AMBER+FINITO+UT Science Demonstration Proposal

Studying the gas kinematics in the accretion and outflow-launching region of YSOs

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Abstract:

Accretion and outflow processes are of fundamental importance for our understanding of the formation of stars and planetary systems. To trace these processes, diagnostic lines such as Brγ are widely used, although due to a lack of spatial resolution, their origin is still unknown. We propose to use the unique capabilities provided by VLTI/AMBER and FINITO fringe tracking to spatially resolve the distribution of the line-emitting gas and to measure its kinematics for a small sample of YSOs. Our target stars cover a wide range of stellar properties, magnitudes and celestrial coordinates, providing therefore good targets for different atmospheric conditions in various parts of the night of the AMBER+FINITO SV run.

Scientific Case:

Herbig AeBe (HAeBe) stars are intermediate-mass, pre-main sequence stars, which are still associated with substantial quantities of gas and dust, the residual material from their formation. In recent years, infrared interferometry could provide already important information about the structure of the circumstellar disks, which are believed to be responsible for the characteristic infrared continuum excess emission. However, only very little is known about the origin of the line-emission observed towards HAeBe stars. For example, it has been proposed that the hydrogen recombination lines might trace the following processes (see also illustration in Fig. 1):

(a) Magnetospheric accretion of matter onto the star (Calvet et al. 2004)
(b) Optically-thin gas located inside of the dust sublimation radius (Muzerolle et al. 2004)
(c) Stellar winds (e.g. Catala & Kunasz 1987)
(d) Outflows launched from the inner edge of the accretion disk (Shu et al. 1994)
(e) Outflows launched from the disk surface (Drew et al. 1998)

The line profile fitting techniques which are currently used to constrain the geometry and kinematics of the line-emitting gas are known to be highly ambiguous (e.g. Catala et al. 1999). Therefore, high spatial and spectral resolution is required to constrain the physical mechanism and spatial origin of important tracer lines like Brγ.

Recent observations, which we obtained using AMBER's MR-mode ($R = 1,500$) on 5 Herbig Ae/Be stars (see Fig. 2; Malbet et al. 2007; Tatulli et al. 2007; Kraus et al. 2008) provided the surprising results that the line emission can trace at least two physical mechanisms: One mechanism resulting in a very compact line-emitting region (likely tracing magnetospheric accretion; 1 object) and another resulting in a rather extended line-emitting region, likely tracing stellar winds or disk winds (4 objects).

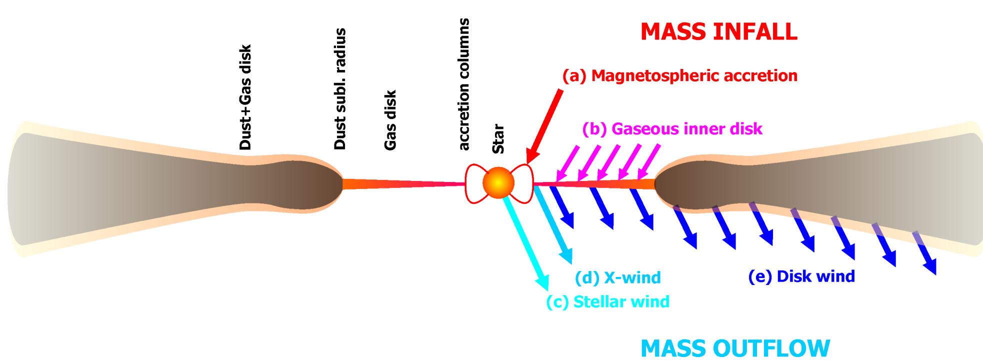

Figure 1: Illustration of the regions which have been proposed as the origin of the Brγ hydrogen line emission observed towards HAeBe stars.

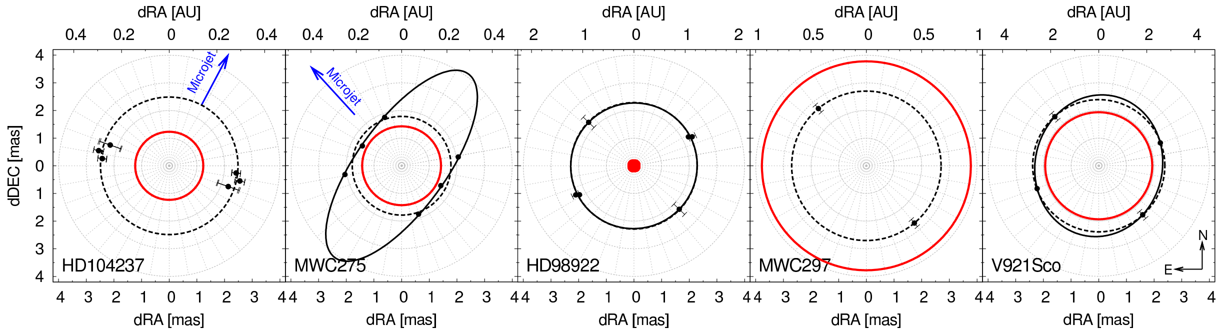

Figure 2: In a recent study, we measured the size of the continuum- (black curves) and Brγ line-emitting region (red line) for a sample of 5 Herbig Ae/Be stars (Kraus et al. 2008), finding that this line can trace either accretion columns close to the stars (HD98922) or outflowing wind components (HD104237, MWC275, MWC297, V921 Sco). The proposed SV observations will dramatically extend our observational sample and (due to the higher spectral resolution) reveal for the first time also the gas kinematics.

For the upcoming SV observations, we propose to employ FINITO fringe tracking with the UTs in order to measure the geometry of the Brγ-emitting region around a small sample of YSOs for the first time with high spectral resolution ($R = 12,000$). Since this will reveal not only the spatial extension of the line-emitting gas, but also it's kinematics, these observations will provide completely new and unique insights into fundamental processes in YSOs.

As target stars, we selected T Tauri (T Tau N) and intermediate-mass Herbig Ae (MWC 120, V1295 Aql) and Herbig Be stars (MWC 147, MWC 166, MWC 297, HD 58647), which will allow us to draw conclusions about the dependence of the line-formation mechanism on stellar/environmental properties and to probe the fundamental relation between the accretion and outflow processes in YSOs. Furthermore, this sample offers the advantage that it contains targets of various correlated magnitudes and in different parts of the night, which will allow the SV observing team to select an appropriate target for different conditions and to test the FINITO performance for various object magnitudes. The differential visibilities, differential phases, and closure phases, which we will measure within the spectrally resolved Brγ line of these objects will allow us to study the kinematics of the gas and to distinguish whether the material is infalling onto the star or ejected from the system in an outflow.

Calibration strategy:

The primary goal of our science project is to measure the differential signatures within the Brγ 2.166 μm line with high spectral resolution. A good absolute visibility calibration is not required.

Targets and number of visibility measurements

Target	**RA**	**DEC**	**V** mag	**H** mag	**K** mag	**Size** (mas)	**Vis.**	**Mode**	**# of** Vis.
T Tau N	04 21 59	+19 32 06	9.6	6.2	5.3	3	0.9/0.7/0.4	HR 2.172	1
MWC 120	05 41 02	-02 43 01	8.0	6.3	5.4	3	0.9/0.7/0.4	HR 2.172	1
MWC 147	06 33 05	+10 19 20	8.8	6.7	5.7	2	0.9/0.8/0.5	HR 2.172	1
MWC 166	07 04 26	-10 27 16	7.4	6.2	6.1	2	0.9/0.8/0.5	HR 2.172	1
HD 58647	07 25 56	-14 10 44	6.8	6.1	5.4	2	0.9/0.8/0.5	HR 2.172	1
MWC 297	18 27 40	-03 49 52	12.3	4.4	3.0	8	0.3/0.2/0.1	HR 2.172	1
V1295 Aql	20 03 02	+05 44 17	7.8	6.6	5.8	3	0.9/0.7/0.4	HR 2.172	1

Note: In case the FINITO performance is not sufficient for some objects to use the HR-mode, the MR 2.1-mode could be used, although some targets in our sample (T Tau N, MWC 120, MWC 147, MWC 166, HD 58647) are protected for this mode by OT-programme 082.C-0627(A).

Time Justification:

Observations on a single hour angle and a sub-set of our sample are sufficient. Already a single successful observation on one of the targets might have a strong science impact.