Stars, Transits & Habitability

SUMMARY.
Astrobiology aims to understand the conditions that allow life to exist in the Universe, which makes it essential to study stars and their planets as possible habitats. This project introduces these conditions by learning the key physical and chemical factors that shape planetary systems in our Galaxy. Students will apply theoretical concepts of stellar evolution, planet formation and habitability together with practical analysis of ground-based and space-based NASA TESS light-curve data and stellar spectra from the Molėtai Astronomical Observatory and archives. The work focuses on detecting and modelling planetary transits, determining essential star and planet parameters and evaluating the potential habitability of the studied system. Through this METEOR, students will gain experience in star and planet data analysis and in linking astrophysical measurements with astrobiological interpretation.

OBJECTIVES

- *The student will understand the key concepts of astrobiology, including the Galactic Habitable Zone, planet characterisation, habitability, and the chemical and organic components relevant to life, as well as the main open issues on these topic.*
- *The student will learn to analyse light-curves and stellar spectra to model planetary transits, determine basic system parameters.*

INSTITUTE

- Vilnius University, Faculty of Physics, Institute of Theoretical Physics and Astronomy
- Institute URL
- Saulėtekio av. 3, LT-10257 Vilnius, Lithuania

THEORY

by R. Minkevičiūtė

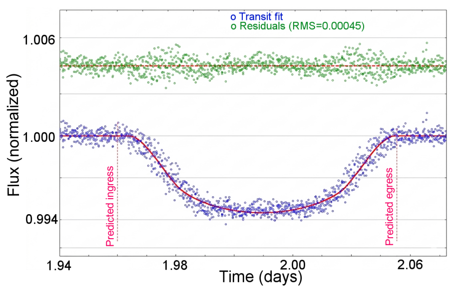
Are we alone in the universe? The question of whether there is life beyond Earth has captivated us for thousands of years. During the METEOR, the student will learn the key theoretical concepts of astrobiology, including star formation, protoplanetary disks, exoplanet detection and characterisation, the habitable zone around stars, and the distribution of chemical elements and organic molecules in the Universe. The theoretical part will also address the geological history of Earth and the origins of life on our planet.

APPLICATIONS

The students will pick a project with a focus on exoplanet transit or on planet-hosting star analysis.

by E. Pakštienė

The student, with guidance from the supervisor, will analyse ground-based and NASA TESS light-curve data to detect and model planetary transit, determine orbital period and planet radius, and combined with stellar data evaluate the potential habitability of the studied system.



Phase-folded light curve of the hot Jupiter HD 201033 b transit, observed with the TESS space telescope in Sector 56 at a 2-minute cadence.

by E. Stonkutė

The student, with guidance from the supervisor, will run a research project based on observational data of a planet-hosting star, using spectra from the Molėtai Astronomical Observatory archive together with Gaia data. From these datasets, the student will determine the stellar parameters and the abundances of key chemical elements (e.g., C, N, O, S, Mg, Si, Fe), as well as the star's mass, age and kinematics.

MAIN PROGRESSION STEPS

- Week 1-2: Project introduction
- Week 1-4: Lessons & Seminars on Theory
- Week 3-8: Research project
- Week 9: Final exam with presentation of the research project

EVALUATION

- *Theory grade [30%]*
  - *Presentation of an article*
  - *Participation in seminars*
- *Practice grade [30%]*
  - *Initiative, progress, analysis*
  - *Oral presentation*
- *Defense grade [40%]*
  - *Oral and slides quality*
  - *Context*
  - *Project / Personal work*
  - *Answers to questions*

BIBLIOGRAPHY & RESOURCES

- *Pakštienė et al. 2026*
- *Huber et al. 2022*
- *Stonkutė et al. 2020*
- *NASA Exoplanet Archive*
- *Madhusudhan 2026, "Habitability and biosignatures"*
- *Molėtai Astronomical Observatory*

CONTACT

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