CV of Paul Maurice Mollière, Research Group Leader

Last updated: 3 November 2024

Contact

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Scientific interests

Clouds and variability of exoplanet atmospheres

Retrievals of exoplanet spectra

Formation of exoplanets

Scientific code development

Positions

2022 – **Staff scientist**, group leader, Max-Planck-Institut für Astronomie, Heidelberg, Germany

2019 – 2022 **Postdoctoral researcher**, Max-Planck-Institut für Astronomie, Heidelberg, Germany

2017 – 2019 **Postdoctoral researcher**, Leiden Observatory, University of Leiden, the Netherlands

Education

2013–2017 **PhD in astronomy**
Max-Planck-Institut für Astronomie / University of Heidelberg, Germany
Supervisors: Prof. Dr. Thomas Henning, Dr. Roy van Boekel
Final grade: 1.0, "very good", with distinction "summa cum laude"

2012–2013 **Master of Advanced Study in Astrophysics**
Institute of Astronomy, University of Cambridge, United Kingdom
Final grade: Distinction (equivalent to First Class)

2011–2012 Master of Science in Physics: 2-year program, discontinued in 2012 (went to Cambridge instead), University of Heidelberg, Germany

2008–2011 **Bachelor of Science in Physics**
Final grade: 1.3, "very good"
University of Heidelberg, Germany

Awards

2017 **Otto Hahn Medal**
Max Planck Society

2013 **Institute of Astronomy Prize**
University of Cambridge

2013 **Ida Freund Prize** & **Henry Tomkinson Scholarship**
Girton College, University of Cambridge

Supervision

Students

2024 – **David Hägele** (Master thesis)
Topic: efficient calculation of high resolution opacities from the largest linelists

2024 – **Antonia von Stauffenberg** (PhD thesis)
Topic: unlocking the properties of exoplanet clouds by combining retrievals and climate models

2020 – 2024 **Evert Nasedkin** (PhD thesis)
Topic: retrievals of (mostly directly imaged) planets (mostly in the HR 8799 system)

2022 **Elise Lei** (Summer intern)
Topic: porting Fortran chemistry code to Python. Now publicly available [1]

2019 **Robin Petermann** (Master thesis)
Co-supervisor, title: "Atmospheric characterization of terrestrial planets using high-resolution spectroscopy with ELT/METIS"

2018 **Joost Wardenier** (Master thesis)
Title: "A Bayesian Retrieval Tool for Clouds in Exoplanet Atmospheres"

2016 **Patrick Barth** (Bachelor thesis)
Title: "Large-Scale Circulation with Cloud Formation in Planetary Atmospheres".

Postdocs

2024 – **Beatriz Campos Estrada**
Starting in November. Topic: retrieving weather in GCM-predicted lightcurves of directly imaged planets

2021 – 2024 **Doriann Blain**
Topics: full restructuration, factorization and optimization of pRT, now pRT3[2], high-resolution retrievals

Teaching

2025 (upcoming) **Contributing a new lecture on Bayesian model fitting and selection**
Numcerical Practicals, together with Prof. Hubert Klahr, University of Heidelberg, Germany

2024 **Lecture on radiative transfer, transmission spectra, and Bayesian model fitting**[3]
HGSFP Grad Days, University of Heidelberg, Germany

2024 **Seminar Advisor: Physics of Planet Formation**
Together with Prof. Hubert Klahr, University of Heidelberg, Germany

2023 **Lecture on "Radiative Transfer and Line formation"**[4] **+ retrieval demonstrations**[5]
Sagan Summer Workshop 2023, Caltech / NexScI, Pasadena, USA

2018 **Lecture on "Atmospheric models of exoplanets and spectroscopic retrievals"**
DFG "Hands-on Numerical Astrophysics School for Exoplanetary Sciences" in Höchst, Germany

2014/15 **Exercise teacher of the "Principles of Simulations Methods" lecture**
held by Prof. Dullemond and Prof. Klahr, University of Heidelberg, Germany

Observing Experience

2022-2023 **CRIRES+ at VLT's UT3: Transit observations of HD 209458b**
four transits, remote observations in designated visitor mode

2015 **FEROS (RV follow-up) with the MPG-ESO 2.2m telescope at La Silla, Chile**
16 nights

2010 **Exoplanet transit observations on Köngistuhl in Heidelberg, Germany**
Summer internship, development of own light curve fitting algorithm. Supervisor: Christoph Mordasini

Successful observing proposals

2024 **"Testing a new formation tracer for cold gas giant planets with JWST/MIRI"**
awarded 4 hours of JWST MIRI/MRS observations in Cycle 3, PI: Patapis, Co-PI: Mollière

2023 **"Vaporized rocks: Detecting silicate cloud precursors in ultra-hot Jupiters"**
awarded 9 hours for one eclipse of WASP-121b with JWST MIRI/LRS in Cycle 2, PI: Mollière

2021 **"Osiris calling: disentangling the surprising atmospheric composition of HD 209458b"**
awarded four half-nights for four transits with CRIRES+, PI: Mollière

2019 **"ExoGRAVITY" Large Program with VLTI/GRAVITY**
awarded 14 nights, PI: Lacour, significant contribution to written proposal, serving as lead modeler

[1] `https://easychem.readthedocs.io/en/latest/`
[2] `https://petitradtrans.readthedocs.io/en/latest/`
[3] `https://keeper.mpdl.mpg.de/d/1779f795077a4205b2b7/`
[4] `https://nexsci.caltech.edu/workshop/2023/molliere_radiative_transfer_corrected.pdf`
[5] `https://nexsci.caltech.edu/workshop/2023/handson.shtml`

Organization of scientific meetings

2025 (upcoming) **"Planetary formation and Exoplanets in the ELT era" Workshop**
SOC member, ESO, Garching, Germany

2024 **"Two HoRSEs" Conference**
Chair of SOC and LOC, Harnack House, Germany, talks available on meeting website[6]

2024 **"Challenge Accepted: Linking Planet Formation with Present-Day Atmospheres" workshop**
SOC member, HdA, Germany[7]

2023 **"petitRADTRANS" Workshop**
Chair of SOC and LOC, HdA, Germany

2023 **"Cloud2Con" Workshop**
Chair of SOC and LOC, Ringberg Castle, Germany[8]

2022 **"Celebrating JWST's first six months of exoplanet data"**
SOC member, Ringberg Castle, Germany[9]

2021 **"Cloud Nine Con"**
Chair of SOC (and LOC for the MPIA people), online meeting, talks available on meeting website[10].

Other responsibilities

2024 – **Steering committee member of the IAU's Office of Astronomy for Education**

2023 – **Internal institute functions**
Coordinating undergrad thesis and internship applications, member of the computing committee

2021 – **Local Science Case Leader**
ANDES consortium K-band spectrometer for the ELT telescope

2021 – **Science Team Co-Chair**
ANDES consortium Exoplanet and Disks Working group for the ELT telescope

2020 – **Steering committee member of the ExoGRAVITY collaboration**

∞ Referee for ApJ, A&A, MNRAS, Nature

Outreach

2023 **"Atmosphären(modellierung) in der Ära des James-Webb-Weltraumteleskops"**
"Atmospheric modeling in the era of JWST", talk for high school teachers, HdA, Heidelberg

2021 **"Wie Astronom*innen Atmosphären von Exoplaneten erforschen"**[11]
"How astronomers study exoplanet atmospheres", Faszination Astronomie Online, HdA, Heidelberg

Nov.-Oct. 2019 **"Atmosphären von Exoplaneten - Beobachtung und Modellierung"**
"Exoplanet atmospheres: observations and modeling", talk for high school students, MPIK, Heidelberg, talk for high school teachers, HdA, Heidelberg

Oct. 2019 **"Wie Astronomen Atmosphären von Exoplaneten erforschen"**
"How astronomers investigate exoplanet atmospheres", outreach talk at HdA, Heidelberg

2014-1017 **Outreach fellow of the Haus der Astronomie (HdA)**
Including observatory tours, planetarium presentations, Heidelberg, Germany

Talks (invited only)

2024 (upcoming) **"Clouds and Weather in Exoplanet Atmospheres"**
Zurich Physics Colloquium, ETH Zurich, Switzerland

2024 (upcoming) **"Clouds and Weather in Exoplanet Atmospheres"**
Astrophysics Seminar, University of Zurich, Switzerland

2024 **"Ammonia isotopologues as a new planet formation tracer"**
StarPlan Seminar, Copenhagen, Denmark

[6] https://sites.google.com/view/two-horses/
[7] https://the-great-link.github.io/
[8] https://www2.mpia-hd.mpg.de/~molliere/ringberg_clouds/
[9] https://www2.mpia-hd.mpg.de/~molliere/ringberg_jwst/
[10] https://sites.google.com/view/cloudninecon
[11] https://www.youtube.com/live/giX_XT-NBlw?si=db4Pf1kR5WSRt9B-

2024 **"Radiative transfer modeling for exoplanet atmospheres"**
Radiative Transfer in Astrophysics Workshop, Heidelberg, Germany

2024 **"Ammonia isotopologues as a new planet formation tracer"**
From Star to Planet Formation, Villa Vigoni, Italy

2024 **"Ammonia isotopologues as a new planet formation tracer"**
IPAG Seminar, Grenoble, France

2023 **"Molecules in Exoplanet Atmospheres"**
799th Heraeus Seminar, Heidelberg, Germany

2023 **"Inferring the atmospheric properties of directly imaged planets"**
ICDSS Meeting, China (virtual)

2023 **"Inferring the atmospheric properties of directly imaged planets"**
NAOC Exoplanet Seminar, Beijing, China (virtual)

2022 **"Giant exoplanet (atmospheric) modeling as driven by observations"**
Five Years of GRAVITY workshop, Ringberg, Germany

2022 **"Inferring the atmospheric properties of directly imaged planets"**
DFG SPP 1992 Seminar, remote

2022 **"Retrieving the properties of cloudy directly imaged planets"**
Exoplanets & Habitability Seminar, ETH Zurich, Switzerland

2022 **"Unlocking the atmospheric properties of cloudy, directly imaged exoplanets"**
MPI for Meteorology, Hamburg, Germany

2022 **"Retrieving the properties of cloudy directly imaged planets"**
Exoplanet Seminar, Liège, Belgium (virtual)

2022 **"Retrieving the properties of cloudy directly imaged planets"**
Exoplanet Seminar, University of Cambridge (virtual)

2021 **"1-d radiative-convective equilibrium models of exoplanet atmospheres"**
ERS Pre-Launch Theory Webbinar (virtual)

2021 **"Modeling and Characterization of Cloudy Exoplanet Atmospheres"**
Laboratory Astrophysics Workshop, Jena, Germany (virtual)

2021 **"Measuring and interpreting the abundances of exoplanet atmospheres"**
Séminaire de l'Institut d'Astrophysique de Paris, France (virtual)

2021 **"From atmospheric to planet formation retrievals"**
Astrophysics Seminar, online talk at the McMaster University, Hamilton, Canada

2021 **"From atmospheric to planet formation retrievals"**
Astronomy Seminar, online talk at the University of Stockholm, Sweden

2021 **"From atmospheric to planet formation retrievals"**
Séminaire Lagrange, online talk at Observatoire de la Côte d'Azur, Nice, France

2020 **"Retrieving the atmospheric properties of directly imaged planets"**
IMPRS Summer School, Heidelberg, Germany

2020 **"From exoplanet atmospheres to planet formation"**
Königstuhl Colloquium, MPIA, Heidelberg, Germany

2019 **"The hunt for isotop(ologu)es in exoplanet atmospheres"**
Exocomets workshop, Lorentz Center, Leiden, the Netherlands

2019 **"The hunt for isotop(ologu)es in exoplanet atmospheres"**
Astrophysics Colloquium, Universität Göttingen, Germany

2019 **"Opacities in Spectral and Atmospheric Modeling"**
Digital Exoplanets workshop, Prague University, Czech Republic

2018 **"Detecting Isotopologues in Exoplanet Atmospheres"**
Exoplanets & Habitability Seminar, ETH Zurich, Switzerland

2018 **"Detecting Isotopologues in Exoplanet Atmospheres"**
Astrophysics Colloquium, Universität Tübingen, Germany

2018 **"Detecting Isotopologues in Exoplanet Atmospheres"**
Oort Workshop: "Planet Habitability and the Search for Life outside the Solar System", Leiden, the Netherlands

2017 **"Exoplanet characterization with JWST"**
"CSH Seminar", Center for Space and Habitability, Bern, Switzerland

2017 **"Modeling of Exoplanet Atmospheres and and Parameter Retrieval"**
Königstuhl Colloquium, MPIA, Heidelberg, Germany

2016 **"Synthetic JWST Spectra for Prime Exoplanet Targets"**
Leiden Observatory, the Netherlands

2016 **"Synthetic JWST Spectra for Prime Exoplanet Targets"**
CEHW Seminar, Pennsylvania State University, State College, USA

2014 **"Models of Planet Formation"**
Invited review, "Towards Other Earths II: The Star-Planet Connection" conference, Porto, Portugal

2014 **"Linking a planet's formation history to its present-day composition"**
"The Disk in Relation to the Formation of Planets and their Protoatmospheres" ISSI-BJ/ISSI workshop, Beijing, China

Publications

Number of refereed papers: 113, Citations: 5615, H-index: 41
Number of first-author refereed papers: 8 (+1 submitted), first-author citations: 1026

First author publications

[1] E. Lei and P. **Mollière (shared first authorship)**. easyCHEM: A Python package for calculating chemical equilibrium abundances in exoplanet atmospheres. *arXiv e-prints, submitted to JOSS*, page arXiv:2410.21364, Oct. 2024, 2410.21364.

[2] D. Barrado, P. **Mollière**, P. Patapis **(shared first authorship)** et al. $^{15}NH_3$ in the atmosphere of a cool brown dwarf. *Nature*, 624(7991):263–266, Dec. 2023, 2311.08054.

[3] P. **Mollière** et al. Interpreting the Atmospheric Composition of Exoplanets: Sensitivity to Planet Formation Assumptions. *ApJ*, 934(1):74, July 2022, 2204.13714.

[4] P. **Mollière** et al. Retrieving scattering clouds and disequilibrium chemistry in the atmosphere of HR 8799e. *A&A*, 640:A131, Aug. 2020, 2006.09394.

[5] P. **Mollière** et al. petitRADTRANS. A Python radiative transfer package for exoplanet characterization and retrieval. *A&A*, 627:A67, July 2019, 1904.11504.

[6] P. **Mollière** and I. A. G. Snellen. Detecting isotopologues in exoplanet atmospheres using ground-based high-dispersion spectroscopy. *A&A*, 622:A139, Feb. 2019, 1809.01156.

[7] P. **Mollière** et al. Observing transiting planets with JWST. Prime targets and their synthetic spectral observations. *A&A*, 600:A10, Apr. 2017, 1611.08608.

[8] P. **Mollière** et al. Model Atmospheres of Irradiated Exoplanets: The Influence of Stellar Parameters, Metallicity, and the C/O Ratio. *ApJ*, 813(1):47, Nov. 2015, 1509.07523.

[9] P. **Mollière** and C. Mordasini. Deuterium burning in objects forming via the core accretion scenario. Brown dwarfs or planets? *A&A*, 547:A105, Nov. 2012, 1210.0538.

Group member publications

[1] E. Nasedkin et al. Four-of-a-kind? Comprehensive atmospheric characterisation of the HR 8799 planets with VLTI/GRAVITY. *A&A*, 687:A298, July 2024, 2404.03776.

[2] E. Nasedkin, P. **Mollière**, and D. Blain. Atmospheric Retrievals with petitRADTRANS. *The Journal of Open Source Software*, 9(96):5875, Apr. 2024, 2309.06755.

[3] E. Lei and P. **Mollière (shared first authorship)**. easyCHEM: A Python package for calculating chemical equilibrium abundances in exoplanet atmospheres. *arXiv e-prints, submitted to JOSS*, page arXiv:2410.21364, Oct. 2024, 2410.21364.

[4] D. Blain, A. Sánchez-López, and P. **Mollière**. A Formally Motivated Retrieval Framework Applied to the High-resolution Transmission Spectrum of HD 189733 b. *AJ*, 167(4):179, Apr. 2024, 2402.14001.

[5] D. Blain, P. **Mollière**, and E. Nasedkin. SpectralModel: a high-resolution framework for petitRADTRANS 3. *The Journal of Open Source Software*, 9(102):7028, Oct. 2024.

[6] D. Blain, R. Landman, P. **Mollière**, and J. Dittmann. Four HD 209458 b transits through CRIRES+: Detection of H_2O and non-detections of C_2H_2, CH_4, and HCN. *A&A*, 690:A63, Oct. 2024.

[7] E. Nasedkin et al. Impacts of high-contrast image processing on atmospheric retrievals. *A&A*, 678:A41, Oct. 2023, 2308.01343.