AMBER+FINITO

Investigating the gas emission regions of the T Tauri system GW Ori

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Abstract:

We propose to use AMBER in medium resolution mode with FINITO to resolve the gas emission regions in the circumstellar environment of the T Tauri star GW Ori. This young binary system displays a rich IR emission line spectrum signalling the presence of active, spatially not yet resolved, regions (accretion flow, gaseous disk, inner stellar/disk wind) likely connected with a circumbinary disk. It thus represents a particularly suited case to test the ability of AMBER+FINITO to investigate the geometry of the inner regions of low-mass young sources, whose physical structure plays an important role in the properties of the forming solar-type planetary systems.

Scientific Case:

During the first evolutionary stages of a young stellar object (YSO), the protostellar system is characterised by the presence of different structures in the circumstellar environment, such as the accretion disc, the magnetospheric accretion region, collimated jets, and (in the more embedded sources), the dusty envelope that has not been dispersed yet. According to the models (Königl A. & Pudritz, R. 2000, Protostars and Planets IV, p.759, Casse F. & Ferreira, J. 2000, A&A 353, 1115), the physical processes occurring in these structures are intimately related. In particular, accretion and ejection of matter are connected through the presence of a magnetised accretion disk: the jets carry away the excess angular momentum, so that part of the disk material can move toward the star. While there is wide agreement on this general picture, different models have been proposed for the accretion process (e.g. magnetospheric accretion or boundary layer), for the wind/jet launching (disk-wind, Garcia et al. 2001, A&A, 377, 589, vs X-wind, Shang et al. 2002, ApJ, 564, 853) and for the structure and composition of accretion disks (e.g. Dullemond et al. 2001, ApJ, 560, 957). Since the relevant spatial scales for the investigation of these phenomena range between $\sim$0.1 $\sim$10 AU, it is clear that only interferometric observations are able to test the different proposed models.

Recently, the AMBER instrument on VLTI has allowed the inner active regions of pre-main-sequence (pms) stars to be investigated for the first time in few bright sources (Malbet, F., et al. 2007, A& A, 464, 43, Kraus, S., et al. 2008, A&A in press). In particular, the Brγ emission has been used to test different hypothesis on the origin of the hydrogen lines in pms stars, i.e. whether they are generated in the magnetospheric accretion region, in stellar winds or in winds from the disk. Similarly, the region responsible of the relatively warm and dense CO gas giving rise to the bright band-heads at 2.3 μm have been for the first time resolved in one Herbig Be star (Tatulli, E., et al. 2008, arXiv:0806.4937); such observation shows that CO is emitted in a gaseous disk, where dust has been destroyed by the stellar radiation field.

Due to the restricted sensitivity limits of AMBER without the fringe tracker, however, positive detections have been so far obtained only on bright Herbig Ae/Be stars. Such massive sources are already quite evolved and the star radiation field is high enough to influence the physical structures of the circumstellar environment, such for example destroying the inner dusty disk or halting the accretion process. Hence, results found on these sources cannot be extended to solar mass objects (i.e. the T Tauri stars); it is on the other hand of crucial importance to investigate the accretion/ejection inner regions of such low mass young stars, since their physical structure plays a fundamental role in defining the characteristics of the forming solar-type planetary systems.

We propose here to test the capability of AMBER + FINITO to probe the inner line emission regions in T Tauri circumstellar environments, by observing GW Ori, an active T Tauri located at a distance of 400 pc. This source is a spectroscopic binary with a separation of 1.1 AU in a nearly circular orbit. A circumbinary disk with an inner gap devoid of material has been predicted on the basis of spectroscopic and SED modeling of the system (Mathieu, R. D., Adams, F. C., & Latham, D. W. 1991, ApJ, 101, 2184). The source presents strong CO emission from the fundamental band at 4.6um, expected to rise from the inner region of the disk (Najita, J., Carr, J. S., & Mathieu, R. D. 2003, ApJ, 589, 931). GW Ori also has strong Paβ and Brγ emission (Folha, D. F. M., & Emerson, J. P. 2001, A& A, 365, 90) : the profiles of these lines are asymmetric, with red-shifted absorption that may suggest an origin in the magnetospheric accretion region (Muzerolle et al. 1998). On the other hand, the source also presents a strong P Cygni profile in the He I 1.083 μm (Edwards, S., Fischer, W., Hillenbrand, L., & Kwan, J. 2006, ApJ, 646, 319) , evidencing the presence of an inner ionized wind which could be in part also responsible for the HI emission . This object is therefore very well suited to probe the different active inner regions at AU resolution. We propose here to perform medium resolution spectroscopy at 2.16 and 2.3 μm in order to measure the visibility contrast between the Br γ and CO band-head lines with respect to the dusty disk continuum and constrain the geometry of the inner gas emission region of this system. The obtained differential visibilities will be analysed by using both geometrical models and specific radiative transfer models developed by the proponents (Nisini, Antoniucci & Giannini 2004, A&A, 421, 187, Li Causi et al. in preparation). A low resolution (H-K) measurement is also requested in order to have several visibility measurements of the continuum emission and disentangle the relative contribution from the binary system and from the inner dusty disk region. This source has a K magnitude (6.6 mag), typical of the brightest T Tauri stars, that leads to a correlated magnitude just at the limit of the AMBER+FINITO sensitivity in medium resolution. It therefore represents a suitable case to test the general capability of this instrument to address the proposed science in solar-mass pms stars.

Calibration strategy:

We aim to measure differential visibilities between emission features (the Brγ at 2.16 μm and the CO band-heads at 2.3μm) and the adjacent continuum. Long DIT will be used in order to obtain a good S/N in the differential visibilities, even if these will result in larger errors in the absolute calibrations. A calibration star will be however requested before and after the science observations in order to better monitor atmospheric condition changes. The selected target has a visual magnitude of 9.9 mag, and can therefore be used as a guide star.

Targets and number of visibility measurements

Target	**RA**	**DEC**	**V** mag	**H** mag	**K** mag	**Size** (mas)	**Vis.**	**Mode**	**# of** Vis.
GW Ori	05 29 08.4	+11 52 12.7	9.9	7.1	6.59	3.0	0.9/0.7/0.4	MR 2.3	2
GW Ori	05 29 08.4	+11 52 12.7	9.9	7.1	6.59	3.0	0.9/0.6/0.35	MR 2.1	2
GW Ori	05 29 08.4	+11 52 12.7	9.9	7.1	6.59	3.0	0.88/0.6/0.3	LR HK	1

The expected visibility values have been found assuming that the K band 2μm emission originates mainly from the inner region of the circumbinary disk, located between 1-2 AU from the main binary component (Najita et al., 2003).

Time Justification:

We request 2 AMBER+FINITO measurements in MR-K for each spectral setting, in order to increase the S/N on each baseline. Each calibrated AMBER measurement (CA-SCI sequence) takes 70 minutes to be executed: we additionally ask for a further calibration measurement at the end of the observations for each spectral setting, in order to bracket each visibility measurement with a calibration. Since a sequence CAL-SCI-CAL requires 105 minutes, the total requested time in MR is 5.7 hrs. Additional 70min are requested for the LR observations, for a total of 6.9 hrs.