Astrophysical Sciences & Technology
Ph.D. Dissertation Defense

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Infrared Investigations of the Composition and Structure of Nearby Protoplanetary Disks

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Abstract:

Near- to far-infrared imaging and spectroscopy of nearby (≤100 pc), low mass pre-main sequence stars that are orbited by gaseous and dusty circumstellar disks allow astronomers to probe the chemical composition and structure of protoplanetary disks, and further understand disk evolution and planet formation processes. In this dissertation, I present an infrared imaging and spectral analysis of the young star-disk systems V4046 Sgr, T Cha and MP Mus. V4046 Sgr is a nearby (D~73 pc), ~20 Myr-old spectroscopic binary surrounded by a large (R~350 AU) circumbinary disk. T Cha and MP Mus are similarly nearby (D≤110 pc) and young (≤ 22 Myr old) single-star systems orbited by relatively gas-rich circumstellar disks. Both V4046 Sgr and T Cha display evidence for recent or ongoing planet formation in the form of large inner disk holes detected via submm imaging. Spitzer and Herschel spectroscopy of V4046 Sgr reveals emission from atomic and molecular species (e.g., [Ne II], [O I], OH) suggesting that high-energy photons from the central stars are driving the disk chemistry. Modeling of the Spitzer spectra reveals the presence of large (μm-sized) dust grains and a high crystallinity fraction, signifying that grain growth and planet formation may be occurring within the inner disk hole. Analysis of the Spitzer and Herschel spectra of T Cha and MP Mus reveal that MP Mus shows emission from [O I] and has a high fraction of crystalline dust, whereas T Cha shows emission from [Ne II] and has a low crystallinity fraction. Polarimetric/coronagraphic imaging of V4046 Sgr at near-infrared wavelengths with the new Gemini Planet Imager (GPI) traces starlight scattered off small (≤μm sized) dust grains in the inner disk. The GPI imaging reveals a double ring structure with gaps at R≤12 AU and R~18, suggesting one or more Jupiter-sized planets are forming in the disk. These data, combined with current and future infrared to sub-mm imaging and spectroscopy of nearby young star+disk systems, will provide essential constraints on simulations aimed at understanding the conditions in which giant planets might form in protoplanetary disks.