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SPECTRAL CHARACTERISTICS OF DUST IN CARBON-RICH OBJECTS

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ABSTRACT

Some carbon-rich objects exhibit a strong broad emission feature beginning at $\lambda \sim 24\mu m$ and extending to $\lambda > 30\mu m$. We present a 20-65μm spectrum of the carbon star IRC+10216 and 30-55μm spectra of three carbon-rich planetary nebulae, IC 418, NGC 6572, and BD+30°3639 in Figs. 1 and 2. The 30-55μm observations were made with a six-channel spectrophotometer with ~ 3.5μm spectral resolution, while the IRC+10216 spectrum was obtained using a two band 20-65μm 24-channel spectrometer with 3% resolution. The strong emission feature around 30μm is seen clearly in IRC+10216, IC 418 and NGC 6572. The decline at $\lambda > 40\mu m$ is particularly steep in these objects, while BD+30°3639 has a very flat spectrum in this spectral region.

It is remarkable to note that 22% of IC 418's far infrared ($\lambda \geq 10\mu m$) flux is emitted in this feature if a reasonable underlying continuum is removed. This fact puts stringent limits on our identification of this feature as thermal emission from dust. The short wavelength edge of the feature fits very well with that of MgS (Fig. 3), but the long wavelength emissivity in the laboratory spectrum is greater than in IC 418 or IRC+10216. This may be due to differences in grain structure between the laboratory dust and the nebular dust. The spectral match of amorphous MgS to the excess IC 418 and IRC+10216 emission is much better at long wavelengths than MgS in the cubic crystalline form.

The grains responsible for this feature must intercept at least as much ultraviolet and visible stellar and nebular radiation as is radiated in the infrared. This requires a rather large absorption cross section for these grains. We make the conjecture that the large infrared cross section can be produced by a thin ($< 0.1\mu m$) coating on existing SiC grains. This model can serve to increase the MgS ultraviolet absorption cross section as well as the infrared emission efficiency with an acceptable amount of MgS.

The MgS feature is seen in some but not all carbon stars and carbon-rich planetary nebulae. In general, objects having the MgS feature also exhibit the SiC feature, while objects with the narrow lines (e.g. NGC 7027, BD+30°3639) do not have the far infrared feature. Following Barlow, we suggest that this variation is related to the C/O ratio. If C/O is only somewhat greater than unity, Si, which is about 10% as abundant as carbon, can occupy much of the excess carbon forming SiC, leaving the Mg and S to form MgS. If $C/O \gg 1$, much of the S will be bound up in the stable gas molecule CS at the time of dust condensation. Therefore, MgS formation is inhibited by the reduction in available S and amorphous carbon or graphite grains would dominate the dust population rather than SiC.

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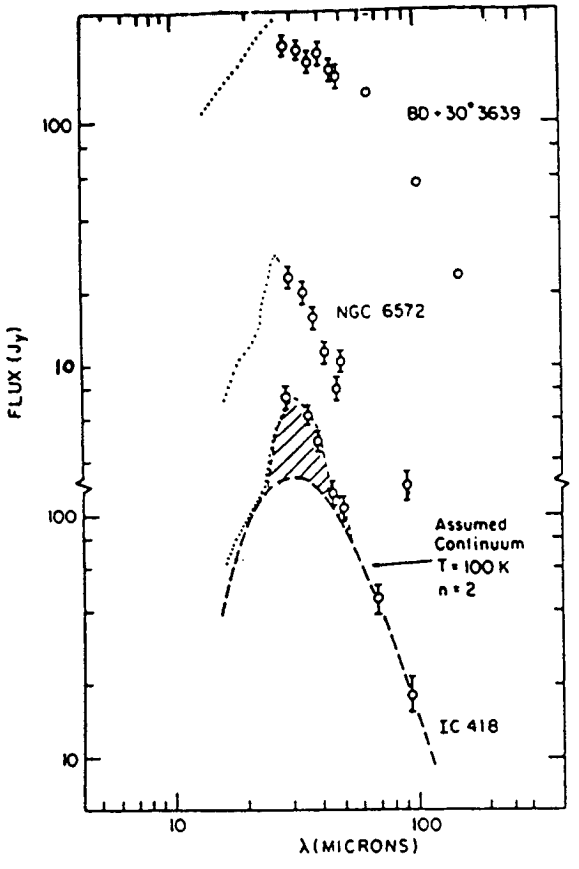

Figure 1

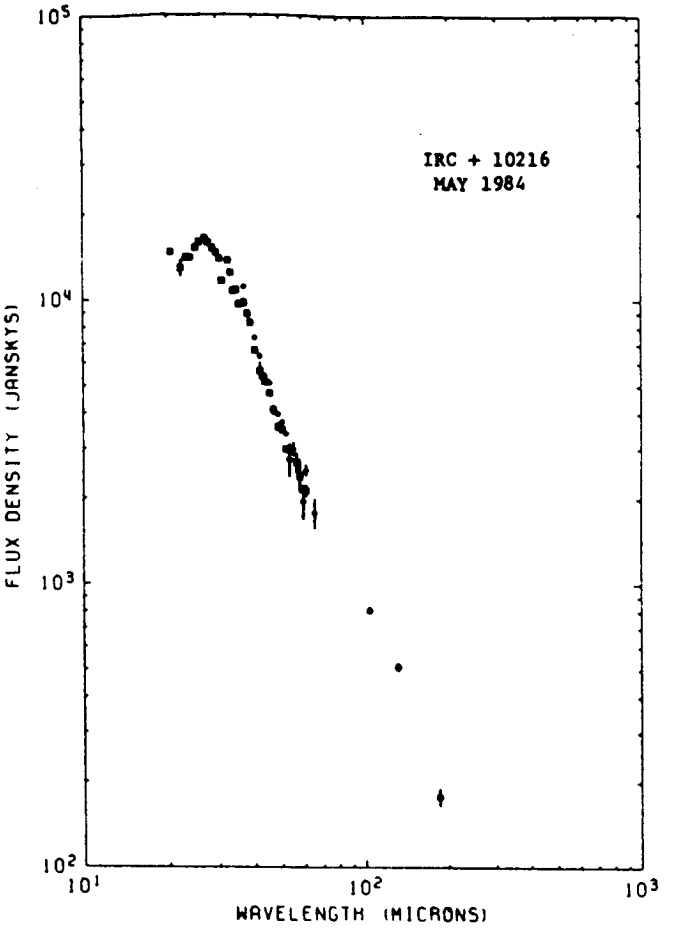

Figure 2

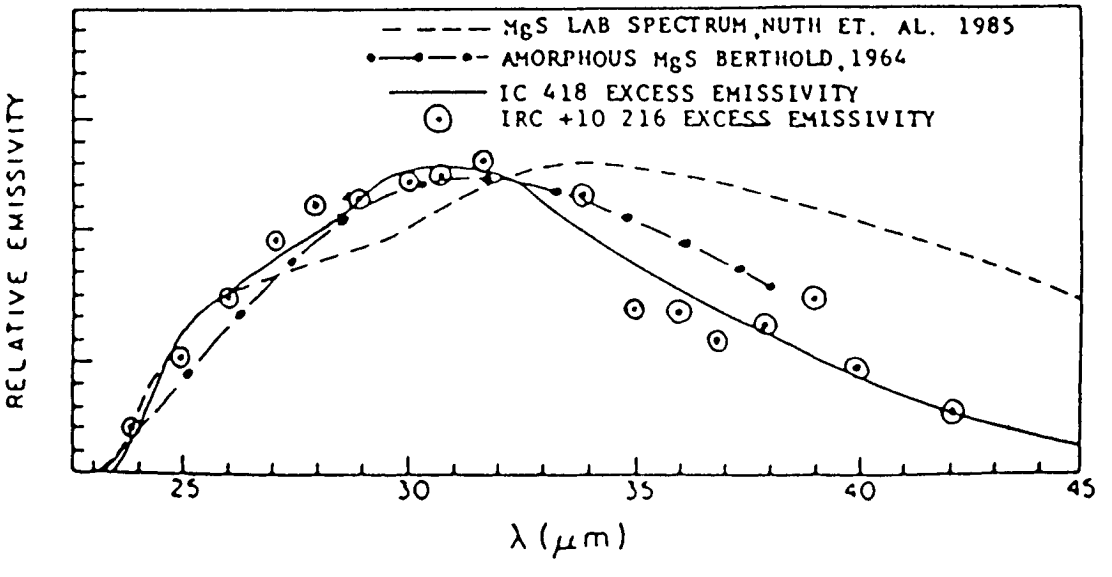

Figure 3