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MODELING OF INFRARED FLUX SPECTRA FROM DISK-SHAPED INTERSTELLAR DUST CLOUDS.

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Although there is growing observational and theoretical evidence for many disk-shaped objects of astrophysical interest, spherical geometry is assumed in most radiative transfer models. Recently we generalized the "quasi-diffusion" method developed by Leung (1975, 1976) for spherical geometry to solve the problem of scattering, absorption, and reemission by dust grains in a medium of disk geometry. The details of the numerical method and computational procedure are given elsewhere (Spagna and Leung 1986a). The method is applicable to a variety of astronomical sources whose dynamics are angular-momentum dominated and hence not accurately treated by spherical geometry, e.g., protoplanetary nebulae, circumstellar disks, bipolar-flow molecular clouds, accretion disks and disk galaxies.

Using this technique and realistic grain opacities we construct theoretical models to determine self-consistently the dust temperature distribution and infrared emission from disk-shaped, quiescent dark globules heated externally by the intersteller radiation field. The effects of the following parameters on the temperature structure and the emergent spectrum are studied: grain type (graphite and silicate), optical depth, density inhomogeneity, degree of disk flattening. Values for the grain opacities and the ambient interstellar radiation field are taken from the work of Mathis, Mezger, and Panagia (1983). The disk models are characterized by an aspect ratio (ratio of radius to half-thickness, R:Z) and an optical depth at 0.55 μm (measured from the cloud surface to the disk center in the midplane). For inhomogeneous models, a gaussian density distribution is assumed such that the ratio of central to surface density is 100.

To study the effects of source geometry, we also compare results for models with spherical and disk geometry. In this case both models have the same radius (taken to be 1 parsec) and central optical depth, the disk models having a 1:1 aspect ratio. While the dust temperature distributions in the two cases are very similar, the emergent flux for the disk model depends sensitively on the viewing angle. For clouds which are unresolved, one would naively expect, since the thermal emission is isotropic in the neighborhood of an emitting grain, and since the emission (in the far infrared) is optically thin, that the emergent flux spectrum should be characteristic only of the dust temperature, and independent of viewing angle. However, because of the lack of complete symmetry and the resulting radiation anisotropy, this is found *not* to be the case for the disk models. As an example, the figure shows the excess flux (emergent flux minus the ambient external flux at the cloud surface) spectrum for a disk model viewed at three different angles. The brightness of the disk clearly varies with viewing angle θ, being somewhat brighter seen edge-on than face on, and with both extremes brighter than when seen at an intermediate angle. The edge-on ($\theta = 90°$) spectrum is identical in shape to that of the spherical model, but the flux is lower by about 30%. The flux at other viewing angles are even weaker and the longer wavelength side of the emission peak falls off faster, indicating that we are seeing less of the cooler interior dust.

An important consequence of this variation in emergent flux with viewing angle is that it implies a large uncertainty in estimating the radiating dust mass.

In particular, for disk-shaped clouds which are unresolved, one is likely to underestimate the mass of dust for obliquely viewed disks of all aspect ratios, and to grossly overestimate the the dust mass for flattened disks viewed edge-on. On the other hand, if spherical geometry is incorrectly assumed, the estimated dust mass may easily be off by over an order of magnitude. Other observational implications related to the interpretation of infrared observations of unresolved disked-shaped objects are discussed in Spagna and Leung (1986b).

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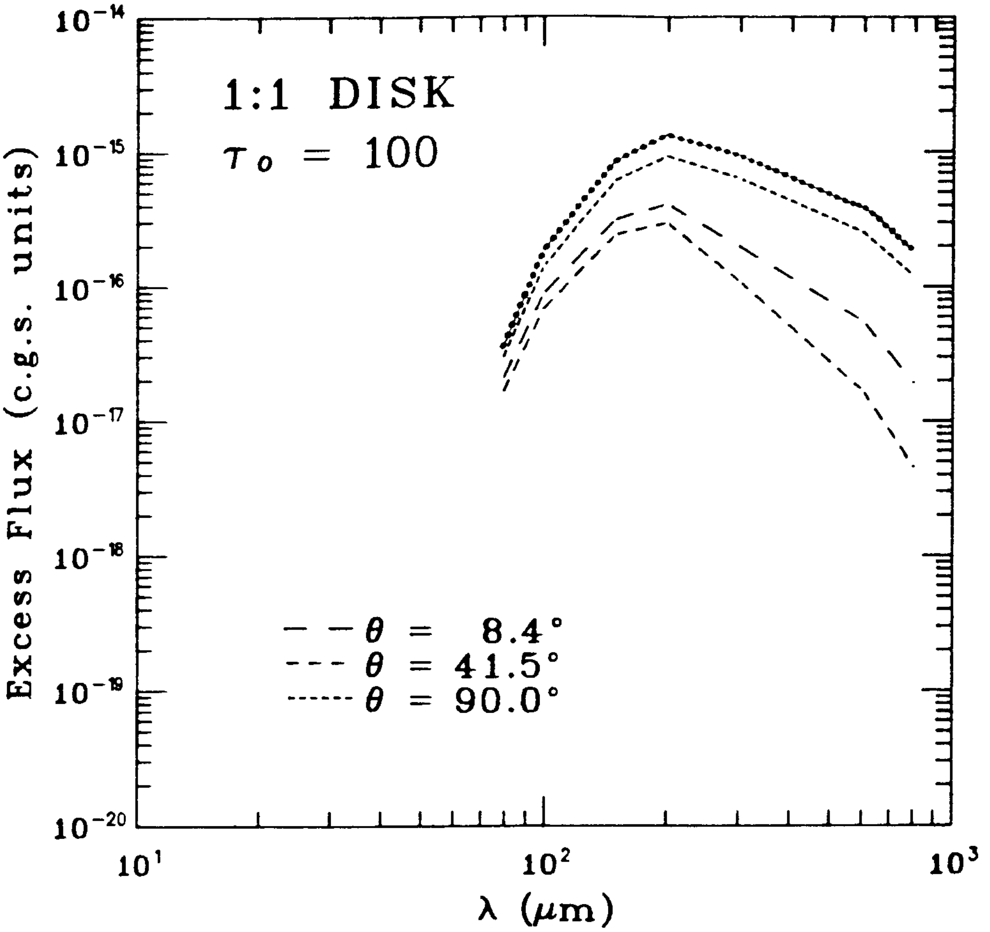

Comparison of excess flux spectra for graphite grains in centrally condensed spherical and disk models of the same optical depth. The dotted line is for the spherically symmetric model. For the disk model, the excess flux profile depends on the viewing angle θ and is strongest for edge-on viewing (θ = 90°).

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