Baltic Astronomy, vol. 16, 101–103, 2007.

3D DUST RADIATIVE TRANSFER SIMULATIONS IN THE INHOMOGENEOUS CIRCUMSTELLAR MEDIUM

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Received: 2007 January 15

Abstract. Circumstellar dusty disks seem to be a ubiquitous feature around stars in different phases of their evolution, including post-AGB stars. We present 3D radiative transfer simulations of circumstellar disks with an inhomogeneous dust distribution to investigate the effect of a clumpy medium on the dust temperature distribution. Our initial results indicate that the structure of the dust temperature distribution is rather insensitive to the structure of the ISM, but nevertheless we find a systematic dependence on the parameters describing the structure of the clumpiness of the dust medium.

Key words: radiative transfer – stars: circumstellar matter

1. INTRODUCTION

The interstellar medium in our Galaxy has a non-homogeneous structure over many scales. Similarly, we can expect that the distribution of dust in typical circumstellar disks will be inhomogeneous rather than smoothly distributed. Such a complicated clumpy 3D structure poses a strong challenge for dust radiative transfer calculations, which are necessary to investigate the coupling between the radiation field and the density and temperature of the gas-dust mixture. Only recently, efficient 3D radiative transfer simulations have become available that enable us to tackle these issues. We present 3D radiative transfer simulations of circumstellar disks with an inhomogeneous dust distribution to investigate the effect of a clumpy medium on the dust temperature distribution.

2. MODELS

We present detailed radiative transfer simulations of a circumstellar disk around a solar-type star. The disc is extended (ranging from 1 AU to 200 AU) and has a flaring geometry. The density is exponential in the vertical direction and a power law in the radial direction. We create a two-phase dust medium, consisting of dense clumps in a smooth interclump medium. We adopt the methodology of Witt & Gordon (1996). In this methodology, the two-phase medium is characterized by two parameters, the filling factor ff and the density contrast C between each clump and its surrounding medium. The models presented here were performed using the 3D Monte Carlo radiative transfer code SKIRT (Baes et al. 2003). For a given distribution of stars and dust, the code computes the equilibrium dust temperature distribution and emerging spectra and surface brightness maps from UV to mm wavelengths.

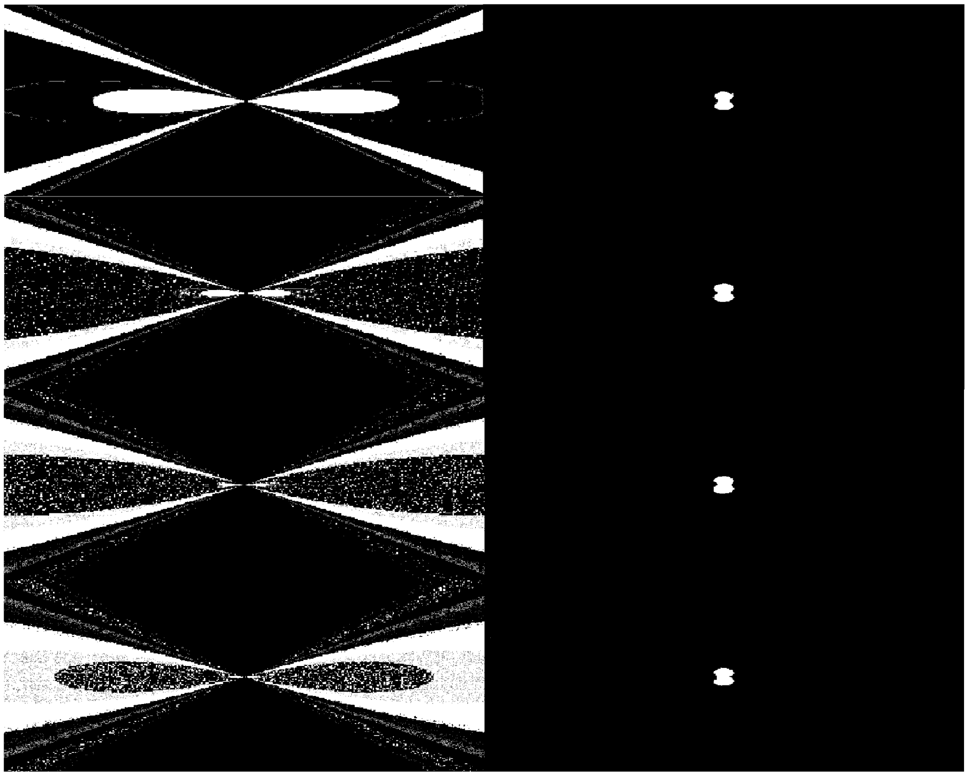

Fig. 1. Cuts in a meridional plane of the dust mass density (left) and the dust temperature (right) for circumstellar disk models with a density contrast of 50 and filling factors of 0.0, 0.05, 0.1 and 0.2 from top to bottom. The disks are very optically thick (τ_V=100).

3. RESULTS

Figure 1 shows the resulting dust mass density (left) and temperature (right) distributions for models with a constant density contrast but different filling factors. As the filling factor increases, more dust is locked in the clumps and the interclump medium becomes less dense. At first sight, the dust temperature distribution seems independent of the structure of the dust medium. The dust temperature does depend systematically on the clumpiness parameters in a subtle way though. This is shown in Figure 2, where we plot the mean temperature of the circumstellar dust medium explicitly as a function of *ff* for two different values of C. For a fixed density contrast, the maximum mean dust temperature is reached at intermediate filling factors. This is normal, as the medium is completely smooth in both the limits $ff = 0$ and $ff = 1$. For the intermediate cases, the interclump medium is less dense and warmer, whereas the clumps are dense and cool. The maximum mean dust temperature is higher and reached at lower *ff* values if C increases. This seems to be a consequence of the fact that relatively more dust mass is locked in clumps at a given *ff* with increasing C. We are currently running more simulations over a larger range of parameters to investigate the systematic behavior of the clump and interclump medium in more detail. We are also examining cases with different clump sizes (larger clumps are probably more realistic for circumstellar disks around post-AGB stars) and we are investigating models with increasing optical depth.

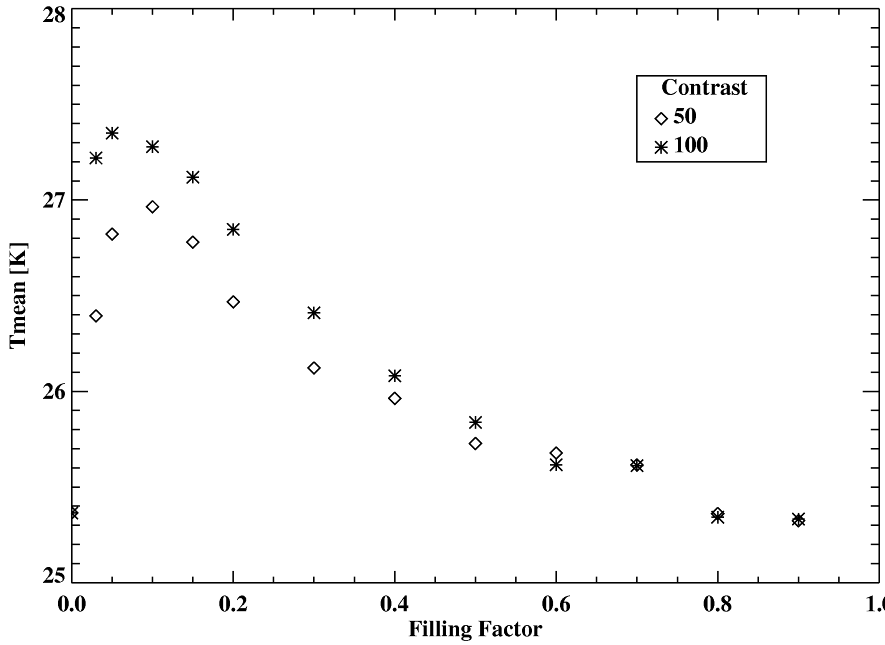

Fig. 2. The mean dust temperature of our circumstellar disk for various models with different clumpiness parameters.

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