A joint venture in the red:
The Herschel+MIDI+VISIR view on mass-loss from evolved stars

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Motivation

Asymptotic Giant Branch (AGB) stars are a late evolutionary stage of low to intermediate mass stars. These objects are crucial for the cosmic matter cycle because through the mass-loss process they enrich the interstellar medium with freshly processed material. An important aspect of the mass-loss process which is poorly understood is its geometry. Is the mass-loss episodic? Is it symmetric or asymmetric? And if it is asymmetric at which height of the atmosphere do asymmetries appear? Is there a correlation between asymmetries and chemistry, and/or variability class? Our **ESO/ Large Program** will try to answer these questions by combining the results of the MESS program of Herschel with VLT/VISIR and VLTI/MIDI.

Out there: Herschel/PACS

The Mass-loss of Evolved StarS (MESS, Groenewegen et al. 2011) is a Guaranteed Time Key Program that uses the PACS and SPIRE instruments onboard the Herschel Space Observatory. MESS investigates the dust and gas chemistry and the properties of the circumstellar environment for a large, representative sample of post-main-sequence objects using both imaging and spectroscopy.

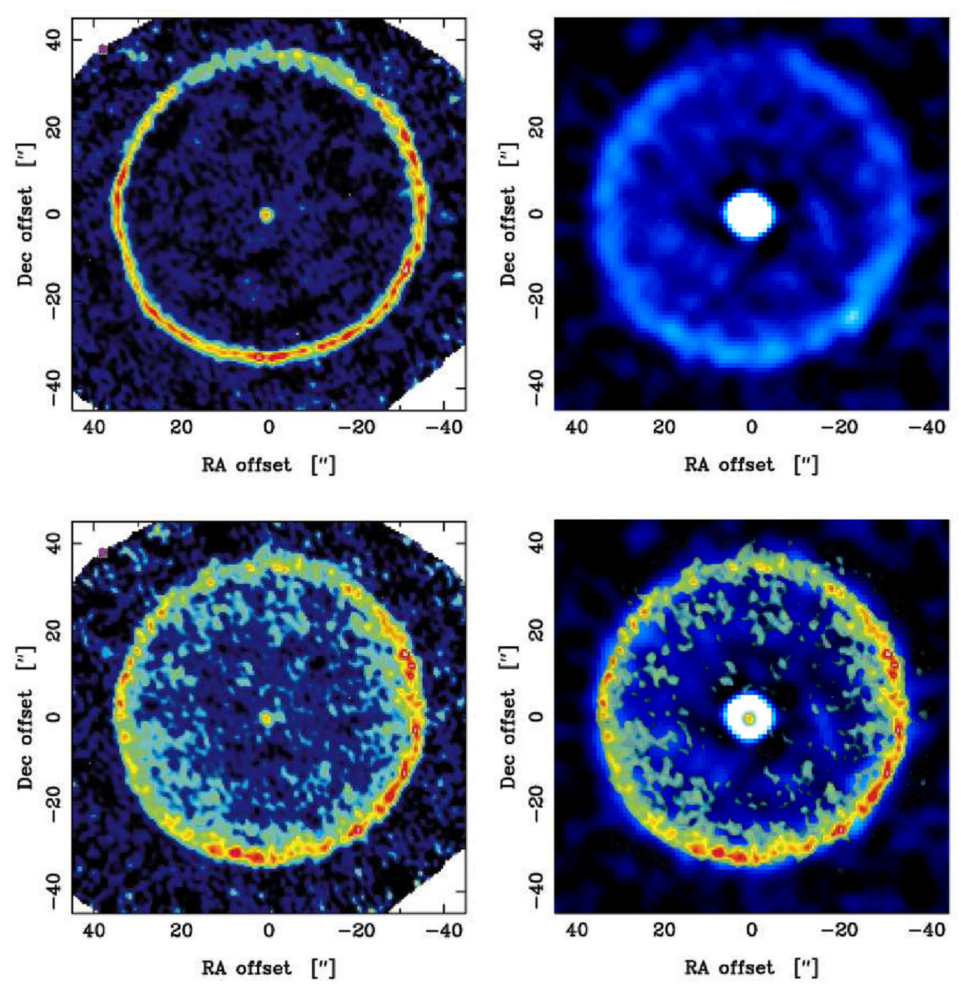
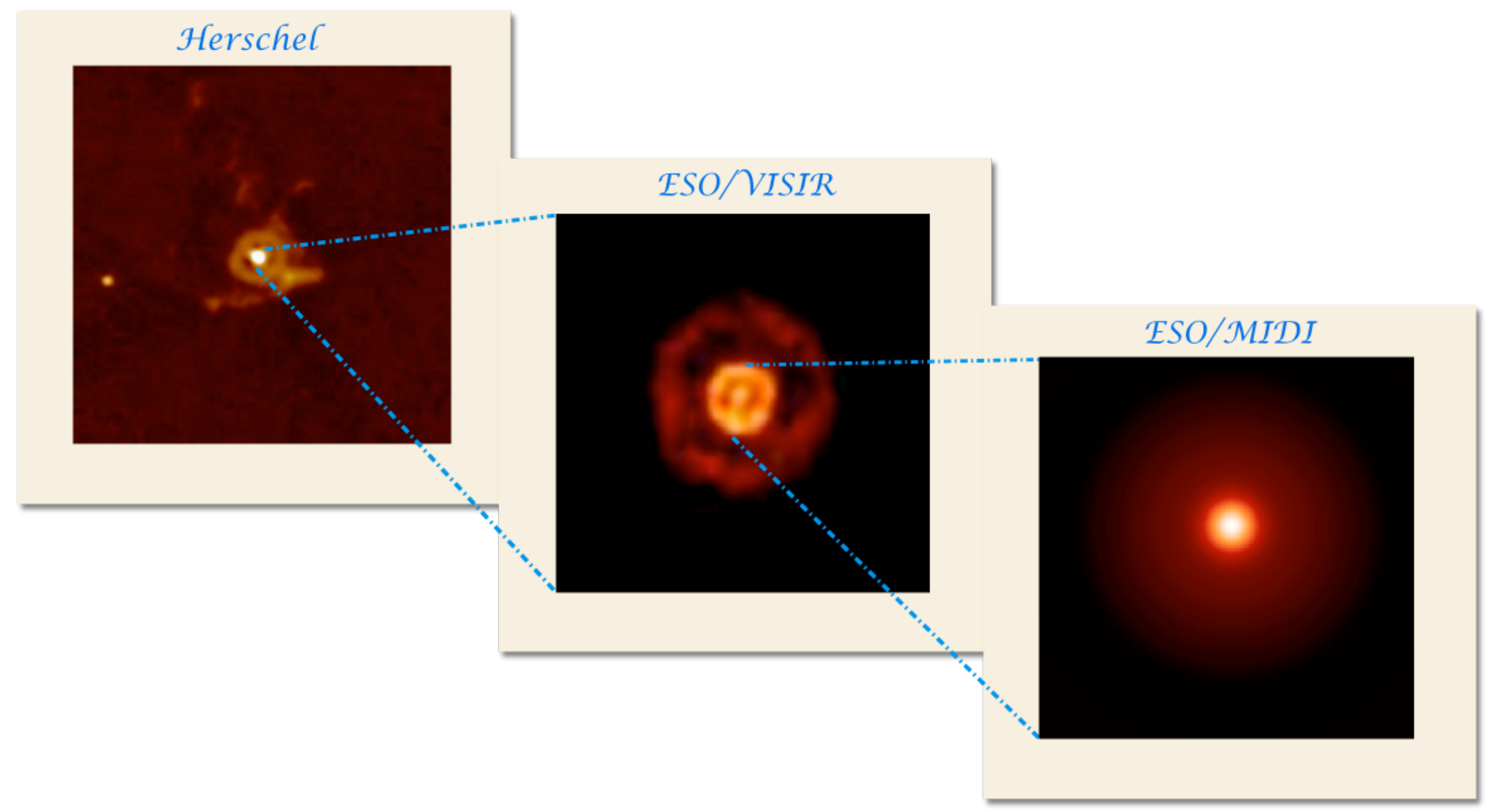


Fig.1 Detached shells

On the left the detached shell of TT Cyg by IRAM in the CO(J=1-0) transition at systemic velocity as well as velocity integrated (Olofsson et al. 2000). On the right the PACS image at 70 μm of the same shell (Kerschbaum et al. 2010) and with the velocity-integrated CO map overplotted. MIDI and VISIR complement the observations of such kind of objects. The next step in order to understand the geometry of the mass-loss will be ALMA.

Early MESS results from the imaging campaign (Kerschbaum et al. 2010; Ladjal et al. 2010; Jorissen et al. 2010; Mayer et al. 2011) evidenced that clumpiness is seen on all scales. The spatial distribution of the dusty material can be categorised in 4 forms: (i) perfectly spherical, sometimes detached material (Fig.1); (ii) bow shock structures correlated with the stellar motion with respect to the surrounding ISM; (iii) mixture of both; (iv) influence of binarity.



Schematic view of the scales probed by the different instruments involved in the project. ***Left***: PACS image of TX Psc adapted from Jorissen et al. (2011). ***Center***: VISIR image of a the detached shell of a planetary nebulae adapted from Lagadec et al. (2011). ***Right***: simulation of the spatial scales probed by MIDI (model from Klotz et al., 2011).

Going inside: VISIR

VISIR fills (partially) the gap between MIDI and Herschel and it will probe spatial scales between 25 and 2500 stellar radii . The burst mode was selected for the observations (~3 nights). This mode will allow to obtain high quality diffraction limited observations (0.3 arcsec) as already showed by Lagadec et al. (2011).

These observations allow us to relate the large scale asymmetries observed with Herschel to smaller structures and determine when and where those asymmetries were created.

Deeper inside where dust forms: MIDI

MIDI with its very high angular resolution probes the inner part of the atmosphere were dust is forming (2-25 stellar radii).

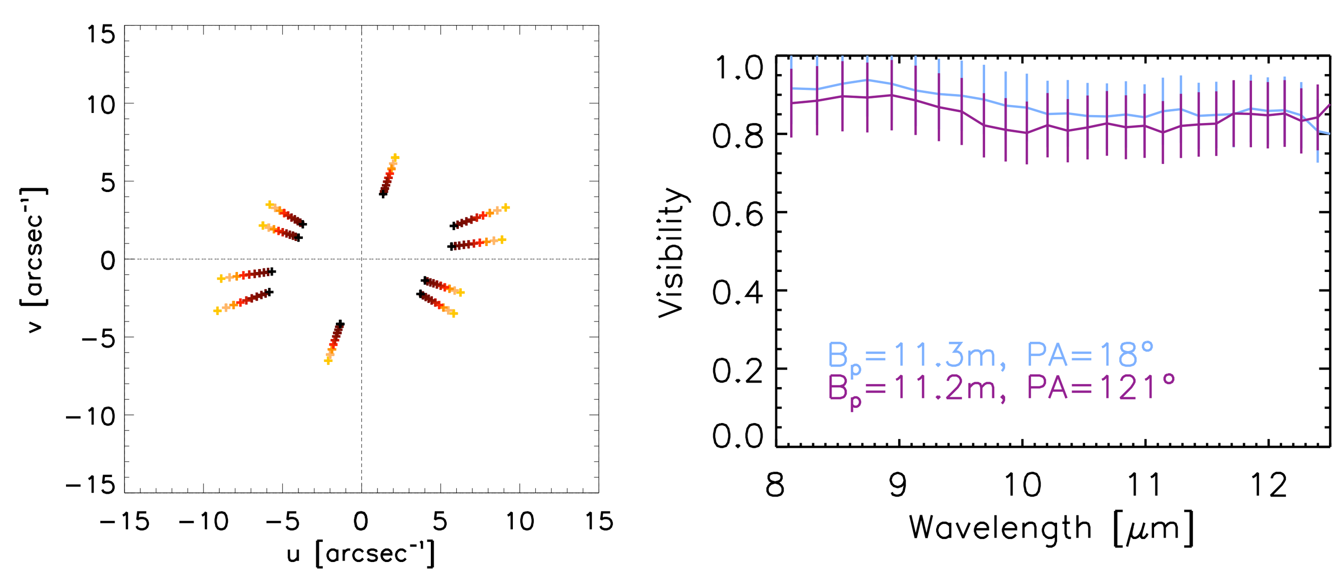


Fig.2 MIDI preliminary results
Left: MIDI *uv* coverage for one of the targets of the Large Program, T Mic. **Right**: visibilities at different position angles and similar baselines. The preliminary analysis indicates that in the MIDI range the star does not exhibit departure from central symmetry.

Every target is observed with 6 baselines (see an example in *Fig.2*) for a total of 114 hours on the ATs. The visibilities obtained from different position angles and at same spatial scales, together with the differential phase, will be compared with geometric models (*GEM-FIND*, Klotz et al. 2011, subm.) seeking for departure from spherical symmetry.

The sample

We selected 15 targets from the original MESS sample. They are shown in the IRAS two color diagram (van der Veen & Habing 1988) in *Fig.3*.

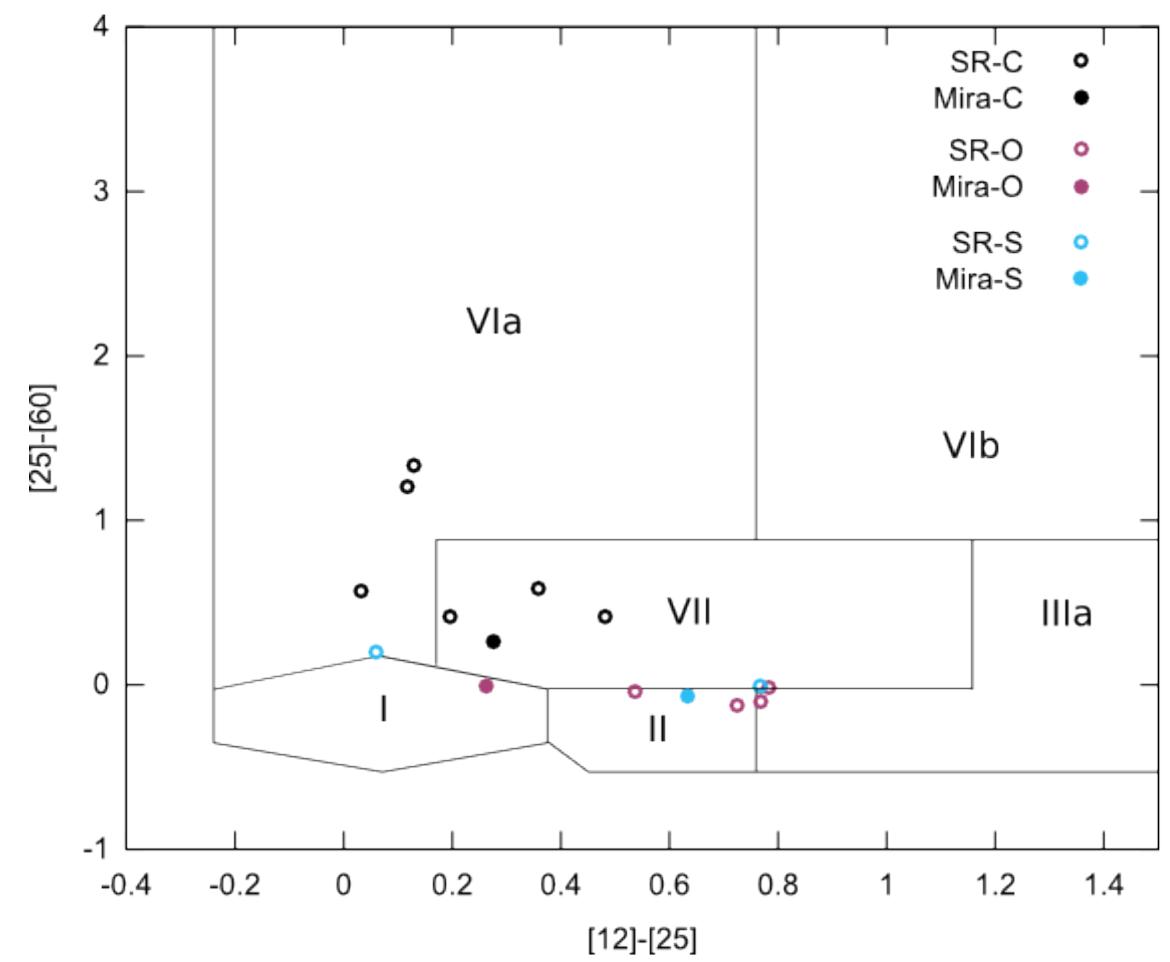


Fig.3 IRAS diagram

Box I: O-rich non variable stars with no extended circumstellar shells. Box II: objects surrounded by young O-rich shells. Box IIIa: objects surrounded by more evolved O-rich shells. Box VIa: C-rich objects with relatively cold dust. Box VIb: objects with hot dust close to the star, and cold dust at larger distances. Box VII: typical variables with more evolved C-rich shells.

The targets have different chemistry, variability class, and mass-loss rates. We already obtained MIDI data for 6 objects and the data analysis and modeling is ongoing.

Stay tuned!

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