

PAHs in circumstellar disks around T Tauri stars

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Abstract. We have begun to investigate the emission from Polycyclic Aromatic Hydrocarbons seen toward circumstellar disks around young low mass pre-main-sequence (T Tauri) stars, observed as part of our Spitzer Legacy program “From Molecular Cores to Planet-Forming Disks” (Evans *et al.* 2003). In this poster we will present some of our first Spitzer spectra of PAH features in T Tauri stars and discuss these features in the context of the disk structure and the UV radiation field needed to excite the PAH molecules.

Laboratory measurements show that PAH molecules are strongly heated/excited when they absorb a single UV photon, and that they re-radiate the energy through C-H and C-C stretch and C-H bending mode transitions, in the form of infrared photons. These give rise to characteristic PAH features at 3.3, 6.2, 7.7, 8.6, 11.2 and 12.8 microns. These emission features have now been observed toward about 60% of intermediate mass Herbig Ae/Be stars with the ISO satellite (Acke & van den Ancker 2004) and for a few of these sources, ground-based spatially resolved spectroscopy has confirmed that the emission originates from the inner ~100-150 AU region around the star (Geers *et al.* 2004, van Boekel *et al.* 2004, Habart *et al.* 2004), so typically on the scale of circumstellar disks.

Our investigation of PAHs in disks around young stars takes two approaches. On the one hand, we address the question how the PAH abundance evolves in these disks during this period of planet formation and how their presence can have an impact on the circumstellar environment. The observed PAH emission is believed to originate from the surface layers of the disk, where the large molecules / small grains are mixed with the gas. The high opacity of PAHs to FUV radiation can significantly reduce the stellar UV field in the inner parts of the disk, while at the same time, through the photo-electric effect, PAHs can provide an important heating mechanism for the gas in the surrounding environment through photo-ionization and thereby influence the temperature and chemistry in the surface layers of the disks.

On the other hand, the presence of PAHs can provide observers with important diagnostics for both the structure of the disk as well as the size of dust grains in the disk. Detections of PAH features provide diagnostics of the presence of small grains in the surface layer and can thus be used to address questions such as: do PAHs, as being the smallest “solid” particles, disappear at the same time as the silicate/carbon dust grains or do they have a longer timescale for settling and/or growth? If the timescales are different, how does this relate to the stability of the PAH to the UV field versus the PAH destruction in the inner region?

These type of studies have, until recently, been restricted mostly to Herbig Ae/Be stars, which are relatively bright compared to T Tauri stars. With the arrival of the Spitzer Space Telescope we can now extend the studies of PAHs in disks to fainter low mass young stars. A key difference with the previously studied Herbig Ae/Be stars, is that for these sources of spectral type G and later, the stellar UV field is orders of magnitude weaker than for Herbig Ae/Be stars, which will directly affect the PAH excitation and emission. However, for these low mass sources accretion luminosity from the accretion of material onto the surface of the star can contribute significantly

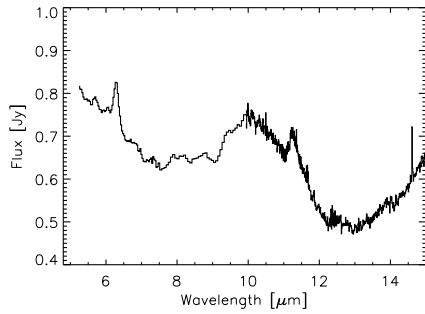


Figure 1. Spitzer IRS spectrum of the T Tauri star LkH α 330 (spectral type G3), showing PAH emission features at 6.2 and 11.3 microns, and a broad silicate emission feature at 10 microns.

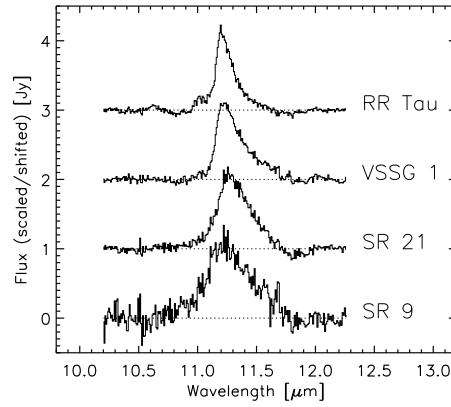


Figure 2. Close-up of the 11.3 micron feature observed towards a selection of the young stars + disks. The top spectrum is generally consistent with the observed shape of the 11.3 micron PAH feature (van Diedenhoven *et al.* 2004), while the feature in the bottom spectrum is potentially affected by crystalline silicate emission.

to the UV radiation and is expected to dominate the radiation field at wavelengths shorter than 0.55 microns, that is seen by the (inner regions of the) circumstellar disk (van Zadelhoff *et al.* 2003, Bergin *et al.* 2003). Our first results from the Spitzer spectra confirm this, since we observe much stronger PAH line fluxes than expected when the central star is assumed to be the main source of UV radiation.

For the interpretation of the PAH features in disks around low mass stars, a PAH chemistry and emission model (Visser *et al.* in preparation) was recently coupled to 3D axi-symmetric radiative transfer models of circumstellar disks (Dullemond & Dominik 2004), to study the relation between disk structure and PAH feature strength. In this poster we present our first Spitzer spectra of PAH features in T Tauri stars and first results from the PAHs in disks modeling.

Keywords. astrochemistry, stars: circumstellar matter, stars: late-type

References

- Acke, B. & van den Ancker, M. E. 2004, *A&A*, 426, 151
 Bergin, E., Calvet, N., D’Alessio, P., & Herczeg, G. J. 2003, *ApJ*, 591, L159
 Dullemond, C. P. & Dominik, C. 2004, *A&A*, 417, 159
 Evans, N. J., Allen, L. E., Blake, G. A., et al. 2003, *PASP*, 115, 965
 Geers, V. C., Augereau, J. C., Pontoppidan, K. M., et al. 2004, astro-ph/0403708
 Habart, E., Natta, A., & Krügel, E. 2004, *A&A*, 427, 179
 van Boekel, R., Waters, L. B. F. M., Dominik, C., et al. 2004, *A&A*, 418, 177
 van Diedenhoven, B., Peeters, E., Van Kerckhoven, C., Hony, S., Hudgins, D. M., Allamandola, L. J., & Tielens, A. G. G. M. 2004, *ApJ*, 611, 928
 van Zadelhoff, G.-J., Aikawa, Y., Hogerheijde, M. R., & van Dishoeck, E. F. 2003, *A&A*, 397, 789