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Probing solid compositions in planetary core formation zones

M. McClure[1], C. Dominik[2], M. Kama[3]

[1]Leiden Observatory, Leiden University, Leiden, Netherlands,
[2]Anton Pannekoek Institute, University of Amsterdam, Amsterdam, Netherlands,
[3]University College London, London, United Kingdom

The bulk elemental ratios of planetary cores and atmospheres are a critical factor in determining a planet’s habitability. Upcoming missions like JWST and Ariel will enable spectroscopic surveys of molecules and atoms in exoplanet atmospheres, allowing us to determine bulk atomic ratios in the outermost atmospheric layers. Radius and mass measurements from TESS and ground-based RV follow-up can determine the bulk density of exoplanets, allowing us to infer their core compositions, with significant degeneracies. In principle, the observed bulk elemental abundances of a given exoplanet should be traced back to its radial birth location in a protoplanetary disk, indirectly probing the process of planet formation. However, planets may form their cores first and then migrate, accreting their envelopes at different locations and times relative to their cores. Furthermore, with current observational methods, we can only measure the radial gas phase composition of disks (e.g. with ALMA); we are blind to the finer details of the solid composition, e.g. iron, refractory carbon, or ice content at the disk midplane. To connect observed exoplanet compositions with the planet formation processes, we need techniques to probe the solid composition at locations where planets might form in disks.

We present a new technique to assess the composition of solids retained in protoplanetary disks during their lifetimes. Using near-infrared spectroscopy of the famous TW Hya disk, we take a snapshot of the gas phase abundances of several key elements (e.g. C, O, Si, Fe) inside the dust sublimation radius of this disk. These elements are all depleted from the gas phase, suggesting that they are trapped in solid dust grains at the inner edges of TW Hya’s known millimeter rings. We identify one refractory-rich dust trap in the terrestrial planet forming region and one trap in the outer rings that is enhanced in nitrogen relative to Solar System bodies. These results highlight how bodies forming in this disk could have compositions both similar to, and different than, our own solar system. Applying this technique to more disks with a broad range of ages will give us insight into the composition of planetary cores formed at different disk radii and times.