fitting spectral lines with a grid of Parker wind models have often resulted in a strong degeneracy between temperature and mass-loss rate, resulting in weak constraints on either parameter. We provide additional theoretical constraints by simulating Parker wind models with NLTE photoionization code Cloudy and identifying models for which the resulting temperature structure is not consistent with the assumed isothermal profile. Combining the observational and theoretical constraints yields much tighter estimates of the mass-loss rate.

Ethan Schreyer
Title: Using Lyman-Alpha transits to test models of atmospheric escape
Abstract: Lyman Alpha transits provide direct observational evidence of atmospheric escape. So far, it has been difficult to match the results of 3D hydrodynamic simulations to observations, due to the large parameter range in which these models need to be run. We present a simple model of the interaction of the escaping gas with the stellar environment based on the results of 3D hydrodynamic simulations and show that it can be used to rigorously fit to observations to distinguish between models of atmospheric escape.