Abstract

Planets, now known to be common companions of nearby stars, are believed to originate in circumstellar disks—disks of gas and dust that form around collapsing protostars. Because of their small angular size, disks in nearby star-forming regions are difficult to spatially resolve. However, since radial temperature gradients are set up by the luminous central star, the peak wavelength of blackbody emission is a proxy for disk location, and spectroscopic observations can thus be used to study disk structure. In this thesis, I present spectroscopic observations of circumstellar disks obtained with the Keck Near Infrared Spectrograph (NIRSPEC) and the Spitzer Space Telescope Infrared Spectrograph (IRS).

High-resolution (R $\sim$ 25000) M-band spectra have been obtained with NIRSPEC for over 100 circumstellar disks. CO vibrational emission in the M-band is nearly ubiquitous from classical, optically thick disks, and can be used to examine the disks' inner structure and gas content. The emission is consistent with high temperatures and densities, and small emitting areas, suggesting that it originates at small disk radii—a few AU or less. An analysis of CO lineshapes shows that the CO gas is truncated at or near the dust sublimation radius for low and mid-mass stars but at larger radii for more luminous stars. CO emission is also present from many transitional disks—disks in which the inner regions have been depleted of small dust grains—demonstrating that many of their inner disks have significant quantities of gas. Although the formation mechanism for transitional disks is not yet known, gas-rich inner disks are consistent with formation via tidal clearing by a giant planet.

Spitzer-IRS spectra have been obtained for 82 disks, as part of the Cores to Disks (c2d) legacy program and other archived programs, and as part of a targeted IRS GO-5 survey at high S/N. Water vapor and other gaseous molecules, including OH, HCN, C_2H_2, and CO_2, are detected from $\sim 40\%$ of disks. Excitation temperatures for the molecular species of $\sim 500\,\mathrm{K}$ or higher and emitting radii of a few AU suggest an origin in the planet-forming regions of the disks. There are no strong correlations between detection rates or line equivalent widths and stellar or disk parameters. However, molecular detection rates are correlated with each other, and with disk color, suggesting a dependence on disk structure. Unlike for classical disks, transitional disks show no evidence for H_2O, OH, or any organic molecules, perhaps because these molecules are easily photodissociated in the optically thin inner disk.