SPECTROSCOPY AND CCD-PHOTOGRAPHY OF EXTENDED RED EMISSION IN REFLECTION NEBULAE

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Recent spectrographic studies of extended red emission (ERE) seen in the 0.6μ to 0.9μ spectral region in many reflection nebulae have shown fluorescence by amorphous hydrogenated carbon to be the most probable cause of the ERE. CCD imaging of reflection nebulae in the B, V, R, and I bands has revealed that the ERE, while generally diffuse and extended with an intensity distribution similar to that of the visual brightness profile, can be spectacularly enhanced in spatially well-defined filaments, visible in the R and I bands, but not in B or V.

Following our discovery of ERE in the sub-micron wavelength region in NGC 2023 (Witt, Schild, and Kraiman 1984), we showed that the ERE was present in other reflection nebulae as well and was most likely the result of an excitation process involving near-UV photons (Witt and Schild 1985). A more recent extensive CCD survey of 14 reflection nebulae (Witt and Schild 1986) shows ERE to be present in about 90% of the nebulae observed.

We have carried out spectrographic observations of the nebulae NGC 2023 and NGC 7023, using the intensified Reticon scanner (IRS) of Kitt Peak National Observatory on the No-2 0.9m telescope. The spectral region covered extends approximately from 0.61μ to 0.84μ, with a spectral resolution $\lambda/\Delta\lambda = 500$. Spectra were obtained for 12 locations in NGC 7023 (beam size 22".0) and for 8 locations in NGC 2023 (beam size 45".5). The nebular spectra, when divided by the energy distribution of the corresponding illuminating star, exhibit a broad emission band (FWHM ~ 1200 Å) with its peak's position ranging from 0.63μ to 0.69μ in wavelength for different fields in NGC 7023, from 0.67μ to 0.72μ for different fields in NGC 2023. The emission band is followed by a pronounced minimum near 0.8μ and strong indications of a renewed rise towards a further band at $\lambda > 0.8\mu$. The emission band provides about 30% of the total nebular intensity in R.

A common material expected to be present in interstellar space and exhibiting fluorescence with characteristics similar to those observed is hydrogenated amorphous carbon (a-C:H). Duley (1985) has suggested fluorescence by a-C:H as the cause of the red emission in the Red Rectangle. Watanabe, Hasegawa and Kurata (1982) have presented laboratory data, showing that the peak of the fluorescence band of a-C:H can be found anywhere between 0.625 and 0.75μ wavelength depending on the hydrogen concentration in the amorphous carbon. The results of Watanabe et al. (1982) applied to our findings suggest the existence of amorphous carbon particles with a hydrogen concentration of about $8 \times 10^{22} cm^{-3}$ within the solid material in NGC 7023 and about 6×10^{22} cm^{-3} in NGC 2023.

CCD images of NGC 2023 and NGC 7023, obtained with the CfA CCD detector on the 0.6m telescope of the Whipple Observatory, reveal spectacular filaments in those nebular regions where the bandstrength of the R emission is enhanced. These regions have a projected offset distance from the respective illuminating star of

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0.10 to 0.15 pc. In NGC 2023, in particular, these filaments are not visible in V or B., suggesting that they are not related to local density enhancements but rather to environmental factors favoring the particular grain material and excitation conditions required for the more efficient production of ERE.

References:

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