AXISYMMETRIC DUST-SHELLS IN PLANETARY NEBULAE

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Aspherical mass loss is likely to be a common feature in the late stages of stellar evolution when the star arrives at the asymptotic giant branch. In the transition phase from the red giant to a proto-planetary nebula (PPN) the star developes an extended circumstellar dust-shell which is in many cases ellipsoid or disk-shaped. An algorithm for treating the radiative transfer problem in dense axisymetric dust shells is presented. The program has been used to determine the temperature distribution in disk-shaped dust envelopes in PNe. The implications of both composition and the spatial structure of the dust shell has been investigated. We confined the viewing angle to the equatorial plane to maximize the effects of the disk geometry. Our computations show that the observed morphology is mainly affected by the geometry of the envelope whereas the integrated spectrum is mainly determined by the characteristics of the grains themselves. The observed morphology in the optical and near infrared wavelength region is determined by scattered starlight in the thin polar region where the optical depth is low both to the the observer and to the central star whereas scattered light in the equatorial plane is blocked by the optical thick disk. This results in the familiar hourglass shaped morphology perpendicular to the orientation of the disk. Towards longer wavelengths the disk becomes more transparent thus the bipolar shape becomes less prominent. At wavelength longer than 5 μm the disk appears as a compact round source produced by scattered light at the inner rim of the disk. In the Mid and Far Infrared thermal emission of dust is the dominant emission process. Observational evidence for dust disks in PNe can be found in several wavelength regions. For example M 2-9 has been observed by Aspin (1984) in the optical region with a CCD Imaging Polarimeter. The polarisation maps show a high degree of polarisation in the lobes whereas emission from the equatorial plane is little or not polarized. In the NIR the change of the appearance from the bipolar to the compact round morphology predicted by our models is confirmed by the presented images in the J (1.2 μm), H(1.6 μm) and K(2.2 μm) filters obtained with the ESO InfraRed Array Camera. This confirms the general picture of M 2-9 as a proto- planetary nebula being surrounded by an extended, optically thick dust disk.

References

Aspin C., 1984 Astron. Astrophys. Vol. 134 p. 333