Physics and chemistry of sub-Neptunes/Neptunes

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Résumé

Detections surveys revealed a high abundance of exoplanets with radii between 1.8 and 3 Earth radii, called sub-Neptunes. These planets, which have no equivalent in our Solar System, are probably surrounded by thick H2- or H2O-rich atmosphere. They are excellent targets for atmospheric characterization and for understanding the transition between rocky and gaseous planets. The determination of the chemical composition, in particular the fraction of heavy elements (the metallicity) and the C/O ratio, would provide strong constraints on the mechanisms of planetary formation and atmospheric escape.
Until now, transit spectroscopic measurements have been quite limited to characterize the atmospheres of sub-Neptunes, mostly due to the presence of high clouds and hazes. HST and Spitzer observations coupled to atmospheric retrieval revealed the presence of water vapour on the warm Neptune GJ 3470 b and on the temperate sub-Neptune K2-18 b, as well as the absence or a very small abundance of CH4 (1,2,3). These results contradict predictions from chemical models, according to which CH4 should be the dominant C-bearing specie.

During this talk, I will present our 1D/3D modelling results for K2-18b (4,5,6) and GJ3470 b, in particular concerning the chemistry with the CH4 $<=>$ CO conversion, the atmospheric dynamics and how H2O can be confused with CH4 in HST transit spectra. I will show how the vertical mixing (induced by the atmospheric circulation or by tidal heating) applied to both the thermal structure and the chemistry contributes to a strong chemical disequilibrium for warm Neptunes. This interior-atmosphere connection opens up the possibility to probe the interior of exoplanets by measuring their chemical composition with future instruments (i.e. JWST, ELTs, Ariel).

Références

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