Extended dust emission around nearby Asymptotic Giant Branch stars

Thavisha Dharmawardena
(Ph.D Student)
Academia Sinica Institute of Astronomy and Astrophysics
JCMT User Meeting – Nanjing 13/02/2017
Asymptotic Giant Branch (AGB) Stars

Schematic view of an AGB star - extended version: (by J. Hron) http://www.univie.ac.at/agb/agbdetail.html

from: http://www.aip.de/en/research/research-area-ea/research-groups-and-projects/4most/science
What makes AGB stars and their winds important to Galaxies?
Long overdue need for a study of nearby AGB stars

- The Herschel Mass-loss of Evolved StarS (MESS) survey - extended emission for nearby AGB stars up to radii ~1′-2′ at 70 µm and 160 µm (Cox et al., 2012) using the PACS instrument.

- Most sub-mm observations for AGB star - often limited to central position pointings - lacking spatial information.

- JCMT can overcome this - low resolution large scale maps.

- SCUBA2: Study thermal dust component of the stellar winds.
  850 µm beam size – 13″
  450 µm beam size – 7.9″

- Combined with the Herschel PACS maps - derive dust mass loss histories.

Herchel MESS observations. Left: PACS 70 µm, Right: PACS 160 µm (right). Cox et al., 2012.
Target selection for JCMT – SCUBA2 observations

- Observed in MESS survey
- Relatively nearby sources (within 500 pc)
- Spatially resolved - study dust mass loss and circumstellar envelope structure
- Strong CO lines

Selected targets - 15

- C – rich: 1
- O – rich: 14
Thermal dust mass loss rates

- MESS survey maps using Herschel PACS at 70 µm and 160 µm.
- SCUBA2 Thermal dust emission maps at 450 µm and 850 µm.

CIT 6

PACS 70µm
(1pix = 1.6 arcsec)

PACS 160µm
(1pix = 3.2 arcsec)
Thermal dust mass loss rates

- MESS survey maps using Herschel PACS at 70 µm and 160 µm.
- SCUBA2 Thermal dust emission maps at 450 µm and 850 µm.
• APEX - LABOCA observations at 870 μm of several southern AGB stars showed extended emissions up to FWHM of ~20″-25″ (Ladjal et al., 2010).

• Similar wavelengths to SCUBA2 – good comparison.

• Look deeper into the SCUBA2 observations.

• Generate radial profiles of surface brightness vs. radius at each wavelength for the SCUBA2 and PACS observations.
CIT 6 – PACS 160 µm

- Characteristic (Peak) Extension: 9.6°
- Maximum (3σ detection) Extension: 41.6°
- Total Flux: 24.02 Jy
- Flux within Central Region (PSF): 10.82 Jy
- Flux within Extended Region: 13.20 Jy (~50% of the Total Flux)

CIT 6 – PACS 70 µm

- Characteristic (Peak) Extension: 4.8°
- Maximum (3σ detection) Extension: 84.8°
- Total Flux: 142.91 Jy
- Flux within Central Region (PSF): 75.62 Jy
- Flux within Extended Region: 67.27 Jy (~50% of the Total Flux)
CIT 6 – SCUBA2 850 μm

- Characteristic (Peak) Extension – 8''
- Maximum (3σ detection) Extension – 44''
- Total Flux – 927.63 mJy
- Flux within Central Region (PSF) – 536.19 mJy
- Flux within Extended Region – 391.44 mJy (~40% of the Total Flux)

CIT 6 – SCUBA2 450 μm

- Characteristic (Peak) Extension – 8''
- Maximum (3σ detection) Extension – 12''
- Total Flux – 1767.76 mJy
- Flux within Central Region (PSF) – 1039.88 mJy
- Flux within Extended Region – 727.88 mJy (~40% of the Total Flux)
Ongoing - Fitting SEDs

- Combine data from all four wavelengths:
  - SCUBA2 850 μm, 450 μm and PACS 160 μm, 70 μm.

CIT 6 – Total flux comparison at the four wavelengths
• Fit a 4 point SED to a modified blackbody at each radial point.

• Determine Dust Temperature ($T_{\text{dust}}$), Spectral Index of the Dust Emissivity ($\beta$) and the Dust Mass ($M_{\text{dust}}$) (Gordon et al., 2010 methods).

\[
F_{\nu} \propto \lambda^{-\beta} B_{\nu}(T_{\text{dust}}).
\]

\[
M_{\text{dust}} = \frac{4}{3} \frac{a \rho d^2}{Q_{\text{em}}(160)} \frac{F_{160}}{B_{\nu}(T_{\text{dust}})}
\]

Form of modified black body. (Gordon et al., 2010)

Dust Mass (a – grain radius). (Gordon et al., 2010)
The Nearby Evolved Star Survey – NESS

- Extend this study to a volume limited (300 pc) sample of AGB stars.

- Multi telescope data
  - JCMT – SCUB2 and HARP - S17A + 17B
  - APEX
  - SMA
  - ALMA

HARP observation of U Ant obtained in semester 17A as part of the NESS project
Summary

• We observe extended emission in a sample of 15 AGB stars using JCMT - SCUBA2 (450 μm and 850 μm) and Herschel PACS (70 μm and 160 μm) observations.

• Maximum extension with 3σ detection for SCUBA2 850 μm observations ~40 μas.

• Flux within the extended region up to ~40% for SCUBA2 observations and ~50% for PACS observations.

• Ongoing work – Fitting SEDs at each individual radial point and deriving radially dependent dust temperature, mass and beta profiles.