Gas and dust in an edge-on protoplanetary disk: an in-depth multiwavelength analysis

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Studies of debris disks have revealed an immense diversity in their morphologies such as warps and asymmetries. Certain features could be well explained by gravitational perturbations from planets within the disks. At the same time, theoretical explanations involving stellar flybys, an external source of disturbance, have offered another possibility for the origin of these morphological variations. Our study is an experiment to gain empirical evidence that has been lacking from such theories. Thanks to high-precision astrometric measurements from Gaia, we are now able to accurately trace stellar motion and determine all close encounters one star has experienced with another over a period of time. We computed the time and distance of closest approach for each pair of stars among 462 members of the Sco-Cen association and identified 32 close encounters (< 1 pc) in the past 5 Myr that involve 57 stars in total. Debris disks around 3 of the 57 stars (HD 106906, HD 114082, and HD 146897) have been resolved by the Gemini Planet Imager (GPI). Although all three have experienced at least one flyby, the disk around HD 106906 is highly distorted, whereas those around HD 114082 and HD 146897 appear symmetric. As our next step, the geometry of these three flybys will be studied to further understand the dynamics that could explain the differences. We will also examine the morphological differences between resolved debris disks that have experienced stellar flybys and those that have not. Furthermore, within our sample of flyby stars, 15 of them show infrared excesses, which is suggestive of the presence of disk material around them as well. Additional observations have been proposed to determine the morphological structure of those potential disks so that we could check their correlation with close encounters. This work is supported by NSF AST-1518332, NASA NNX15AC89G and NNX15AD95G/NEXSS.

308.09 — Gas and dust in an edge-on protoplanetary disk: An in-depth multiwavelength analysis

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Circumstellar disks associated with pre-main sequence stars are active sites of planet formation. Among the processes expected to play an important role in the first Myrs of the evolution of the disk are the growth of increasingly larger solid bodies and the decoupling of dust grains from the gas. The latter process, induced by drag forces, leads to the vertical settling and radial migration of millimeter-sized grains. Quantitative comparisons of the distribution of the gas and (grain size-dependent) dust components are necessary to test hydrodynamical and dust growth models. High-resolution observations of edge-on protoplanetary disks offer a unique opportunity to study the vertical structure of disks as their upper layers can be unambiguously disentangled from the midplane. Here we present optical and near-infrared high-resolution scattered light images (from HST and Keck) and sub-millimeter dust continuum and CO maps (from ALMA) of an unusually flat edge-on disk associated with a low-accretion Sun-like star in the Ophiuchus star-forming region. Using this rich dataset, we performed radiative transfer modeling of dust observations and tomographic reconstruction of the gas temperature in the disk. Our results allow us to compare the gas scale height inferred from the scattered light images to the temperatures measured directly in the CO-emitting layers. We also find strong evidence for vertical settling of the millimeter-sized dust, although our prescription for settling does not simultaneously fit well both scattered light images and continuum emission maps. Additionally, the gas emission extends significantly (60% larger) beyond the outer radius at which scattered light and continuum emission are detected. Indeed, while the disk midplane is cold enough for CO to freeze out outside of about 100au, this outer region is characterized mostly by isothermal CO emission throughout the entire vertical extent of the disk, possibly caused by external illumination.

308.10 — Demographics of Protoplanetary Disks: A Simulated Population of Edge-on Systems

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Highly inclined, or “edge-on” protoplanetary disks provide us with unique observations of dust distributions around young stars, allowing us to better constrain the disk structure that plays an essential role in the planet formation process. About