DISCUSSION

Peimbert, M.: Have you observed forbidden CI lines in the spectra of any planetary nebulae?

Andrillat: We have observed [CI] only in NGC 7027 and never in the others.

Zuckerman: In the January 15, 1977 Ap.J. Letters we published a paper concerning CO emission from M1-78. These CO results make it quite clear that M1-78 is a compact HII region, not a planetary nebula, and I suggest that Dr. Kohoutek remove it from his catalogue.

Aller: Therefore it's purged and we can't discuss it anymore!

OBSERVATIONS OF COOL DUST IN PLANETARY NEBULAE

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We have observed BD +30 3639, IC 418, NGC 6572, NGC 6543, NGC 3918, NGC 2440, NGC 3242, A30, M1-78, and NGC 6210 in two broad passbands with effective wavelengths of 35μ and 75μ. All were detected at 35μ, and all but IC 4997 at 75μ. Their spectral energy distributions are similar in that most have peak flux densities at wavelengths ranging from 30μ to 45μ. The two nebulae with markedly different energy distributions are IC 4997, which has a hot spectrum peaking near 20μ, and M1-78, whose flux density rises rapidly from 35μ to 75μ, characteristic of compact H II regions.

These observations allow us to determine accurately the temperature of the cool dust in these nebulae and obtain improved estimates of their infrared luminosities. Typical dust temperatures are ∿95°, roughly a factor of two lower than those determined by Cohen and Barlow (1974, Ap.J. 193, 401) on the basis of 10μ and 18μ observations. This results in dust-mass estimates over an order of magnitude higher than theirs for the same nebulae. Thus, dust-to-gas ratios based on far-infrared data are near or only somewhat below the average interstellar value. (Paper will appear in The Astrophysical Journal.)

DISCUSSION

Forrest: What kind of dust do you assume to estimate the dust masses in planetary nebulae?

Moseley: We assumed an emissivity at 36μ comparable to that of olivine which is a pretty good emitter. Therefore it should give a lower limit.

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Barlow: With reference to the discrepancy between the dust color temperatures determined from 10-18μ data by Cohen and Barlow (1974) on the one hand and from the longer wavelength data presented by Moseley and Harper on the other, recent infrared observations at Cerro Tololo of southern planetaries made by Cohen and myself show that our broad bandpass 10μ filter significantly overestimates the strength of the true continuum, as determined using a narrow bandpass 9.8μ filter. This overestimate is due to the inclusion of various emission lines and features in the broad 10μ bandpass. Use of the 9.8μ data instead of the 10μ data leads to significant lowering of the derived 10-18μ color temperatures and better agreement with the data of Moseley and Harper.

MEDIUM RESOLUTION SPECTROSCOPY OF NGC 7027 FROM 16 TO 38 MICRONS

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NGC 7027 was observed on two nights, 1976 May 18-19 and 20-21, using the 36" telescope of the KAO. A medium resolution, two channel, Helium-cooled grating spectrometer was used to observe the bands, 16-23μ ($\Delta\lambda$ = 0.5) and 20-38μ ($\Delta\lambda$ = 1.2). The beam size was 30". A nearly flat smooth continuum over the entire band was observed with a peak intensity of 7 x 10^{-16} W/cm^{2}μ between 20 and 25μ.

The 8-14μ spectrum of 7027 has several spectral features. The strongest of these is a broad 11.3μ emission band which has been tentatively identified by Gillett et al. (1973) as due to carbonate grains. Laboratory measurements of the carbonate grains that are most likely to be abundant, $MgCO_3$, $CaCO_3$ and $FeCO_3$, have been made by Angino (1967) and Morandat et al. (1967), using various suspension and pellet techniques. Penman has calculated the emission coefficient for small grains on the basis of Mie theory and the bulk dielectric coefficients. These investigations predict long wave-length (22 to 35μ) carbonate lattice resonances, which are in general stronger than the 11.3μ resonance. Our spectrum does not show any isolated emission features in the 22 to 35μ range. This indicates that carbonates are not the dominant source of the radiation observed at these wave-lengths.

The spectrum is fit by grains with an emissivity proportional to $1/\lambda^2$ and a temperature of 90°K. Such an emissivity law is expected for small graphite grains. Several recent determinations (cf. Torres-Peimbert and Peimbert [1977]) indicate carbon is significantly overabundant in NGC 7027, suggesting that graphite is a likely grain material. If the grains are graphite, the mass in dust required to give the observed flux is approximately 2.5 x $10^{-2}M_\odot$ (assuming a distance of 1 kpc) and the corresponding total mass is approximately $1M_\odot$ assuming the carbon

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