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A companion star in the SED modeling of the HD 142527 stellar system

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Abstract. The discovery of a likely companion of the Herbig Ae/Be star HD 142527 motivates the study of the effect that it produces on the SED. The main change on the system configuration is the formation of a gap in the disk in which the companion is embedded, following the orbit of the secondary star. This results in the formation of a wall (at the outer gap edge), which is illuminated by stellar radiation. We present a model for the SED, taking into account all the components of the system: the two stars, the disk with two gaps (one produced by the stellar companion and the other by potential planets), three walls (two associated with the gaps and the other with dust sublimation), optically thin material in the gaps and in a halo. The size of the modeled spherical halo is smaller than found in a previous study.

Keywords. binaries:general, planetary systems: protoplanetary disks

1. The HD 142527 stellar system

An image in the near-infrared by Fukagawa *et al.* (2006) shows two bright opposing arcs and a spiral arm. Mid-infrared images by Fujiwara *et al.* (2006) also show arc-like emission in the outer disk. Fukagawa *et al.* (2006) suggest that an eccentric companion is responsible for these features, while Fujiwara *et al.* (2006) suggest that the far side rim of the outer inclined disk is brighter because it is exposed, and the inner side is brighter due to forward scattering by the small grains, which explains their observation of the opposite arcs. Biller *et al.* (2012) used NIR observations and detected an emission peak which they interpret as a stellar companion about 14 au from the central star.

As a reference, we use the model of Verhoeff *et al.* (2011), which consists of three main components: (i) a small inner disk with inner and outer radii of 0.3 and 30 au, respectively; (ii) an optically thin spherical halo with radius 30 au; and (iii) an outer massive disk between 130 au and 200 au with a very high inner wall. For our model, the inner disk has a gap produced by the likely stellar companion. There is an outer gap between the inner and outer disk. Both gaps have optically thin dust.

2. Results

The SED of the disk is calculated using the model of a passive irradiated circumstellar disk around a Herbig Ae star by Dullemond, Dominik & Natta (2001). In the gaps, there is optically thin material that connects the outer with the inner parts of the disk, its emission is calculated as in Nagel *et al.* (2012). The emission of the outer rim is included using the formalism described by D'Alessio *et al.* (2005). The optically thin dust inside the gap is consistent with a planet at 90 au (Casassus *et al.* 2012). The importance of including this material is highlighted by Verhoeff *et al.* (2011), looking at a radial brightness profile which they were unable to fit. We consider that the innermost wall is

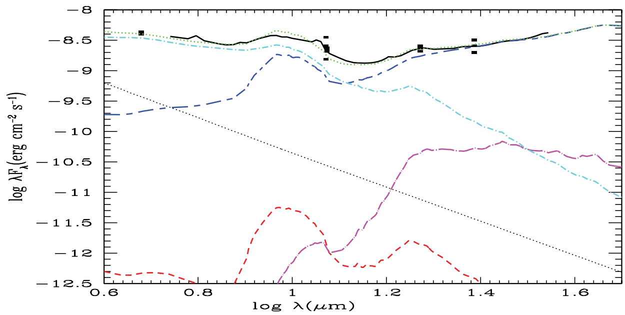

Figure 1. Spectrum of the binary+disk system HD 142527 with a 0.1 $M_\odot$ secondary star. The Spitzer spectrum is represented with a black line. The squares define the photometric fluxes (taken with errors from Verhoeff *et al.* 2011). The stellar spectrum is shown as a black pointed line. The red line represents the inner gap emission, the magenta line corresponds to the outer gap emission, the cyan line is the halo emission, the blue line is the inner and outer disk SED and finally in green is represented the best fit.

curved due to the dependency of sublimation temperature on density and its emission is calculated as in Nagel *et al.* (2013). From the fitting of the SED, the best model for a 0.1 $M_\odot$ companion star is shown in Fig. 1. The mass in dust located in the inner gap and outer gap is $3.52 \times 10^{-12}\, M_\odot$ and $8.88 \times 10^{-8}\, M_\odot$, respectively. The radius of the halo is 5 au, smaller than the value found in Verhoeff *et al.* (2011).

3. Conclusions

The SED fitting with the new distribution of optically thin dust leads to a halo that is six times smaller than previous models (i.e. 5 au rather than 30 au). As pointed out by Verhoeff *et al.* (2011), a spherical halo of dust is not easy to obtain. A possible mechanism is dynamical excitation of planetesimals by an inwardly migrating planet (Krijt & Dominik 2011). For a 3-planet system, the interaction with an outer disk of planetesimals results in spherical clouds $100 - 1000\, au$ in size (Raymond & Armitage 2013). Stirring of material up to a height of 5 au (this model) requires a weaker interaction with planets than the excitation required to produce a 30 au halo (Verhoeff's model).

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