Constraining the bulk composition of disintegrating exoplanets with transmission spectroscopy using future space telescopes

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The bulk compositions of planets are believed to reflect their formation and evolution history. “Disintegrating planets”, ultra-short-period exoplanets discovered by the Kepler/K2 missions (e.g., Rappaport et al. 2012), opened a new window to characterize exoplanets’ bulk compositions. The rocky cores of disintegrating planets are likely to be evaporating due to strong stellar irradiation and/or high energy photons, and the dust produced by the recondensation of mineral vapor is thought to produce a comet-like tail. If the composition of the dust tail can be constrained by transmission spectroscopy, it would be a unique opportunity to directly approach the composition and interior of rocky cores (Bodman et al. 2018).
In this study, we investigated the feasibility of such observations with future observations of JWST and SPICA. For various minerals composed of primary elements of rocky planets (i.e., Fe, Si, and Mg) and additional rock-forming elements found in the Earth such as Al, Ca, and O, we calculated the extinction cross sections based on Mie theory. Taking into account the spatial distribution of the dust tail, we produced theoretical transmission spectra. Assuming the low-resolution spectrographs of JWST MIRI (5―12 μm) and SPICA SMI (17―36 μm), we evaluated observational conditions to constrain the mineral composition of dust tails.
Based on these simulations, we found that infrared transmission spectra at wavelengths longer than a few μm show different features depending on minerals. Since many spectral features show up in the wavelength regions of JWST and/or SPICA, the combination of those space observations allows us to diagnose the various components of dust tails. JWST will be able to detect absorption peaks of SiO_2, Mg_2SiO_4, and Al_2O_3 if a disintegrating planet is located within ~200 pc from the Earth with the transit depth deeper than 0.25% (SiO_2) ―2% (Al_2O_3). SPICA can distinguish between other minerals such as Fe_2SiO_4, FeO, and $CaTiO_3$, assuming a system at ~100 pc with a transit depth of 1―2%. Current and upcoming dedicated missions for transit searches (e.g., TESS, PLATO) would be able to provide optimal targets for this kind of studies.

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