Image synthesis of HD100546 using SAM data at NACO/VLT

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Introduction

HD100546 is a system of a Herbig Ae/Be star surrounded by a circumstellar disk. From the spectral energy distribution (SED), polarimetric differential imaging (PDI) observations and line profiles observations and modeling, it has been inferred that the disk has a zone with a decrement (gap) in the gas and dust density. The existence of this gap is probably due to **planet formation** and it has not been observed in with direct imaging yet.
We report on observations at 3.81 μm (**L′** filter) of HD100546, obtained with NACO/VLT Sparse Aperture Masking. The data was reduced by Sylvestre Lacour. We performed different image synthesis methods detecting apparently the gap in the disk. We also studied if the current MCFOST axisymmetric model is enough to explain the closure phases or if it needs more extended emission.

About HD100546

- The star
  - Young star (5-10 Myr).
  - 2.4± 0.1 $M_{\odot}$.
  - B9Vne star.
  - 97 pc from the Sun.
- The disk
  - Inclination of ∼45-50°.
  - Inner disk: ∼0.2-0.7 AU.
  - Gap: ∼0.7-13 AU.
  - Outer disk: 13-∼380 AU.

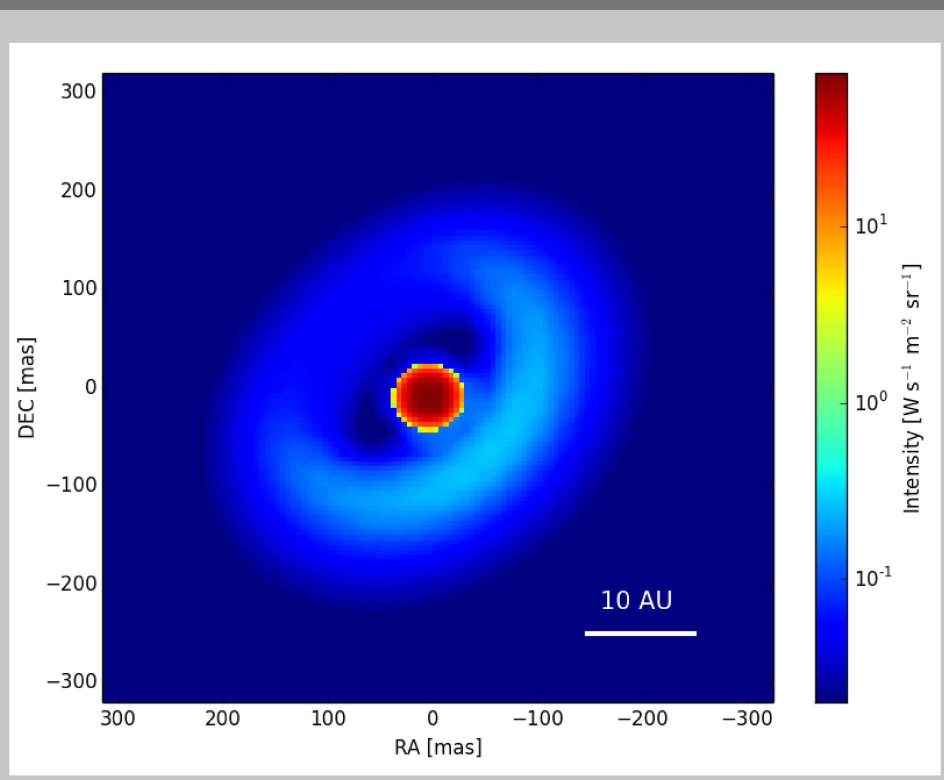

Figure 1: Smoothed MCFOST Model image.

Dynamical evidence of a massive planet based on asymmetries in lines profile, also supported by spiral arms seen on images. In figure 1 it is presented a MCFOST model image made by Christophe Pinte based on the SED.

Optical Interferometry

Two main issues appear when trying to reconstruct an image:

- Sparseness of the **u** − **v** coverage: non unique solution (image).
- Atmospheric turbulence contamination of the complex gain: Phase calibration becomes an impossible task.

To avoid this problem, we used the *Powerspectrum* (2) to recover information of the modulus of the visibilities and *Closure phases* (3) to recover information about the phases. Both quantities remove the atmospheric effects on the data.

$$V_{j_1j_2} = |V_{j_1j_2}| e^{i\varphi_{j_1j_2}} \quad (1)$$
$$S_{j_1j_2} = |V_{j_1j_2}|^2 \quad (2)$$
$$\beta_{j_1j_2j_3} = \mathrm{arc}(\varphi_{j_1j_2} + \varphi_{j_2j_3} + \varphi_{j_3j_1}) \quad (3)$$

Sparse Aperture Masking data

- NACO/VLT
- 3.81 μm
- Max baseline: 6.4 m
- Min baseline: 1.8 m
- 7 holes mask
- 126 Baselines
- 126 *Powerspectrum* measurements
- 210 *Closure phases* measurements

Analysis

- From a axisymmetric disk model which reproduce the SED, we produced an image with MCFOST and visibilities to compare an axisymmetric model with our data.
- We used a software for image reconstruction for optical interferometric data named **MIRA** written by Éric Thiébaut.

Axysimmetric model results

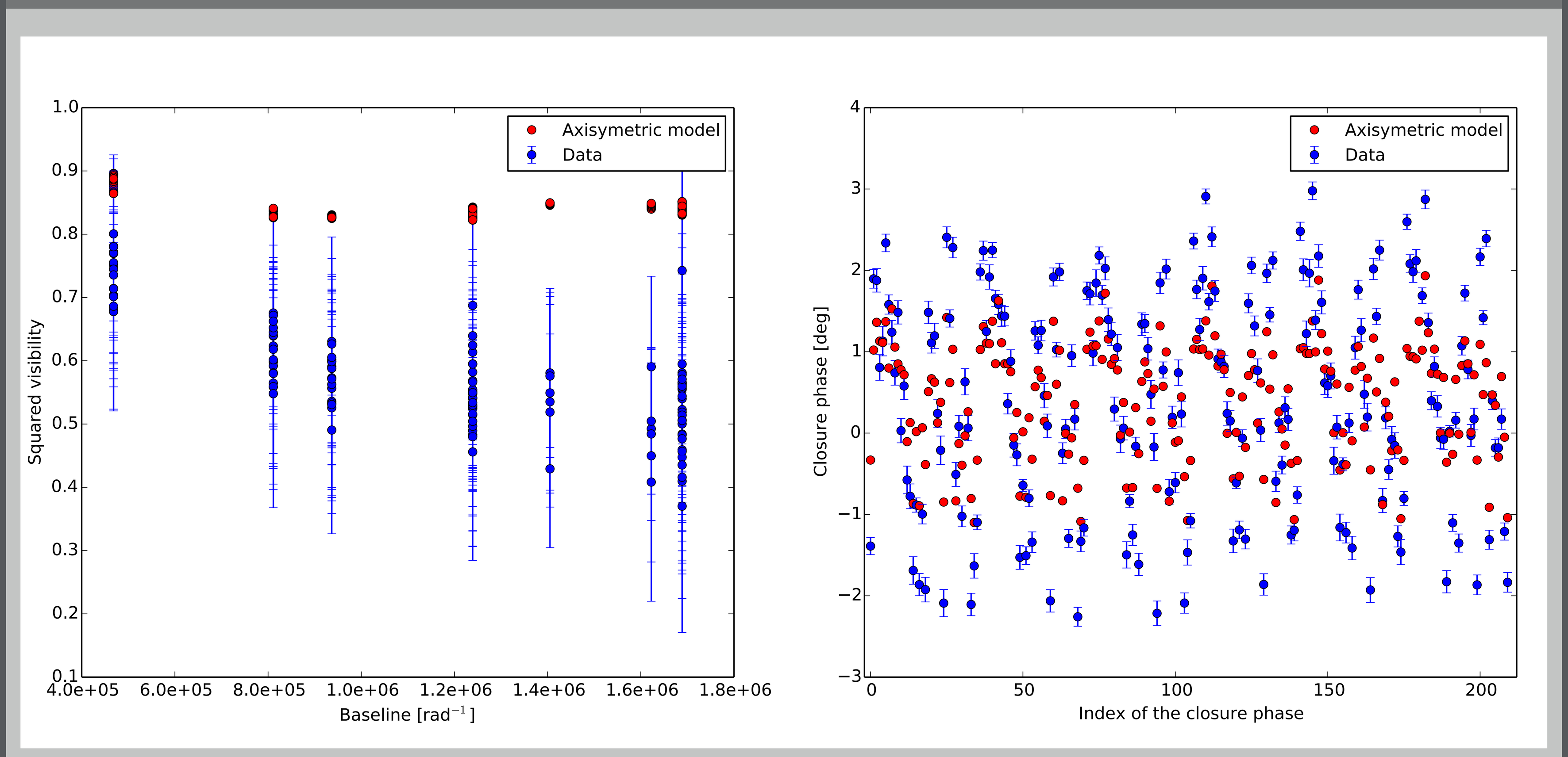

Figure 2: Observed and model power spectrum and closure phases

MIRA results with different regularization methods

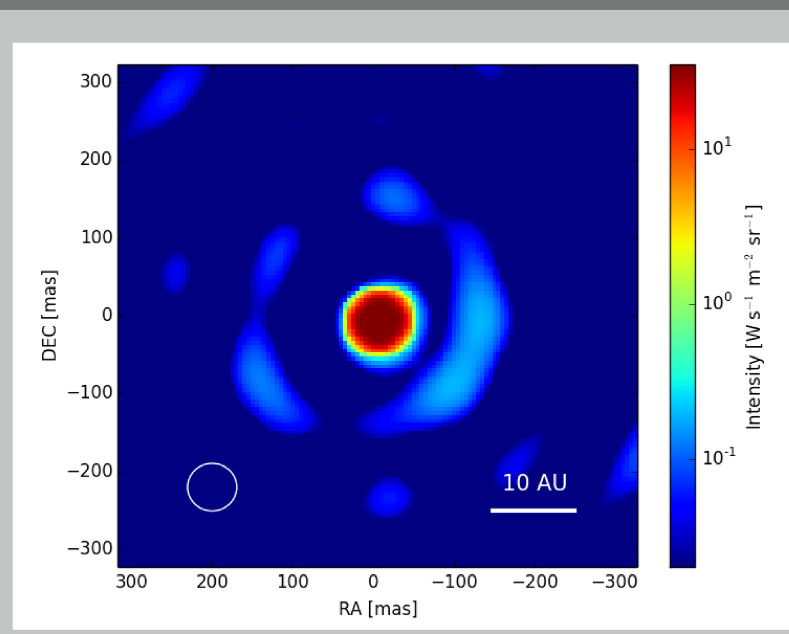

Figure 3: MIRA results using *Total variation*.

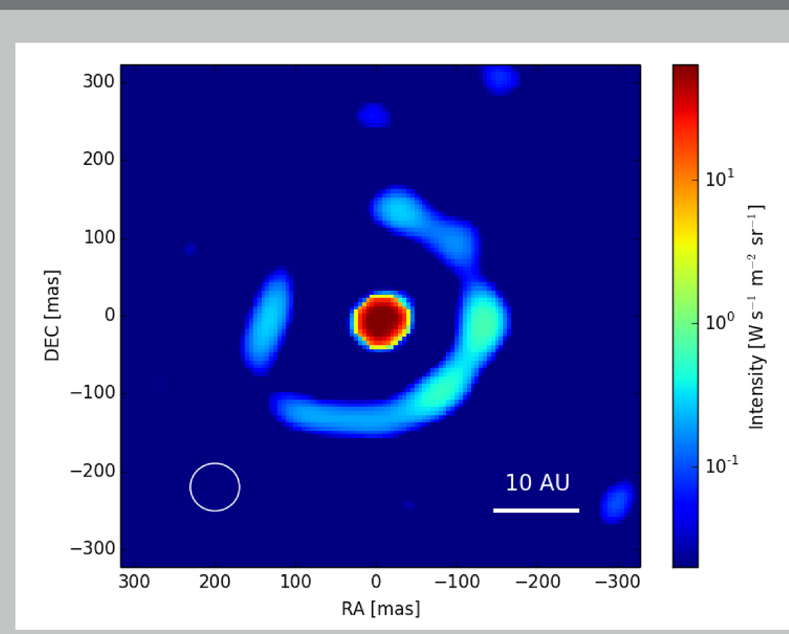

Figure 5: MIRA results using *Xsmooth*.

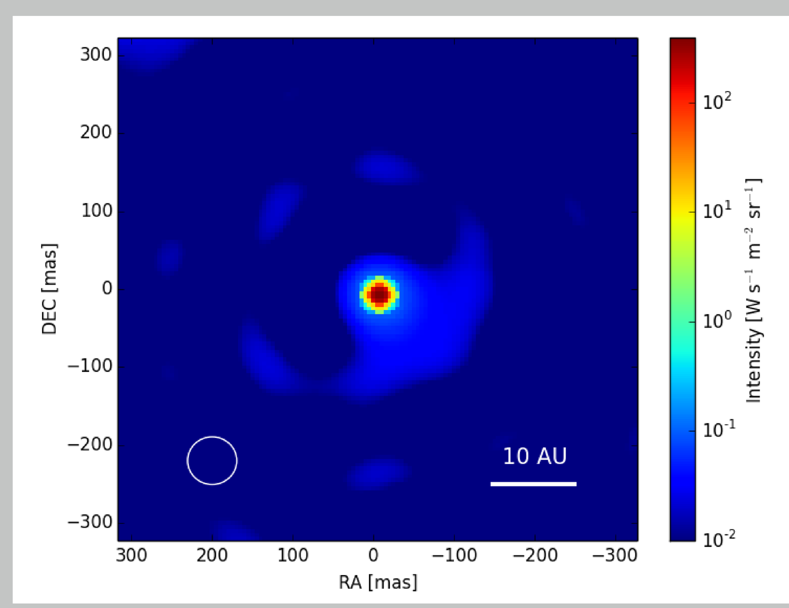

Figure 4: MIRA results from the MCFOST model using *Total variation*.

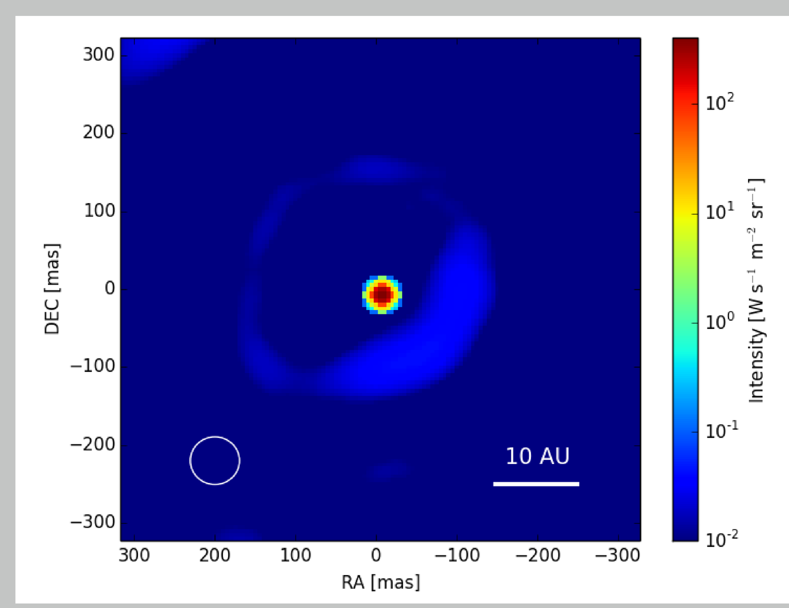

Figure 6: MIRA results from the MCFOST model using *Total variation*.

Comparison with PDI images

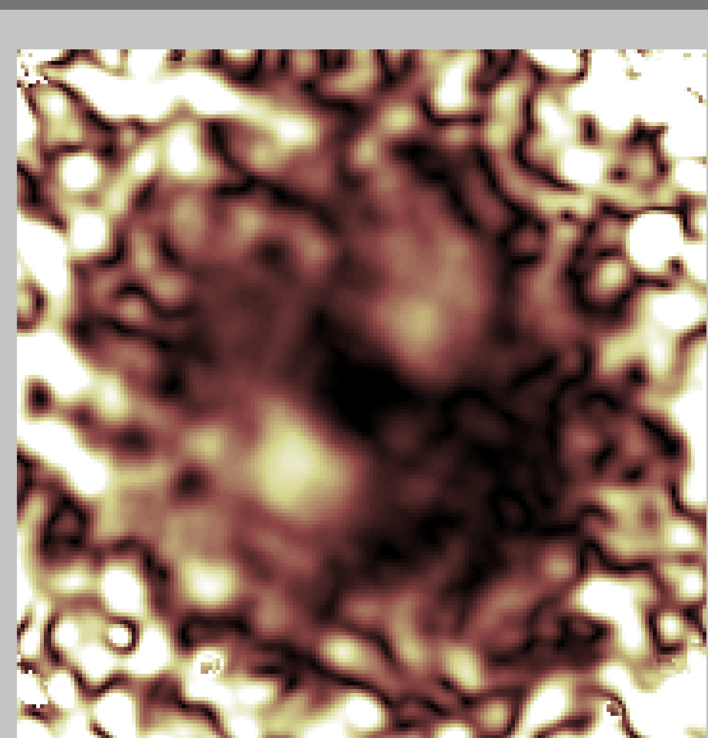

Figure 7: PDI L' image from Avenhaus et al. 2014.

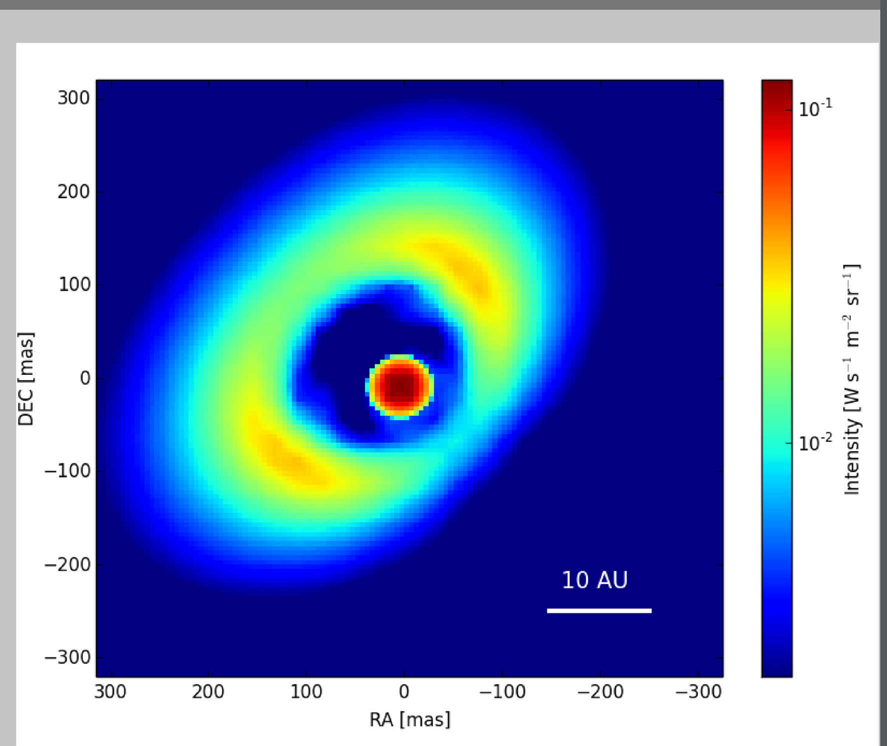

Figure 8: MCFOST Polarized intensity image.

PDI images from Avenhaus et al. 2014 where a "dark lane" is seen in the south west side of the disk are consistent with the observations and current MCFOST model.

Conclusions

- Using MIRA **we detected the inner part of the outer disk**. As in the MCFOST model we found that the south west side of the disk (near side) is the brightest.
- Comparing the measured power spectrum and closure phases we found that the current MCFOST model need **more extended emission to explain data**. It can be achieved putting larger grains and larger scale height in the outer disk. A future work is to match the .
- A future work is to **match the observed power spectrum and SED**. Another interesting study is **to fit a parametric model** of the outer disk with a gap.

References

-Augereau, J., et al. 2001, A&A, 365, 78
-Avenhaus, H. et al. 2014, ApJ, 790, 56
-Boccaletti, A., et al. 2013, A&A, 1310, 7092
-Bouwman, J., et al. 2009, ApJ, 700, 56
-Brittain, S., et al. 2013, ApJ, 767, 159
-Liskowsky, J., et al. 2012, ApJ, 760, 153
-Mulders, G., et al. 2013, A&A, 557, 68
-Pani, O., et al. 2014, A&A, 562, 101
-Quanz, S., et al. 2011, ApJ, 738, 23
-Quanz, S., et al. 2013, ApJ, 766, 1
-Renard, S. et al. 2011, A&A, 533, 64
-Thibaut, E. 2009, NewAR, 53, 312

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