3D dust radiative transfer simulations in a circumstellar disc environment

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Abstract

Circumstellar dusty discs seem to be a ubiquitous feature around stars in different phases of their evolution, this and purely theoretical matters motivate their study. With this aim we present 3D radiative transfer simulations of a circumstellar disc. For this task we employ SKIRT, an efficient 3D Monte Carlo radiative transfer code designed to treat continuum radiative transfer problems in dusty systems.

INTRODUCTION

Circumstellar dust disks are a common phenomenon in various phases of stellar evolution. In particular, the recent homogeneous and systematic study by De Ruyter et al. (2006) strongly suggests that Keplerian dust disks are very common around post-AGB stars. Irrespective of the effective temperature of the central star, the SEDs of all post-AGB stars display a large IR excess with dust near the sublimation temperature.

We have embarked on an extensive study to investigate the geometry, composition and formation of the dust disks around post-AGB stars using a multi-wavelength observing campaign and a detailed radiative transfer modelling.

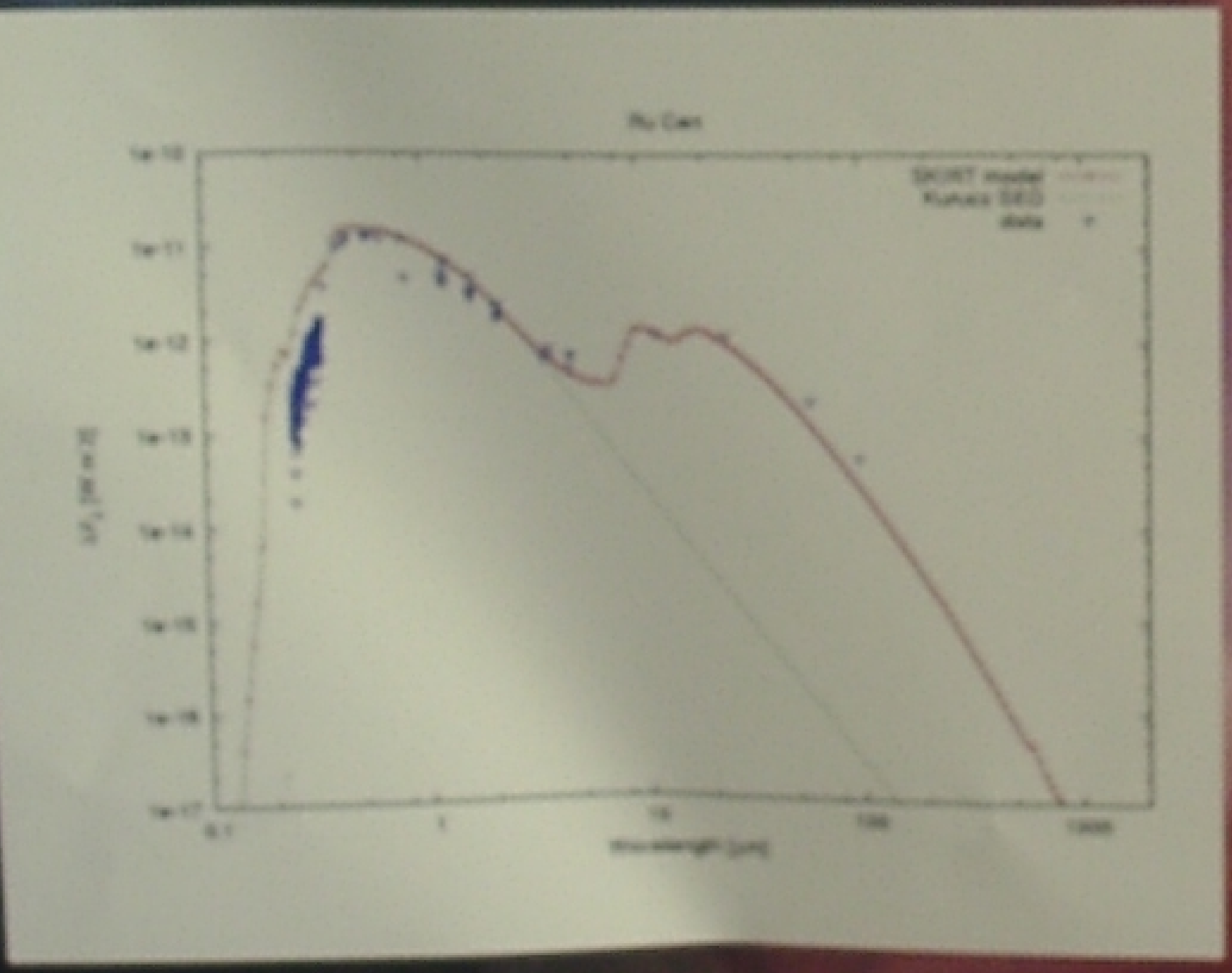

Fig 1: The observed spectral energy distribution for RU Cen and a circumstellar dust model fit. We could see the big infrared excess, in this RV Tauri star, created by the hot dust in its disc.

MAIN CHARACTERISTICS OF THE SKIRT CODE

- Full treatment of absorption and multiple anisotropic scattering
- The temperature distribution of the dust and the thermal dust re-emission can be computed self-consistently without iteration
- Use of polychromatic photon packages to speed up calculations
- Efficient computation, even for very small and very large optical depths
- No geometry limitations: full 3D approach. Spherical 1D and axisymmetric 2D geometries can be chosen for particular models.
- Several built-in components for the distribution of the stars and the dust are available.
- A suite of instruments are available to measure the radiation field. These instruments mimic real astronomical instrumentation and include imaging and 3D spectroscopic devices.

SIMULATIONS

The simulations we present consist in a circumstellar disc with a density profile divided in two components. A power law in the radial direction and a Gaussian distribution in the z direction. The final result is obtain after 4 simulations, each correlated with the last one through its temperature and scale height, due to the hydrostatic equilibrium of the gas+dust disc. The dust is 100% silicates, with sizes between 0.001 microns and 200 microns, distributed with a power law of -3.5, what means that extinction is dominated by small grains and the mass of dust dominated by big grains. The optical properties for this dust were calculated using the Mie theory (Wolf & Voshchinnikov 2004).

The input parameters for the simulation were taken from De Ruyter et al. (2006).

Fig 2: Density and temperature profile

RESULTS

The images presented in Fig. 2 are density and temperatures maps. In the temperature profile (right) is evident the presence on the dust, which is cooler.

The resulting SED is presented in Fig. 1, together with the dereddened observed fluxes and the scaled photospheric model representing the stellar photosphere. As we expected, the shape of the SED is the same as the star photosphere for small wavelengths, but then in the infrared the dust emission becomes evident. The form of the SED is dominated by the small grains properties in the mid infrared, while the slope in the far infrared is completely dependent of the maximum size included in the dust mixture.

Is easy to see that as we get closer to the submillimiter, the exactitud of our model, in comparison with the real data, is decreasing considerably. This effect, we believe, is an effect of not including considerably big grains, which theoretically would make the slope flatter in the far infrared.

Given the parameter space we are working in, and the few data existing, we cannot consider this only fit as the best one. Actually there will be several input sets that will going to drive us to considerably good results. Then the next step in our research is use the interferometric data to have better a constraint in this parameter space.

In this way we present this results just in a manner of example to show our radiative transfer code and its advantages.