FU ORIONIS - THE MIDI PERSPECTIVE. S. P. Quanz, Th. Henning, C. Leinert, T. Ratzka, S. Wolf, *Max Planck Institute for Astronomy, 69117 Heidelberg, Germany, (quanz@mpia.de).*

1 Summary

We present recent observations of the peculiar pre-main sequence star FU Orionis with VLTI/MIDI. FU Ori was observed at the end of 2004 with three baselines ranging from 45m to 86m. The resulting maximum resolution of 24 mas corresponds to approximately 11 AU at a distance of 460 pc. We obtained visibility curves and spectra from 8 micron to 13 micron with all baselines. In addition, the recently discovered companion FU Ori S was visible in the acquisition images from which 8 micron photometry could be derived. The observations are compared to current models describing the FU Ori system and first results from new radiative transfer modeling are presented.

2 The Acquisition Image

Knowing about the existence of the fainter companion FU Ori S, the integration time of some MIDI acquisition images was increased in order to derive N-band photometry for both components. In three images FU Ori S was clearly visible (see Figure 1) and aperture photometry could be applied to the observations. Interestingly, FU Ori S shows a relatively higher N-band excess than FU Ori itself. Comparing the dereddened IR colors of both components to what is found in the literature, it turns out that the NIR and MIR photometry is fairly consistent with Class II YSOs [3]. The additional N-band flux of FU Ori S can be explained in terms of differences in the geometry of the assumed circumstellar disks (e.g. larger flaring angle).

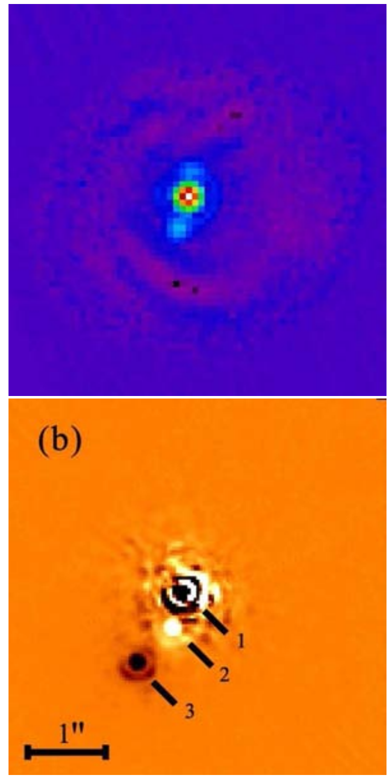

Figure 1: MIDI acquisition image (upper panel) and K-band image obtained by Wang et al. 2004 [1] (lower panel). FU Ori S is labelled with a '2'. The position angle ($\sim 162.5^\circ$) and the separation ($\sim 0''.484$) to FU Ori agree very well between the N- and K-band images. (North is up, east to the left.)

3 The Spectrum

Figure 2 shows an averaged MIR spectrum of FU Ori based on on the results of the three observing nights. In contrast to other YSOs no prominent silicate feature is detected.

In principle this could mean that there are indeed hardly any silicates in the circumstellar material of FU Ori. However, this appears rather unlikely in the context of YSOs. Another explanation could be that the assumed accretion disk is inclined to a certain extent, so that no $10\mu m$ feature can be seen [4]. For an optically thick accretion disk, however, only a narrow range of inclination angles provides this possibility. Apart from this geometric effect also dust properties can explain the absence of the silicate feature. When the dust particles grow due to coagulation, the contrast between the feature and the continuum will decrease [5]. Thus, it might be the case that silicates surrounding FU Ori have already grown to sizes beyond the micrometer size. In addition to larger grains the vertical structure of an optically thick viscous accretion disk can also account for the observed spectrum. High internal heating and turbulent motion in the disk might prevent the creation of a

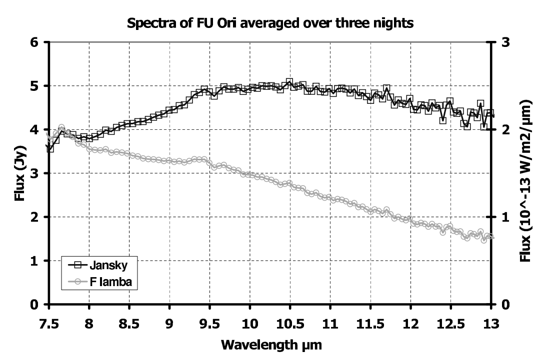

Figure 2: This spectrum combines data of all three observing nights. The flux is given in F_ν and F_λ and agrees very well to earlier measurements [2]. Neither an absorption nor a strong emission feature is apparent.

well-defined vertical temperature gradient required to produce spectral features.

4 The Visibility Measurements

In Figure 3 the visibilities measured for FU Ori at three different baselines are shown. The object was resolved during each observation. As expected, for the longest baseline (UT2-UT4, 86m) the lowest visibility is observed ranging from ∼0.8 at 8μm to ∼0.65 at 9.5μm from where it remains almost constant. Whereas the visibility of the shortest baseline (UT2-UT3, 45m) remains almost constant at ∼0.8 over the whole wavelength range, the visibility observed with the intermediate baseline (UT3-UT4, 56.7m) increases from 0.8 at 8μm to almost 1.0 at 13μm.

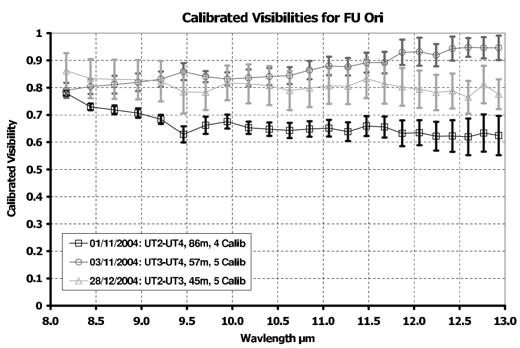

Figure 3: Visibility measurements of FU Ori for three different baselines. The errors are derived from applying different calibrators to the interferometric measurements.

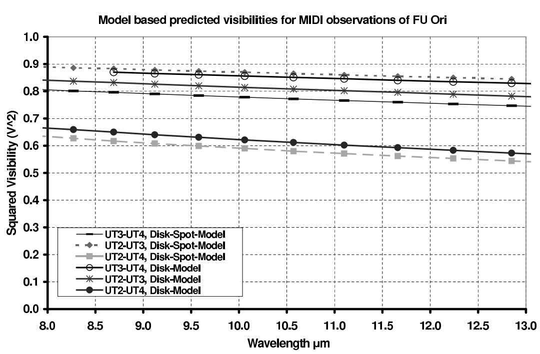

Figure 4: MIDI squared visibilities computed for the two different models published in [7]. The data were kindly provided by R. Lachaume and F. Malbet.

Comparing the results to observations of circumstellar disks around Herbig Ae/Be stars [6] reveals, that those stars as well as the models applied to them normally show a sharp drop in the visibility between 8-10μm from where they remain almost constant. This difference can be expected assuming that Herbig stars are surrounded by extended passive disks whereas FU Ori hosts an optically thick accretion disk. Observations carried out over the past six years using different interferometer (PTI, IOTA and VLTI/VINCI) demonstrated that the NIR visibilities can indeed be fitted with a simple accretion disk model [7]. However, a second model consisting of an accretion disk with an embedded "bright spot" provided an even better fit to those data. Figure 4 depicts MIDI visibilities derived from these two models. The data were kindly provided by R. Lachaume and F. Malbet and are computed for the same baselines as shown in Figure 3.

It becomes clear that with the current errors in the visibilities due to calibration uncertainties MIDI is hardly able to distinguish between the two models. However, both models do not fit the observations very well. First, both models predict visibilities that are clearly higher than the observed values. And second, the predicted decrease in the visibility (regardless of baseline) is not present in our data. Such a decrease could be expected for an accretion disk with a radial temperature profile following a simple power law.

5 Modeling

A detailed and thorough modeling of FU Ori, based on the spectral energy distribution, the spectrum and the new MIR interferometric observations will bring new insights not only in the disk geometry, but also in disk structure and dust composition. Different radiative transfer models are currently investigated and applied to the data. First results will be presented during the poster session on "Protostars and Planets V" in October.

References

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