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First images from the PIONIER/VLTI optical interferometry imaging survey of Herbig Ae/Be stars

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Abstract. The close environment of Herbig stars starts to be revealed step by step and it appears to be quite complex. Many physical phenomena interplay : the dust sublimation causing a puffed-up inner rim, a dusty halo, a dusty wind or an inner gaseous component. To investigate more deeply these regions, getting images at the first Astronomical Unit scale is necessary. This has become possible with near infrared instruments on the VLTI. We have developed a new imaging method adapted to young stellar objects where we process separately the stellar component from the rest of the image to reveal the environment by using the spectral differences between these two components. We present the result of this method on the first imaging survey of Herbig stars carried out by PIONIER on the VLTI.

Keywords. techniques: high angular resolution, techniques: image processing, techniques: interferometric, circumstellar matter, planetary systems: protoplanetary disks, stars: pre–main-sequence

1. Introduction

Young stellar objects are forming planets in dusty and gaseous disks surrounding them. The disks are emitting in the infrared. They are detectable in the Spectral Energy Distribution (SED) by an infrared excess to the stellar photosphere (see Fig. 1). These inner parts (≈1500K) create a bump in the SED at NIR wavelengths which is not well explained. Various models can explain the SED shape : a puffed-up inner rim (Isella & Natta, 2005), disk winds (Bans & Königl 2012), dusty halo (Vinkovic *et al.* 2003), etc... The variety of the models comes from the lack of information about the spatial distribution of matter close to the star. Thanks to the high angular resolution provided by optical interferometry, we are able to resolve the geometry of these objects, bring spatial constraints and disentangle between the different scenarios.

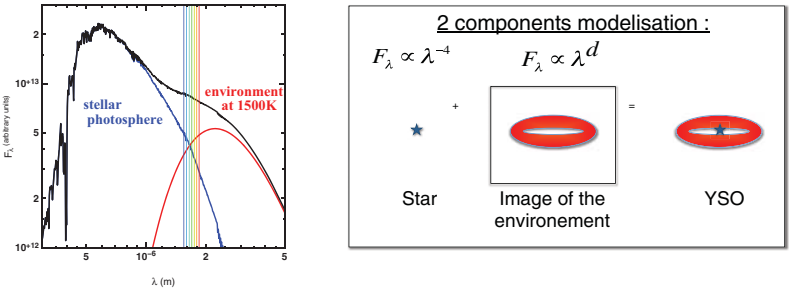

Figure 1. Left : Typical SED of a Young Stellar Object. Vertical lines : the spectral channels of PIONIER in H band. The spectral channels are exactly at the intersection of the spectra of the stellar (shorter wavelengths) and the environment (longer wavelengths) components. Right : In our image reconstruction method, we treat the star and the environment separately.

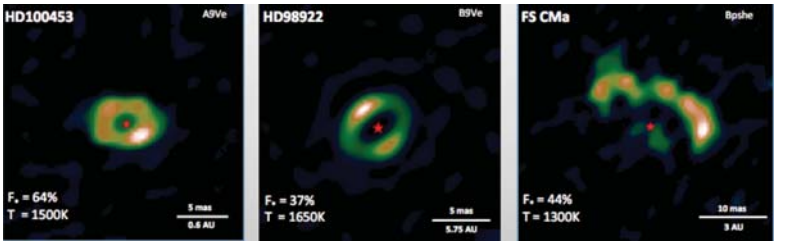

Figure 2. First results of the survey : Reconstructed images of HD100453, HD98922 and FS Cma. The flux ratios and the environment temperature are indicated on each image

2. Image Reconstruction

The main benefit of image reconstruction is to obtain a model-independent image The NIR bands are transition wavelengths between the stellar and environmental fluxes (Fig. 1). We then have to take the star-environement chromatism into account (Kluska *et al.* 2012). We use it to separate the star from the image and reconstruct the environment only (Fig. 1). This method also allows the stellar to environment flux ratio and the environment temperature to be computed. This method was used with the `mira` algorithm (Thiébaut E., 2008) as well as `macim` (Ireland *et al.* 2006).

3. Results

We are carrying out a Herbig Ae/Be survey with VLTi/PIONIER to get statistical information on the inner parts of Young Stellar Objects and to reconstruct a dozen images of the most resolved objects. The first results are shown in Fig. 2. In these images we are able to see inner rims structures with asymmetries due to the inclination and inhomogeneities. We are also able to derive temperatures of the environments which are close to the dust sublimation radius and independently from SED modeling.

The survey is not yet finished and we are expecting more objects to image.

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