Constraining the detectability of water ice in debris disks

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Abstract

Given the importance of water ice in the development and preservation of life, identifying the distribution of water ice in debris disks is of central interest in the field of astrobiology. Furthermore, icy dust grains are expected to play important roles in the planet formation process. However, currently available observations only allow weak conclusions about the existence of water ice in debris disks.

We investigate the feasibility to detect water ice in typical debris disk systems. We take following ice destruction mechanisms into account: sublimation of ice, dust production through planetesimal collisions, and photosputtering by UV bright central stars. We consider dust mixtures with various shapes consisting of amorphous ice, crystalline ice, astrosilicate, and vacuum inclusions (i.e., porous ice grains).

We calculate optical properties of inhomogeneous ice/dust mixtures using effective medium theories, i.e. Maxwell-Garnett rules. Subsequently, we generate synthetic debris disk observables, such as the spectral energy distributions and spatially resolved scattered light, thermal re-emission, and scattered light polarization images with our code DMS (Kim et al. 2018).

We find that the prominent ~ 3 μm and 44 μm water ice features can be potentially detected in future observations of debris disks with the James Webb Space Telescope (JWST) and Space Infrared telescope for Cosmology and Astrophysics (SPICA). We show that the sublimation of icy dust grains, collisions between planetesimals, and photosputtering due to UV sources clearly affect the observational appearance of debris disk systems. In addition, highly porous ice (or ice-rich aggregates) tends to produce highly polarized radiation at 3 μm. Finally, the location of the "ice survival line" is determined by various dust properties, e.g., the fractional ratio of ice for the icy dust mixture, physical states, or porosity of ice.

Keywords: *circumstellar matter – planetary systems – methods : numerical*

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Biography

He achieved his master degree (Astronomy and Astrophysics) in Ruprecht-Karls-Universität Heidelberg. Currently, he is the Ph.D. researcher in the Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel. His research focuses on looking at traces in the dust around stars that reveal details about the formation and evolution of these planetary systems, e.g., debris disks system.