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Models of Polarized Infrared Emission from Bipolar Nebulae

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Many stars with circumstellar dust shells show a high degree of linear polarization (Sato et al. 1985). We are developing a model which assumes that the polarization arises from scattering by circumstellar dust. This model is similar to those investigated by Heckert and Zeilik (1985), Shawl (1975), and Elsasser and Staude (1978). Our model assumes a geometry in which the star is surrounded by an optically thin spherical dust shell and embedded within an optically thick disc. This geometry is consistent with that proposed for objects with bipolar molecular outflow. This is important because many bipolar flow objects have also been observed to be highly polarized (Sato et al. 1985).

The high degree of linear polarization is produced because the disc differentially attenuates the light from the star. The light incident from the point source is attenuated by a factor of $\exp(-\tau/\cos\theta)$ where θ is the angle between a ray from the point source to the scatterer and a ray normal to the disc; τ is the optical depth at the wavelength of interest. Hence, the light scattered from the regions directly above and below the disc give the largest contribution to the total flux. The scattering angle for light from these regions is near 90°, so the light is strongly polarized and, in the Rayleigh scattering regime, is polarized parallel to the disc.

The Stokes parameters for the scattered light from each particle in the shell are calculated by using the scattering matrix elements generated by a Mie scattering program. After the Stokes parameters for each particle are computed they are summed to give the Stokes parameters for the entire shell. The two graphs on the next page show the intensity and polarization spectrum generated by our model using the optical constants for "astronomical" silicates as defined by Draine and Lee (1984). A narrow (σ=0.06 μm) log-normal particle size distribution was used with a mean size of 0.3 μm. The plane of polarization is parallel to the disc from 1.1 to 3.0 μm. The disc was assumed to be made up of the same material as the shell and to have an optical depth of 1.5 at 1.0 μm.

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