ESO observing programme INSPIRING

Abstract

This is the first data release of the INSPIRING ESO large programme (ID: 1103.D-0797). This programme aims to use interferometric VLTI observations, consisting of imaging observations with VLTI/PIONIER and snapshots with VLTI/GRAVITY, to study the inner rims of dusty circumbinary discs around post-AGB binaries.
In this release, we present calibrated, spectrally dispersed interferometric science observations taken with VLTI/PIONIER (in GRISM_H mode) for 8 out of the 11 total post-AGB binary targets. These showed clear signatures of the inner disc rim. 2 targets resulted in non-detections of the disc, and one target observed with PIONIER is reserved for a future dedicated multi-epoch imaging data release; the GRAVITY snapshots are also deferred to a future data release. For each target, this release presents a single imaging-grade epoch of data with beam sizes of typically ~1 mas. The epochs consist of observations chosen to have sufficient *uv*-coverage for imaging yet close enough in time to prevent severe temporal smearing from the inner binary motion.

Overview of Observations

Observations were performed in service mode using PIONIER in `GRISM_H` mode on the Auxiliary Telescopes (ATs). Concatenations were performed with `CAL-SCI-CAL-SCI-CAL` or `CAL-SCI-CAL` pointing order of the observation blocks (OBs). Reduction of a single pointing (see the "Release Notes" section below) delivers 36 squared visibility (VIS2) and 24 closure phase (T3PHI) measurements in *H*-band (~1.5-1.8 micron; 6 channels; R~30) per science pointing. The observations span July 2019-February 2022 (P103-P108). Data is provided in the OIFITS1 format ([Pauls et al. 2005, PASP, 117, 1255](https://ui.adsabs.harvard.edu/)), constituting fully reduced pointings of the science targets (one file per pointing). Specifically, we present PIONIER imaging epochs for 8 post-AGB binary systems (See the "Release Content" section below for more details). The epochs were chosen to have sufficient *uv*-coverage for imaging yet short enough in total imaging time to prevent temporal smearing from the binary.
Here, we provide a plot of the resulting spatial frequency coverage of the selected observations:

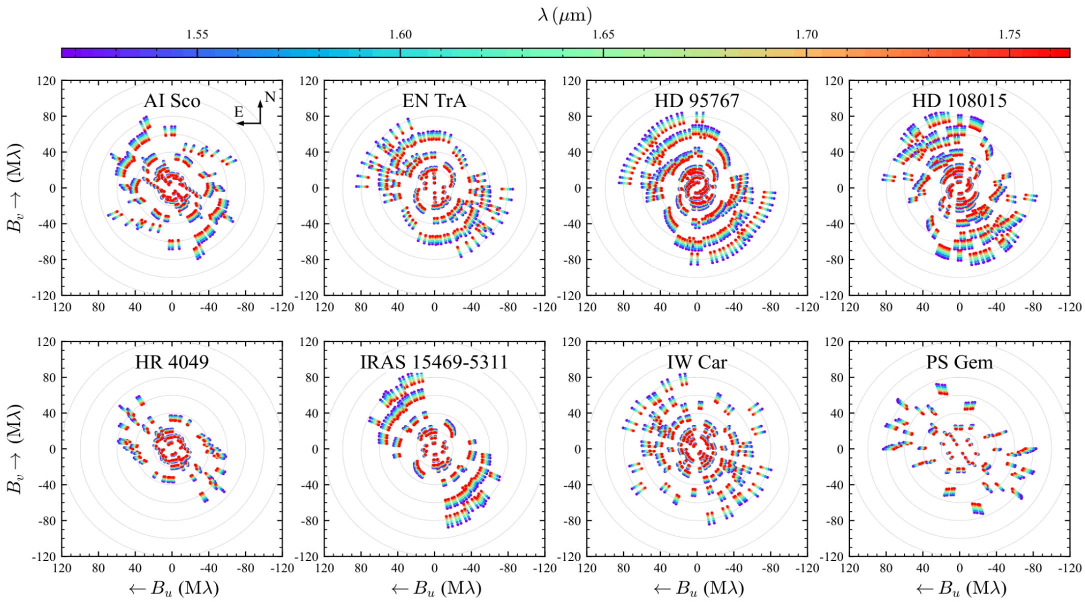

Fig 1: Spatial frequency coverage of the selected imaging epoch observations for each post-AGB binary science target.

Release Content

The data are provided as fully reduced and calibrated OIFITS1 files ([Pauls et al. 2005, PASP, 117, 1255](#)) of the science targets, with one file per science target pointing. Each file includes fully calibrated VIS2 and T3PHI observables, stored in the `OI_VIS2` and `OI_T3` header-data units (HDUs). Please note this release contains only calibrated science OIFITS files. Raw interferograms and calibration exposures or intermediate pipeline products are not included.
Below, we provide an overview table, summarizing for each science target their positions (J2000 RA and Dec), the number of pointings #P, MJD timespan of the selected observations, used baseline configurations, the median observing conditions (median for seeing, airmass M, atmospheric coherence time Tau0), the amount of VIS2 and T3PHI data collected (#VIS2 & #T3PHI, excluding pipeline-flagged data as specified by the `FLAG` column in the `OI_VIS2` and `OI_T3` HDUs), median VIS2 SNR and T3PHI error and used calibrator targets:

Table 1: Summary of observations in this data release ordered per science targets. See the text above for a description of the columns.

Target	J2000 RA / DEC (deg)	#P	MJD timespan	AT configs	M	Seeing (")	Tau0 (ms)	#VIS2 / #T3PHI	VIS2 SNR	T3PHI ERR (deg)	Calibrators (HD ID)
AI Sco	269.077408 / -33.812021	28	58693.04 - 58726.15	A0-B2-D0-C1; K0-G2-D0-J3; A0-G1-J2-K0; A0-G1-J2-J3	1.15	0.7	3.6	1008 / 672	24	0.9	HD 162238; HD 164745; HD 165490; HD 163603; HD 164088; HD 161119
EN TrA	224.252854 / -68.839693	20	59267.21 - 59295.36	K0-G2-D0-J3; A0-G1-J2-J3; A0-B2-D0-C1; K0-B2-D0-J3	1.45	0.6	7.4	712 / 477	33	1.2	HD 126908; HD 127454; HD 130424; HD 131648; HD 131742
HD 95767	165.517981 / -62.161898	36	59577.23 - 59616.32	A0-G1-J2-J3; K0-G2-D0-J3; A0-B2-D0-C1; A0-G2-D0-J3	1.38	0.6	7.0	1296 / 864	33	1.1	HD 90246; HD 94186; HD 95946; HD 97744; HD 94130; HD 98513
HD 108015	186.222931 / -47.152083	35	59576.31 - 59621.29	A0-G1-J2-K0; A0-G1-J2-J3; K0-G2-D0-J3; A0-B2-D0-C1; A0-G2-D0-J3	1.35	0.6	8.0	1260 / 840	35	1.1	HD 107186; HD 108952; HD 109323; HD 106441; HD 107916; HD 108497
HR 4049	154.531624 / -28.991998	19	58884.20 - 58899.29	A0-B2-D0-C1; K0-B2-D0-J3; K0-G2-D0-J3	1.20	0.75	4.8	684 / 456	31	0.4	HD 87659; HD 88287; HD 86830; HD 86712; HD 87019; HD 91249
IRAS 15469-5311	237.682520 ; -53.345348	20	59266.36 - 59296.39	A0-B2-D0-C1; K0-B2-D0-J3; K0-G2-D0-J3	1.20	0.63	5.0	720 / 480	29	1.0	HD 140805; HD 141150; HD 142133; HD 140094; HD 141391; HD 142450
IW Car	141.722098 / -63.630258	23	58812.25 - 58893.13	A0-G1-J2-K0; A0-G1-J2-J3; K0-G2-D0-J3; A0-B2-D0-C1	1.35	0.55	7.3	828 / 552	42	0.5	HD 80694; HD 82369; HD 82934; HD 78790; HD 81280; HD 88210
PS Gem	105.915127 / +10.770296	12	58817.33 - 58928.02	A0-G1-J2-K0; K0-G2-D0-J3; A0-G1-J2-J3; A0-B2-D0-C1	1.30	0.60	8.1	432 / 288	37	0.7	HD 50888; HD 54380; HD 57628; HD 48552; HD 48885; HD 50726

Release Notes

The data for this release were reduced automatically at L'Institut de Planétologie et d'Astrophysique de Grenoble (IPAG; efforts led by Jean-Baptiste Le Bouquin). IPAG automatically reduces the PIONIER data using the standard PNDRS pipeline (Le Bouquin et al. 2011, A&A, 535, A67; available from the corresponding website of the JMMC interferometry centre). The observables are calibrated for the transfer function using dedicated calibrator observations of stars with known diameter in the observed concatenations (using their diameter values from the JSDC catalogue; Lafrasse et al. 2010, Proceedings of the SPIE, 7734, 4E). All reduced and calibrated INSPIRING large programme PIONIER data for the targets discussed in this data release were downloaded from the JMMC's Optical interferometry Database (OiDB, available on the corresponding JMMC website). The data reduction procedure, calibration and further selection are discussed in greater detail below.

Data Reduction and Calibration

The data were automatically reduced by IPAG using the PNDRS pipeline (v3.86 and v3.94, depending on the contemporaneous version available at IPAG). The PNDRS data reduction and calibration of the raw observations proceeds in two steps:

1) *Data reduction:* Raw PIONIER data consists of interferometric fringe scans of both science and calibration targets, with 24 scan outputs from the combiner (6 baselines using an ABCD recombination scheme). The scans are corrected using associated calibrations including dark frames (taken once per OB), kappa matrices (observations with one shutter open at a time to correct for flux-splitting ratios in the beam combiner; taken once per concatenation) and wavelength calibration (taken using the internal calibration unit). The complex visibilities for the 6 baselines are extracted from the corrected scans using a Fourier transform. The VIS2 observables are then derived from the visibility power spectrum, and the T3PHI observables from the visibility triple product over closed baseline triangles. These observables are not yet corrected for the overall atmospheric + instrumental transfer function. For this, the `pndrsReduce` script was used.
2) *Observables calibration:* To be science ready, the observables must be corrected for the transfer function. For this, the transfer function is derived from comparison of the observed VIS2 and T3PHI values of the calibrator targets to the expected values from their known geometry (uniform discs of a given angular diameter, given in this case by the JSDC catalogue values; Lafrasse et al. 2010, Proceedings of the SPIE, 7734, 4E). The transfer function is interpolated in time to the time of science target observation. For this, the PNDRS `pndrsCalibrate` script was used on the individual concatenations (normally PNDRS tries to use calibrators observed throughout the entire night to calculate the transfer function at any given time).

Data Quality

During further manual filtering of the data by the INSPIRING team, any observations showing a less than optimal ESO quality control grade (i.e. grade B or C) were visually checked for any obvious problems with fringe tracking or transfer function stability. Any such observations that still presented good quality data on > 4 baseline pairs were kept. For example, some observations were graded as poor due to *uv*-plane overlap with previous observations while still being of excellent quality. Finally, to avoid time-smearing of the image features, observations were carefully selected within the smallest possible time window (<~ 10% of the binary orbital period) that still provided adequate spatial frequency coverage for imaging. Note that some data in the files might still be of dubious quality, as indicated in the `FLAG` column of the `OI_VIS2` and `OI_T3` OIFITS HDUs. The user should filter out these data before proceeding with any further scientific analysis (as was done in the first publication presenting these data, mentioned below in the "Acknowledgements" section).

Known issues

- Science target visibility calibration relies on reliable diameters of the calibrator stars. If the diameter estimates are incorrect or the target is not well-approximated as a single uniform disc (e.g. due to binarity), the science target visibilities of the science targets will be biased. While we did not find any obvious signs of bad calibrators used in the reduction of this data so far, the user should still be mindful of this fact.

- Some data in the files might still be of insufficient quality, as indicated by the `FLAG` column of the `OI_VIS2` and `OI_T3` OIFITS HDUs. The user should filter out these data before proceeding with any further scientific analysis
- It is known that formal errors on reduced PIONIER data can be underestimated (as mentioned on the PIONIER overview website) due to missing systematic calibration uncertainties (e.g. due to differences in total transfer function due to the small isoplanatic angle in *H*-band relative to angular separations between calibrator and science targets). While these were not accounted for, the user should remain mindful of this, and might consider placing floors or add an additional error term (ideally modelled using e.g. some reasonable prior range in Bayesian inference) on the formal errorbars returned by PNDRS during their modelling.
- Calibration uncertainties can induce correlations between the observables, which are currently not included in the final data products (though some previous publications, such as Lachaume et al. 2019, MNRAS, 484, 2656 try to address this).

Data Format

Files Types

The science target data files are provided in standard OIFITS1 format (Pauls et al. 2005, PASP, 117, 1255), though the primary header, in contrast to the data HDUs, are also OIFITS2 compatible (Duvert et al. 2017, A&A, 597, A8). The files are named e.g. “PIONI.2019-07-29T00:58:09.649_oidataCalibrated.fits”, simply based on the corresponding observing date in UT time.
In addition, we provide ancillary figures to assess the transfer function stability in PDF files named e.g. “2019-07-28_TF_vis2_setup01_bin03.pdf”. These PDFs are named after the night of the observation, the type of observable (‘vis2’ or ‘t3phi'), the chronological order of the used instrument setup throughout the night (i.e. if two different setups were used that night, there will correspondingly be both ‘*setup01*’ and ’*setup02*’ files), and the wavelength channel bin corresponding to the displayed transfer function.
File sizes are typically less than 100 Kbyte for the OIFITS files and less than 10 Kbyte for the associated transfer function PDFs.

Acknowledgements

When using this data, please acknowledge the publication by the INSPIRING team in which they were first analysed: De Prins et al. 2026. This article presents image reconstructions for all targets using the data selected for this INSPIRING data release.

According to the Data Access Policy for ESO data held in the ESO Science Archive Facility, all users are required to acknowledge the source of the data with appropriate citation in their publications.

Since processed data downloaded from the ESO Archive are assigned Digital Object Identifiers (DOIs), the following statement must be included in all publications making use of them:

- *Based on data obtained from the ESO Science Archive Facility with DOI: https://doi.org/10.18727/archive/113*

Publications making use of data which have been assigned an archive request number (of the form XXXXXX) must include the following statement in a footnote or in the acknowledgement:

- *Based on data obtained from the ESO Science Archive Facility under request number <request_number>.*