

## Resolution of the 7.7 $\mu$ m Emission Feature in NGC 7027

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The unidentified infrared (UIR) features are a group of emission bands observed in a variety of objects, which can be characterized as having moderate density gas (densities from  $10^4$  to  $10^7$   $\text{cm}^{-3}$ ) and a nearby uv source. The origin of the features is still uncertain, but the current evidence points to polycyclic aromatic hydrocarbons (PAH's) as the most likely candidates. There are a few problems with identifying PAH's as the source of the UIR features. First, each different PAH has bands at different wavelengths, so that from one source to another there would be a variation in some of the UIR features if the mixtures of PAH's varied, and there is no a-priori reason to expect one dominant PAH mixture. Figure 1 shows the positions and strengths of transitions for three different PAH molecules. The region around the UIR band at 7.7 $\mu$ m is particularly sensitive to the particular PAH species since the bands from the different molecules are well separated, unlike at 6.2 $\mu$ m where they are essentially superimposed. Secondly, there is no lab spectrum of any PAH that matches a UIR spectrum. This may be because the UIR spectrum is a combination of PAH emission from a mixture of molecules (discrete bands) and emission from small amorphous carbon particles (broad, continuous features).

Possible tests which would support the PAH hypothesis include observing variations of the UIR features among different objects, and observing sharp features (particularly in the 7-8 $\mu$ m region) that could be associated with individual molecules. Figure 2 shows a spectrum of NGC 7027 from 5.7-8.3 $\mu$ m (open diamonds) compared to a schematic spectrum (solid line) assembled by plotting the positions and relative strengths of bands observed in laboratory spectra of Pyrene, Chrysene, and Coronene, adding a sloping continuum, and assuming a line width of about 0.1 $\mu$ m for illustrative purposes (the natural line width for large PAH's should be about 2% at these wavelengths. Allamandola et al., 1985 ). All three PAH's contribute to the 6.2 $\mu$ m feature, while Chrysene is the primary source of the 7.0 $\mu$ m band. The most interesting and important part of the spectrum is the sharp feature that is observed at 7.6 $\mu$ m in NGC 7027. It is very narrow and is not coincident with an atomic emission line, but occurs at the same frequency as the strong 7.62 $\mu$ m band in Coronene. The sharpness of the feature and the coincidence with the Coronene band leads us to identify this feature with molecular emission, since solid state features would be resolved at this spectral resolution.

Variability of the 7.7 $\mu$ m feature is evident from the spectra in Figure 3. In all three objects, the rise towards 7.7 $\mu$ m starts at the same wavelength, but the width of the 7.7 $\mu$ m peak is quite different between objects. In M1-78 (and NGC 7027) the peak is nearly flat for three channels from 7.60-7.84 $\mu$ m, while at the opposite extreme is BD+30°3639, in which the peak is a single channel wide at 7.84 $\mu$ m. The reason for these differences must lie in the different mixtures of PAH molecules that contribute to this feature. Evidence for this interpretation are apparent in Figure 2, where the sharp feature at 7.60 $\mu$ m accounts for the short wavelength side of the

peak of the  $7.7\mu\text{m}$  feature in NGC 7027 (and probably in M1-78 as well). The lack of this component could result in the spectrum observed for SAO 161375. The even later peak wavelength observed for BD+30°3639 is most likely due to a sharp molecular emission at  $7.84\mu\text{m}$  superimposed on a broad feature similar to that observed in the other objects.

The lack of a significant variation in the  $6.2\mu\text{m}$  feature among these objects is equally important since this is expected if the features arise from PAH's. The variation of the  $7.7\mu\text{m}$  band combined with the lack of variation of the  $6.2\mu\text{m}$  band and the observation of a very sharp (most likely molecular) feature in NGC 7027 combine to argue strongly in favor of PAH's as the material responsible for the UIR features.

Allamandola, L.J., Tielens, A.G.G.M., and Barker, J.R. 1985, Ap.J.Lett., **290**, L25

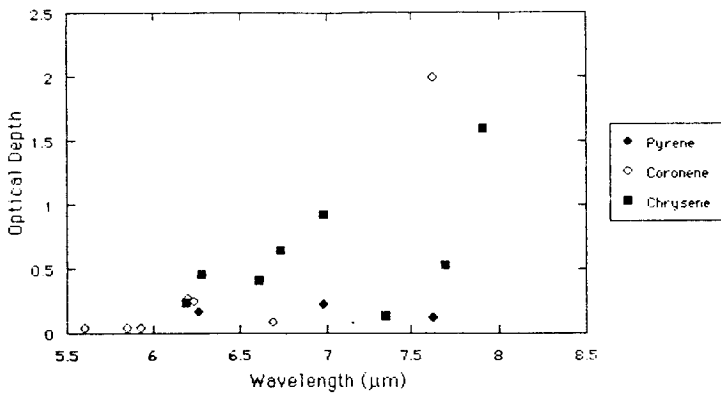


Figure 1  
Schematic diagram of band strengths and wavelengths for 3 PAH molecules.

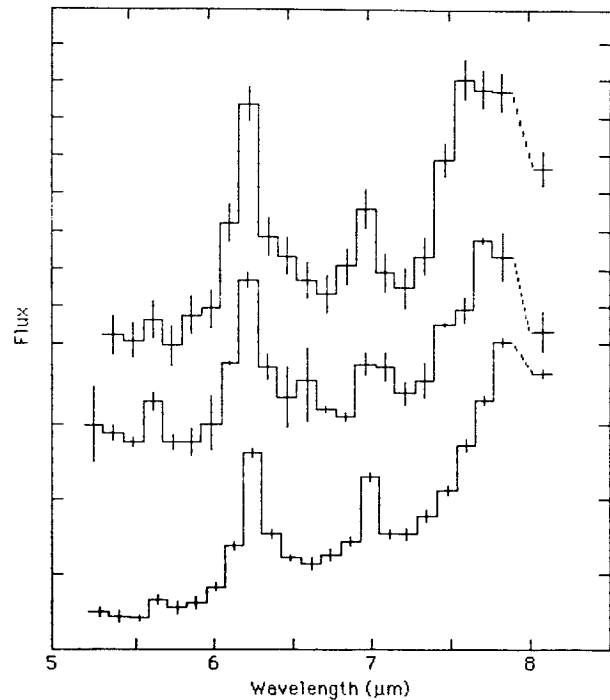


Figure 3  
Spectra of (from top to bottom) M1-78, SAO 161375, and BD+30°3639. Note the variations in the  $7.7\mu\text{m}$  feature.

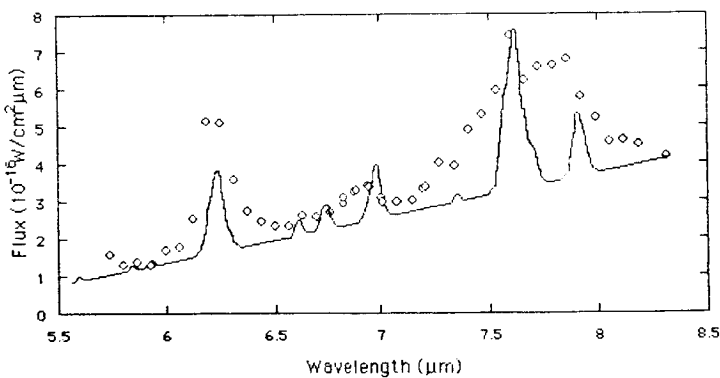


Figure 2  
 $5.7\text{--}8.3\mu\text{m}$  spectrum of NGC 7027 (open diamonds) compared with a schematic PAH spectrum (see text).