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PAHS IN CIRCUMSTELLAR DISKS AROUND T TAURI STARS.

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We present results from our search for Polycyclic Aromatic Hydrocarbon features from circumstellar disks around low mass pre-main-sequence (T Tauri) stars, observed as part of our Spitzer Legacy program "From Molecular Cores to Planet-Forming Disks" (c2d) (Evans et al. 2003). The features will be discussed in the context of the disk structure and the UV radiation field needed to excite the PAH molecules.

Characteristic PAH features arise at 3.3, 6.2, 7.7, 8.6, 11.2 and 12.8 microns due to absorption of UV photons followed by internal conversion to infrared photons. These PAH bands have been detected toward ∼60% of intermediate mass Herbig Ae/Be stars with the ISO satellite (Acke & van den Ancker 2004). 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. 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.

The Spitzer c2d program is surveying ∼100 T Tauri stars with the IRS in the high-resolution mode at $10-38$ μm in five nearby star-forming clouds. Within our current sample of 33 T Tauri and 7 Herbig Ae/Be stars, PAH emission is detected toward at least 11 sources, of which 5 are T Tauri stars. The 11.2 μm PAH feature is detected in all of these sources, as is the 6.2 μm feature for those sources for which we also have low-resolution 5-10μm spectra. Thus, PAH emission is detected in at least 15% of the T Tauri stars, with 11 possible detections still to be confirmed. The lowest mass source with PAH emission in our sample is Haro 1-17 with a spectral type of M2.

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, which will directly affect the PAH excitation and emission. However, luminosity from the accretion of material onto the surface of the star can contribute significantly to the UV radiation in these low-mass sources and is expected to dominate the radiation field at wavelengths shorter than 0.55 microns incident on the disk surface (van Zadelhoff et al. 2003; Bergin et al. 2003). Our results from the Spitzer spectra confirm this. We observe typical 11.2 μm line fluxes between a few $\times 10^{-15}$ and 1.0×10^{-16} W m^{-2}; an order of magnitude lower than those observed for the more massive Herbig Ae/Be stars with ISO. However, these new line fluxes are still 1-2 orders of magnitude stronger than expected from models of the PAH emission from a flaring disk exposed to UV radiation from a ZAMS central star (Habart et al. 2004)

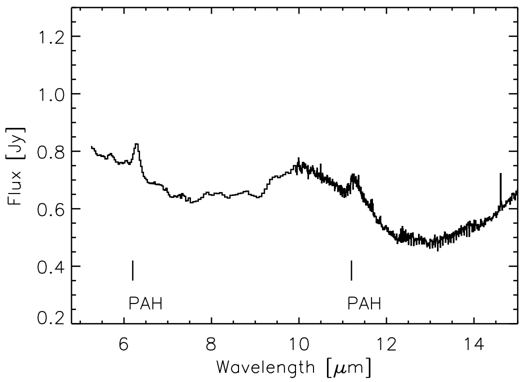

Figure 1: Spitzer IRS spectrum of the T Tauri star LkHα 330 (spectral type G3), showing PAH emission features at 6.2 and 11.3 microns, and a broad silicate emission feature at 10 microns.

For the interpretation of our PAH features, we use the 3D axi-symmetric radiative transfer models by Dullemond & Dominik (2004) to which a PAH emission model for single- and multi-photon excitation has been added. This allows us to study the relation between disk structure and the relative PAH feature strengths, which can be tested against measured Spitzer line fluxes and complementary ground-based VLT-ISAAC data of the 3.3 μm feature. The model can also be used to study the spatial extent of the PAH features and tested against spatially resolved spectra (ISAAC, TIMMI2) as well as recent 11.2 μm VLT-VISIR images.

First modeling results for Herbig Ae stars show that the PAHs cannot be radiating from the inner 1 AU of the disk, because this would produce stronger features than observed. This implies either that the PAHs are shielded from UV radiation in the inner disk (geometry), or that the inner parts have a lower PAH abundance due to destruction by multi-photon events. The model spectra also confirm the difficulty in distinguishing the 7.7 and 8.6 μm emission features from the overall silicate feature and continuum emission, as seen in our Spitzer data.

Finally we are in the process of integrating a full PAH chemistry treatment (Visser *et al.* in preparation) to the disk model, to study the effect of hydrogenation and ionization.

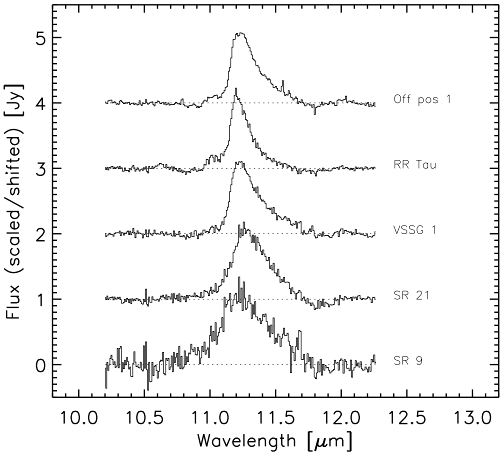

Figure 2: Close-up of the 11.3 micron feature observed towards a selection of the young stars + disks. Using an interstellar PAH spectrum (off-cloud) as a reference, the top spectra of RR Tau and VSSG1 are generally consistent with the observed shape of the 11.3 micron PAH feature (see also van Diedenhoven et al. 2004), while the feature in the bottom spectrum is potentially affected by crystalline silicate emission.

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