GRAVITY Interferometric analysis and modelling of disks around Herbig Be stars

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In the framework of the formation and evolution of planetary disks, we tackle the link between young Herbig Ae and Herbig Be stars and their different theories on formation mechanisms.
Several lines of evidence link HAe stars with Magnetospheric Accretion (MA), while HBe stars are linked with direct disk-to-star accretion through a Boundary Layer (BL) theories. In turn, the different accretion mechanisms may lead to observable differences in the innermost parts of their protoplanetary disks.
Our analysis of K- band observations with the VLTI/GRAVITY interferometer at the Paranal Observatory provides spatially and spectrally resolved data of the inner disks of a sample of HBe stars that are suspected to be non-magnetospheric. With these data, we intend to characterize the inner gas and dust region in terms of sizes, densities, temperatures and velocities of our sample.
We applied specifically designed model-fitting-tools for interferometric observations to our sample of HBes.

Context

Although there is a general consensus on magnetic accretion (MA) being the driving mechanism for circumstellar disk to accrete material in HAes, there is not such a consensus for their more massive counterparts.

In those HBes whose magnetic activity is not observable, boundary layer (BL) is not discarded.

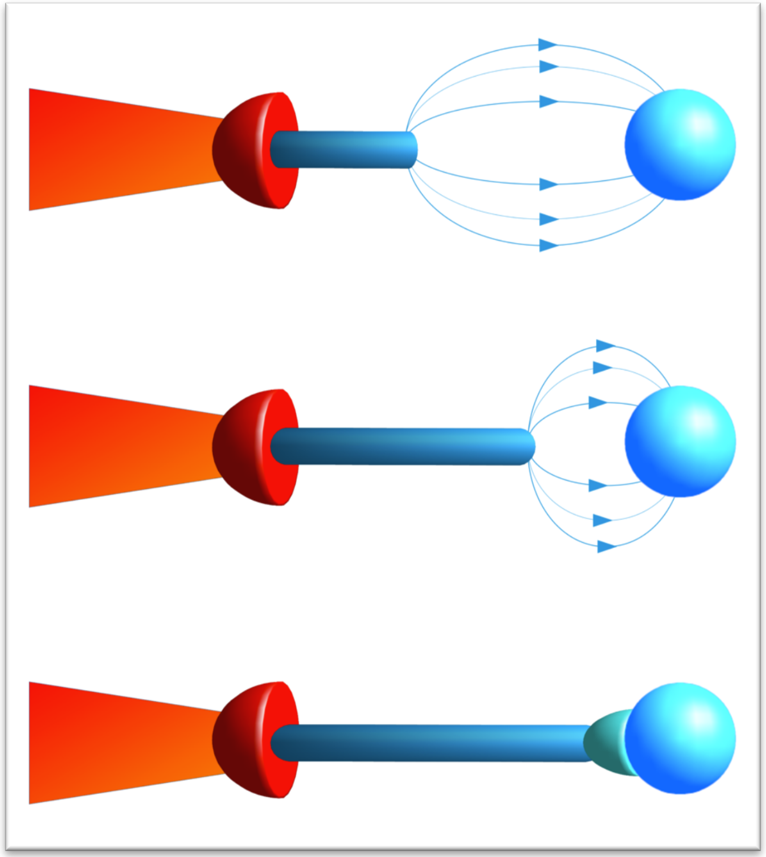


Fig. 1 (from Mendigutía, I. 2020,Galaxies, 8, 39.) Edge-on accreting disk where the dust (red) is further from the star than the gas (blue). Gas is channelled through the stellar magnetic field lines according to MA (top and middle panels, corresponding to decreasing magnetic strengths and sizes of the magnetosphere), and directly onto the star through a BL (indicated in cyan at the bottom panel) in the absence of a strong enough magnetic field.

Project

In order to enlighten this discussion, we observed 5 HBe stars for which MA has been ruled out.
The enormous capabilities on spatial resolution with GRAVITY interferometer at VLTI can provide with valuable information to resolve the disk to star interface.

These observations require from a complex calibration and data reduction (due to the interferometric nature) to retrieve direct information on its visibility, differential phase and closure phase. From these parameters it is inferred the relevant spatial scale and geometry of each systems in our sample.

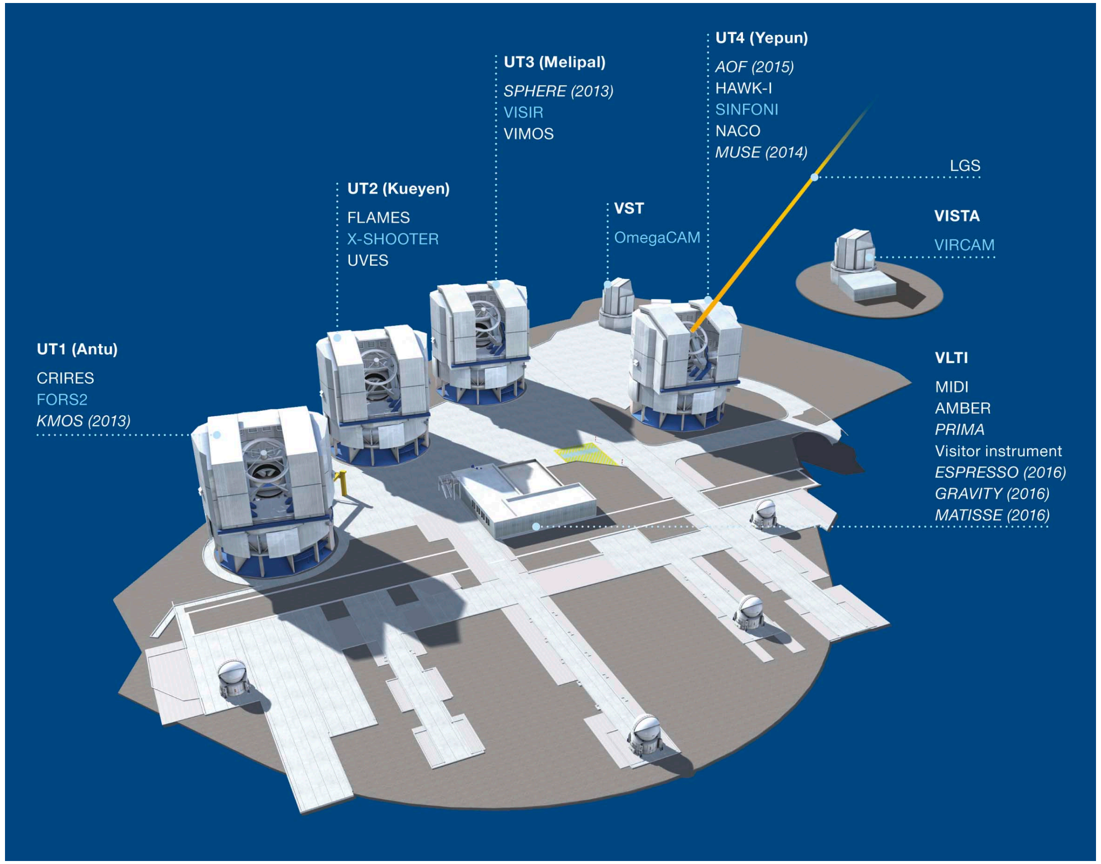
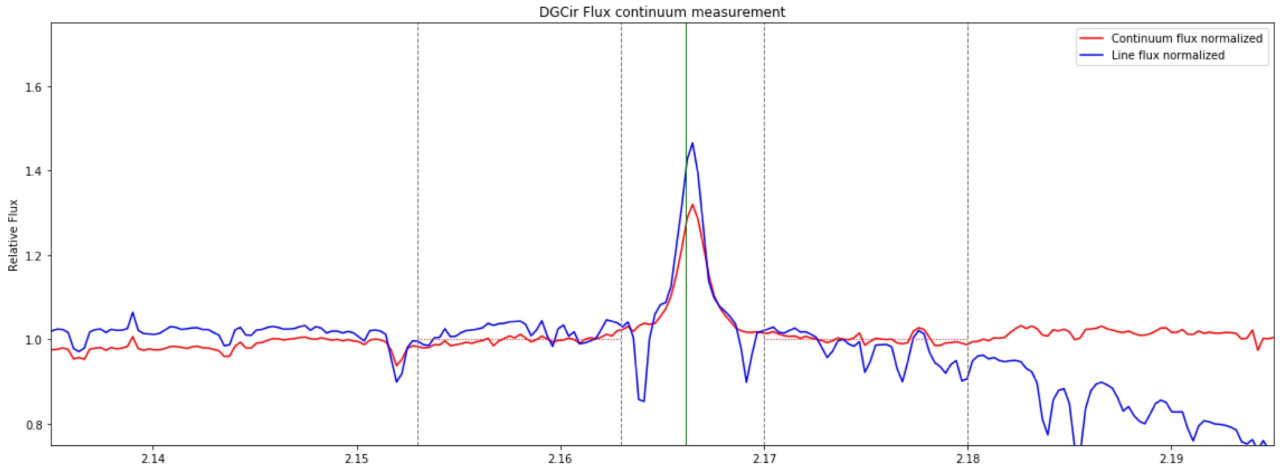


Fig 2. ESO - Paranal Telescopes and Instruments (Credit: ESO)

Results

These observations require extended data processing and calibration. Fig. 3 shows telluric lines removal for continuum measurement (in red) and Brγ emission line (in blue). This observations also provides with the squared visibility (when revealed to be higher than their adjacent continuum's indicates to be more compact than the inner dusty disk. This effect is highly noticeable in three out of the five sources, and so do their models reveal), differential phases and closure phases (when close to zero revealed that they all are quite close to symmetric objects.)



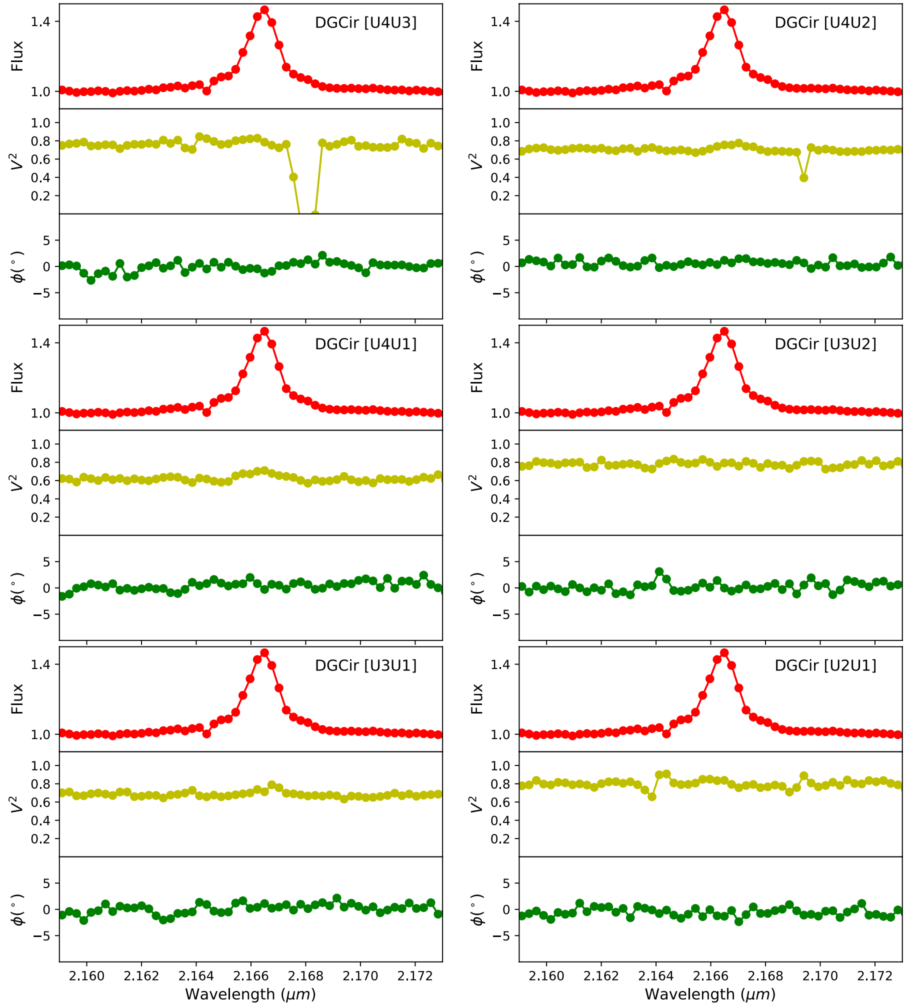


Fig. 3 (left) Continuum and line fluxes normalized. **Fig.4** (right): fluxes, squared visibilities, and differential phases for each of the baselines of DGCir observations as a function of wavelength in Brγ region.

Results

All sources were modelled as gaussian elongated disk concentrical to their host star.
The results from this model fitting are their disks sizes, its orientation, elongation and contribution to the overall emitting flux.
Fig. 5 shows that from the small differences in the squared visibilities of Brγ and its adjacent continuum, the model fitting can provide with differences their corresponding disk sizes. GRAVITY can reveal these under-milliarsec gaps.
The sharp decrease on the shortest spatial frequencies is modelled as a background diffuse emission.

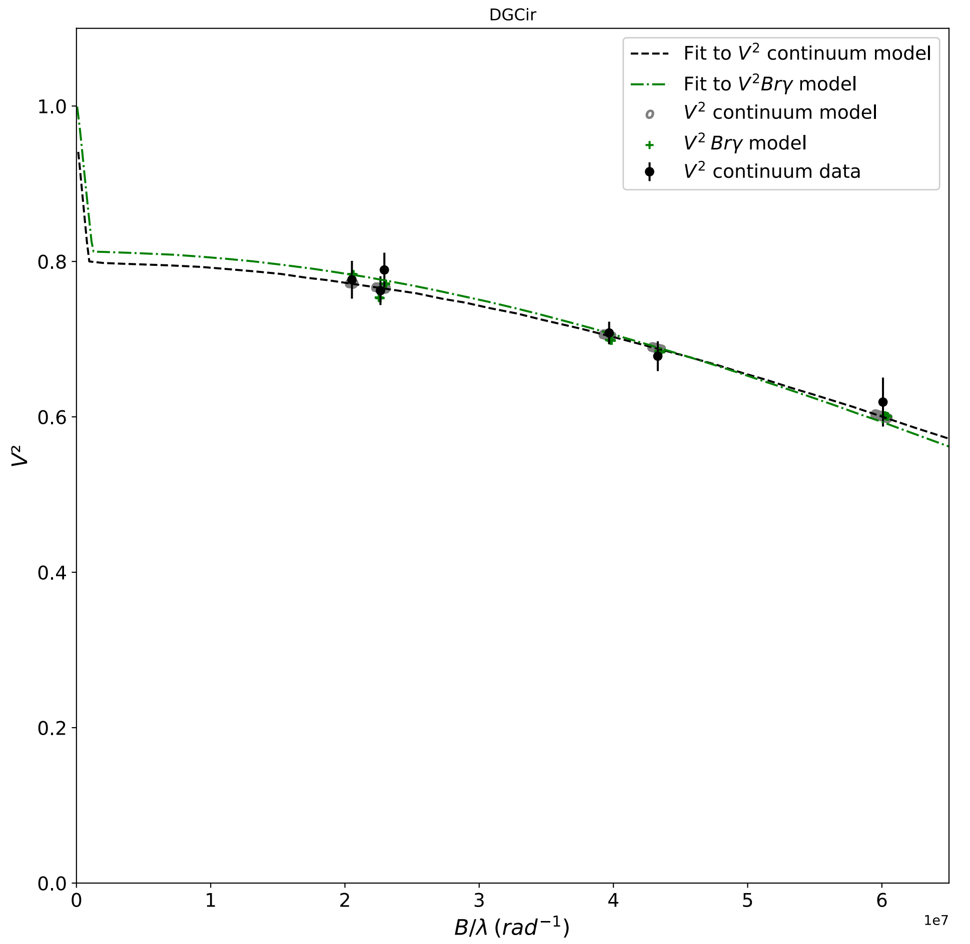


Fig. 5 Squared visibility of DGCir versus the spatial frequency with the measurements on Brγ (green crosses) and continuum (solid black dots) and the fitting to their model.

Impact and prospects for the future

Further analysis of these data is providing valuable information on their morphology and spatial scale, to be compared with previous, similar data on magnetospheric HAe stars. Our ultimate goal is to find observational differences between the two accretion paradigms in competition, based on unique interferometric data we got access to.