Pauline LOMBA

Ph.D. Application

Specialization: PLANETOLOGY,
EXOPLANETARY Sciences, and EXOBIOLOGY.

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Education

2024 – 2025 **Second year of undergraduate degree in Biochemistry, Molecular Biology, and Microbiology**
Toulouse III Paul Sabatier University, *Toulouse, France*

2022 – 2024 **Master's Degree in Astrophysics, Space Sciences, and Planetology**
Toulouse III Paul Sabatier University and ISAE-SUPAERO, *Toulouse, France*
Technical University of Denmark (DTU Space), *Lyngby, Denmark*

Relevant modules: Formation and Evolution of Planetary Systems, Exoplanets and Habitability, Planetary and Exoplanetary Atmospheres, Geophysics and Geodynamics, Planet-Environment Interaction, Seismology of Stars and Planets, Radiation and Transfer, Advanced Fluid Dynamics, Advanced Stellar Physics, Astrometry, Signal and Image Processing, Advanced Space Mechanics, Python and C Programming.

2019 – 2022 **Undergraduate degree in Physics, Chemistry, Astrophysics, Meteorology and Energy (PCAME)**
University of Pau et les Pays de l'Adour (UPPA), *Pau, France*
Toulouse III Paul Sabatier University, *France, Tarbes*

Relevant modules: Atmospheric Physics, Chemistry, Planetology, Electromagnetism, Project Management, Numerical Methods, and Python Programming.

2019 **General Science Baccalaureate specialized in Engineering Sciences and European Physics Class**
Lycée St Cricq, *Pau, France*

Research Experience

5 months
2024 **Interior Composition Model for Sub-Neptune Exoplanets: A Focus on K2-18b.**
Technical University of Denmark (DTU Space), *Lyngby, Denmark*
Supervisor: Dr. João M. Mendonça

5 days
2024 **Internship in Observational and Instrumental Astronomy: Hands-On and Robotic Observations, Data Acquisition and Processing.**
Pic du Midi Observatory, *Bagnères-de-Bigorre, France*
Supervisor: Dr. Frédéric Pitout

1 month
2023 **Determination of the Base of the Convective Zone and the Helium Ionization Zone for Ten Solar-Type Stars.**
Laboratory Universe And Particles De Montpellier (LUPM), *Montpellier, France*
Supervisor: Dr. Morgan Deal

3 months
2023 **The Fate of Planetary Systems: Study of Debris Disk Accretion onto White Dwarfs and Thermohaline Diffusion Using the Stellar Evolution Code MESA.**
Institute of Research in Astrophysics and Planetology (IRAP), *Toulouse, France*
Supervisor: Prof. Dr. Sylvie Vauclair & Dr. Morgan Deal

5 months
2022 **Propagation of Sound Waves in the Atmosphere of R Scuti.**
L'Observatoire Midi-Pyrénées (OMP), *Tarbes, France*
Supervisor: Prof. Dr. Philippe Mathias

Outreach

2024
- **Conference**: *Doomsday Worlds: The Best Exoplanets to Die On*
  For the Cosmic Horror Event at Copenhagen Planetarium, Denmark.
- **Card Game**: *The Diversity of Exoplanets*
  `Click here for preview.`
- **MAGRATHEA Project**: *Educational conferences and workshops for children*
  On astrophysics, chemistry, and biology. `Click here for preview.`

Skills

Languages	French (native), English (fluent), Spanish (conversational), German and Danish (beginner).
Coding	Python, C, HTML, LaTeX, LabVIEW.
Astro Software	MAGRATHEA, MESA, SAOImage DS9, AstroImageJ.

Interest Center

- Member of the SAF (French Astronomical Society) and UPS In Space (University of Toulouse III Paul Sabatier Space Club).
- Sewing clothing and accessories using upcycled materials.
- Knitting, crochet, and embroidery.
- Sports: Dance (8 years), running (1 year).
- Digital music composition.

References

Dr. João M. Mendonça
Senior Researcher
DTU Space,
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2800 Kgs. Lyngby,
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Dr. Natalie Webb
Senior Researcher
Institut de Recherche en Astrophysique et Planétologie (IRAP),
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Statement of Research Interests

Pauline Lomba

Having recently completed my Master's Degree in Astrophysics, Space Sciences, and Planetology at Toulouse III Paul Sabatier University in France, I am currently furthering my education with a second year of undergraduate studies in Biochemistry, Molecular Biology, and Microbiology. Throughout my academic journey, I had the opportunity to undertake four research internships/projects in Astrophysics, which I will detail in Section 1. My goal is to continue my studies by pursuing a PhD in Astrophysics, enabling me to contribute to ongoing research in exoplanetary sciences and exobiology (see Section 2).

1 Research Background:

1.1 Interior Composition Model for Sub-Neptune Exoplanets: A Focus on K2-18b

During the final semester of my master's degree, I completed a five-month internship focused on modeling the interior composition of Sub-Neptune exoplanets. The exploration of exoplanets has revealed a wide range of planetary bulk compositions. However, the differentiation of exoplanet interiors introduces degeneracies among possible compositions, complicating efforts to accurately infer their internal properties. To address this, I developed a novel approach that combines the 1D planet interior structure model, MAGRATHEA, with the nested sampling algorithm, UltraNest. This model explores the parameter space and distinguishes between various compositional possibilities. I applied this approach to K2-18b, one of the most promising exoplanets for habitability, which is creating debate regarding its true composition. These results were then compared with previous studies to validate the effectiveness of the approach. This Master's thesis gave me the opportunity to deepen my knowledge of exoplanetary sciences and confirmed my desire to continue in this field.

1.2 Determination of the Base of the Convective Zone and the Helium Ionization Zone for 10 Solar-Type Stars

During the summer before my second year of the Master's program, I delved deeper into asteroseismology by working on the spectral analysis of the oscillation modes of 10 solar-type stars using Kepler data. The goal was to identify the base of the convective zone and the helium ionization zone. To achieve this, I generated random ensembles of propagation modes within the maximum error bars of the initial data. Then, using the seismic index of the second difference, I was able to find the value of the acoustic glitch, which is linked to the properties of the material. This allowed me to determine the most probable value for the acoustic depth of the convective zone and the helium ionization zone. Although this work isn't directly related to planetary science, it is crucial for enhancing our knowledge of stars, which in turn aids in better understanding and characterizing planetary systems.

1.3 The Fate of Planetary Systems

In the second semester of my first year of master's studies, I completed a three-month project on modeling the accretion of debris disks resulting from the end of planetary systems onto white dwarfs using

the MESA stellar evolution code. We studied the internal structure of white dwarfs and demonstrated that their atmospheric abundances depend on the accretion rate, atomic diffusion, and thermohaline convection due to mean molecular weight inversions. This work represents a step toward understanding the final stages of planetary systems.

1.4 Propagation of Sound Waves in the Atmosphere of R Scuti

In the final semester of my undergraduate degree, I spent five months studying sound wave propagation in the atmosphere of R Scuti, a pulsating RV Tauri star with two luminosity periods, using data from the Narval and Neo-Narval spectropolarimeters of the Pic du Midi Observatory. We developed a program to calculate the pulsation phases of R Scuti at the time of measurement. After identifying these phases, we reconstructed line profiles using Gaussian curves for both the average spectrum and specific atomic lines. This analysis enabled us to calculate the acceleration of the atmosphere and, consequently, the speed of sound wave propagation within it. This also allowed us to identify the double cycle in R Scuti's pulsation, confirming the primary and secondary minima in its luminosity curves.

2 Future Research

I would like to pursue a PhD in exoplanetary sciences or a closely related field, where I can apply what I have learned and develop new knowledge. Some potential topics and areas of interest I have include:

Exoplanets:

- Characterization of exoplanetary atmospheres: chemical composition, temperature gradients, cloud structures, and potential water or other molecular cycles in hot Jupiters, sub-Neptunes and rocky worlds.
- Link exoplanet atmospheric metallicities to those of their host stars, then use machine learning to predict the planet's atmospheric composition based on the star's characteristics.
- Analyze planetary magnetic fields to characterize the planet's core and internal structure.

Exobiology:

- Identification of biomarkers in exoplanets atmospheres.
- Distinguishing true biomarkers from false positives by simulating abiotic processes.
- Connecting prebiotic chemistry to the origins of biological life.
- Search for traces of life or past life within our Solar System.

Instrumentation:

- Enhancing instrumentation to probe deeper into exoplanets atmospheres.