AMBER+FINITO+UT Science Demonstration Proposal

The mass-loss envelopes of dusty post-AGB stars

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Abstract:
We propose to study the mass-loss envelopes of one or more of the dusty post-AGB stars IRAS 19125+0343, AR Pup and HM Aqr. Post-AGB stars are low-mass stars in the short-lived transitional phase between AGB stars and asymmetric planetary nebulae (PNe). Observations of these sources are thus very important to understand the mass-loss process during the final AGB evolution, as well as the break of symmetry between spherically symmetric AGB stars and PNe. The proposed stars have been selected to have an infrared excess well beyond the photospheric $J-K$-colour ($J-K>2$ in the first two cases). We expect a multi-component structure with a central star of angular diameter ~ 1 mas and a dust envelope of ~ 10 to 20 mas, where the star contributes about 50% of the total K-band flux. These observations will provide important information on the innermost dust shell zone, which was produced during the tip-AGB phase, and on possible asymmetric shapes of this region, thanks to the excellent closure-phase capabilities of AMBER used with Finito. Results will be compared to available theoretical models of the mass-loss evolution during the final 10 000 to 50 000 years of the tip-AGB giant.

Alma Ruiz Velasco will be an ESO student from January 2009, and she will lead the project.

Scientific Case:
Low- and intermediate-mass stars evolve, after the red giant branch (RGB) and horizontal branch phases, along the asymptotic giant branch (AGB). Here, mass-loss becomes increasingly important and reaches reaching mass-loss rates of up to $10^{-4}\,M_{\odot}$/year (e.g. Jura & Kleinmann 1990, ApJS, 73, 769). This mass-loss from AGB stars is one of the most-important sources for the chemical enrichment of the interstellar medium. After the AGB phase, when the H/He-burning shell has extinguished, the star evolves toward the hot part of the Hertzsprung Russel diagram, the PN phase. Stars in the short-lived phase right after the AGB evolution with effective temperatures still below $\sim$10 000-15 000 K are called post-AGB stars and are still surrounded by the dust envelope that originated from the strong mass-loss ("superwind") in the tip-AGB phase. Thus, post-AGB stars are crucial targets to study the mass-loss history during the final AGB phase.

Also, very importantly, stars in this evolutionary phase represent the transitional phase between spherically symmetric AGB stars and axisymmetric PNe. While there might already be some slight indication of asymmetric shapes of the molecular layers and dust shells around AGB stars (e.g. Weigelt et al. 1996, A&A, 316, L21; Weiner et al. 2006, ApJ, 636, 1067; Ragland et al. 2008, ApJ, 679, 746), the important break of symmetry toward the often very elongated shapes of planetary nebulae is supposed to happen during this brief phase of post-AGB evolution.

Here, we have selected three post-AGB stars from the "Torun catalogue of Galactic post-AGB and related objects" (Szczerba et al. 2007, A&A, 469, 799) which are observable during the October AMBER-SV run in terms of position on sky and magnitudes. All three objects have an infrared excess well beyond the photospheric $J-K$-colour (for the first two, $J-K>2$): **IRAS 19125+0343, AR Pup** (both classified as RV Tau type post-AGB stars of spectral type F-K), and **HM Aqr** (UU Her type post-AGB star, with spectral type A0III already a little further away from the AGB). The IR excess is commenly interpreted as evidence of a recent mass loss typical of the AGB phase of evolution (Jura 1986, ApJ, 209, 732; Szczerba et al. 2007). We expect the angular diameter of the central stars to be of the order of $\sim$1mas, that of the envelopes of the order of ~ 10 to 20 mas, where the central star contributes about half of the K-band flux.

We propose to study the innermost region of the envelope and to search for asymmetric shapes present in the envelope making use of the excellent closure phase capabilities of AMBER when it is used together with Finito. Post-AGB stars are known to exhibit signatures of Brγ and CO lines in the near-infrared K-band (e.g.; Oudmaijer et al. 1995, A&A, 299, 69; van de Steene et al. 2000, A&A, 362, 984). Hence, we wish to characterize both, the geometrical size and any asymmetry of these features, if present in these targets, by using the AMBER medium resolution mode.

AMBER data will be reduced using the `amdlib` package as, e.g., in Wittkowski et al. (2008, A&A, 479, L21). Furthermore, we have theoretical models of the radial density profile of outer, undisturbed envelopes of C-rich AGB and proto-PNs. These models are based on a well-calibrated evolution code with a parametrized mass-loss prescription of dust-driven (super)winds (see Wachter, Schröder, et al. 2002, A&A 384, 452). These and earlier computations (Schröder et al. 1999, A&A, 349, 898) yield mass-loss and time-scales nicely consistent with the observed properties of PNe. Here, we aim at a first comparison of observed tip-AGB/post-AGB stars with such model predictions for the density profiles.

Calibration strategy:

An absolute calibration of the visibility shall be provided for a detailed modeling of the star. The closure phase is of particular importance to detect asymmetries in the envelope of post-AGB stars.

Targets and number of visibility measurements

Target	**RA**	**DEC**	**V** mag	**H** mag	**K** mag	**Size** (mas)	**Vis.**	**Mode**	**# of** Vis.
IRAS 19125+0343	19 15 01	+03 48 43	10.3	7.1	5.7	1+10	0.7/0.6/0.6	MR 2.1	1
IRAS 19125+0343	19 15 01	+03 48 43	10.3	7.1	5.7	1+10	0.7/0.6/0.6	MR 2.3	1
AR Pup	08 03 02	-36 35 45	9.6	6.8	5.3	1+10	0.7/0.6/0.6	MR 2.1	1
AR Pup	08 03 02	-36 35 45	9.6	6.8	5.3	1+10	0.7/0.6/0.6	MR 2.3	1
HM Aqr	22 35 28	-17 15 27	8.9	7.6	6.7	1+20	0.8/0.7/0.7	MR 2.1	1
HM Aqr	22 35 28	-17 15 27	8.9	7.6	6.7	1+20	0.8/0.7/0.7	MR 2.3	1

Time Justification:

We propose for any of the three suggested target one full K-band visibility spectrum in MR, including MR 2.1 and MR 2.3 (to include Brγ and CO). For three targets, this would mean a total of 6 visibility observations. However, only one of the three targets, to be chosen depending on the time during the night, would already be useful (2 visibility points). If less time is available, the MR 2.3 setting alone would be preferred.