Extrasolar Planets: Atmospheres and Interiors (L26)

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The field of extrasolar planets (or 'exoplanets') is one of the most dynamic frontiers of modern astronomy. Exoplanets are planets orbiting stars beyond the solar system. Thousands of exoplanets are now known with a wide range of masses, sizes, temperatures, and orbital parameters, spanning gas giants, ice giants, rocky planets and more. The field is now in a new era of detailed exoplanet characterization, which involves understanding the atmospheres, interiors, and formation mechanisms of exoplanets, and ultimately finding potential biosignatures in the atmospheres of habitable exoplanets. These efforts are aided by both high-precision spectroscopic observations as well as detailed theoretical models of exoplanets.

The present course will cover the theory and observations of exoplanetary atmospheres and interiors. Topics in theory will include (1) physicochemical processes in exoplanetary atmospheres (e.g. radiative transfer, energy transport, temperature profiles and thermal inversions, equilibrium/non-equilibrium chemistry, atmospheric dynamics and clouds/hazes) (2) models of exoplanetary atmospheres and observable spectra (1-D and 3-D self-consistent models, parametric models and retrieval techniques) (3) exoplanetary interiors (equations of state, mass-radius relations, and internal structures of giant planets, super-Earths/mini-Neptunes, and rocky exoplanets), and (4) habitability and biosignatures. Topics in observations will cover observing techniques and state-of-the-art instruments used to observe exoplanetary atmospheres. The latest observational constraints on all the above-mentioned theoretical aspects will be discussed.

Prerequisites

The course material should be accessible to students in physics or mathematics at the masters and doctoral level, and to astronomers and applied mathematicians in general. Knowledge of basic radiative transfer and chemistry is preferable but not necessary. The course is self-contained and basic concepts will be introduced as required.

Literature

1. Seager, S., Exoplanet Atmospheres: Physical Processes, Princeton Series in Astrophysics (2010).
2. Exoplanets, University of Arizona Press (2011), ed. S. Seager.
3. de Pater, I. and Lissauer J., Planetary Sciences, Cambridge University Press (2010).
4. Chapters on exoplanetary atmospheres and interiors in the book Protostars and Planets VI, University of Arizona Press (2014), eds. H. Beuther, R. Klessen, C. Dullemond, Th. Henning. Available publicly on astro-ph arXiv (e.g., arXiv:1402.1169, arXiv:1401.4738).

Additional support

Four examples sheets will be provided and four associated examples classes will be given. There will be a revision class in the Easter Term.