

Dust Ring Formation due to Ice Sublimation in Debris Disks

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In a disk with a low optical depth, dust particles drift radially inward by the Poynting-Robertson (P-R) drag rather than are blown out by stellar radiation pressure following destructive collisions. We investigate the radial distribution of icy dust composed of pure ice and refractory materials in dust-debris disks taking into account the P-R drag and ice sublimation. We find that icy dust particles form a dust ring by their pile-ups at the edge of their sublimation zone, where they sublime substantially at the temperature 100–110 K. The distance of the dust ring is 20–35 AU from the central star with its luminosity $L_* \lesssim 30L_\odot$ and $65(L_*/100L_\odot)^{1/2}$ AU for $L_* \gtrsim 30L_\odot$, where L_\odot is the solar luminosity. The effective optical depth is enhanced by a factor of 2 for $L_* \lesssim 100L_\odot$ and more than 10 for $L_* \gtrsim 100L_\odot$. The optical depth of the outer icy dust disk exceeds that of the inner disk filled with refractory particles, the residue of ice sublimation, which are further subjected to the P-R effect. As a result, an inner hole is formed inside the sublimation zone together with a dust ring along the outer edge of the hole.

keyword: Debris Disk, Ices, Celestial Mechanics

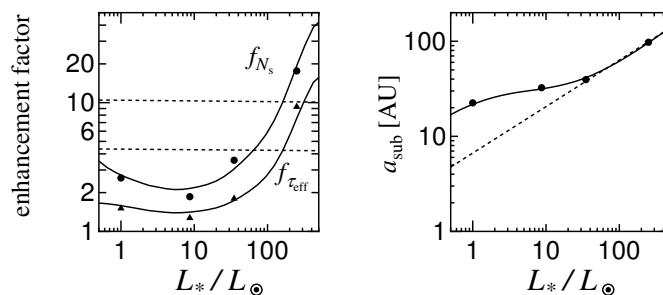


Figure 1. The number-density enhancement factor f_{N_s} and optical-depth enhancement factor $f_{\tau_{\text{eff}}}$ (left panel) and the sublimation distance a_{sub} (right panel) as a function of luminosity of the central star.