Why Galaxies Care About AGB Stars:
A Continuing Challenge through Cosmic Time
Proceedings IAU Symposium No. 343, 2019
F. Kerschbaum, M. Groenewegen & H. Olofsson, eds.

doi:10.1017/S1743921318006981

Stacking analysis of HERITAGE data to statistically study far-IR dust emission from evolved stars

Thavisha E. Dharmawardena[1,2], Francisca Kemper[1], Sundar Srinivasan[1], Sacha Hony[3], Olivia Jones[4] and Peter Scicluna[1]

[1]Academia Sinica Institute of Astronomy and Astrophysics, 11F of AS/NTU Astronomy-Mathematics Building, No.1, Sect. 4, Roosevelt Rd, Taipei 10617, Taiwan, R.O.C.

[2]Graduate Institute of Astronomy, National Central University, 300 Zhongda Road, Zhongli 32001, Taoyuan, Taiwan, R.O.C.
email: tdharmawardena@asiaa.sinica.edu.tw

[3]Heidelberg University, Center for Astronomy, Institute of Theoretical Astrophysics, Albert-Ueberle-Str. 2, 69120 Heidelberg, Germany

[4]UK Astronomy Technology Centre, Royal Observatory, Blackford Hill View, Edinburgh EH9 3HJ, UK

Abstract. We aim to analyse the co-added Herschel images of various categories of evolved stars in the LMC and SMC from the Herschel HERITAGE survey in order to identify, in a statistical sense, a cool historic dust mass component emitted by these sources. The fluxes derived from the co-added stacks can then be compared with those predicted by the GRAMS model grid in order to refine the DPRs estimated for the SMC and LMC.

Keywords. stars: AGB and post-AGB - galaxies: Magellanic Clouds - stars: mass-loss

1. Introduction

By fitting mid-IR SEDs of evolved stars in the Small Magellanic Cloud (SMC) and Large Magellanic Cloud (LMC) using the Grid of RSG and AGB ModelS (GRAMS) radiative transfer model grid, Riebel *et al.* (2012) and Srinivasan *et al.* (2016) estimated the dust budgets in the Magellanic clouds. However this method is primarily sensitive to the present day mass-loss rate and may not have taken into account a cooler older dust component visible only at longer, far-IR and sub-mm wavelengths.

Although emission from cool historic mass-loss will peak at Herschel wavelengths (Boyer *et al.* 2012), confusion caused by Interstellar Medium (ISM) background emission and limited spatial resolution makes it extremely difficult to detect it. Jones *et al.* (2015) only found 35 Herschel point source counter parts to the tens-of thousand evolved stars identified by Spitzer.

2. Stacking Analysis Methods

We revisit the Herschel HERITAGE data (Meixner *et al.* (2013)) in order to determine the presence of the cooler dust component in a statistical sense. In order to achieve this, we utilize a stacking and co-adding method of postage stamp size cutouts ($\sim 2' \times 2'$) of the Herschel HERITAGE maps of the SMC and LMC. By co-adding and averaging a stack

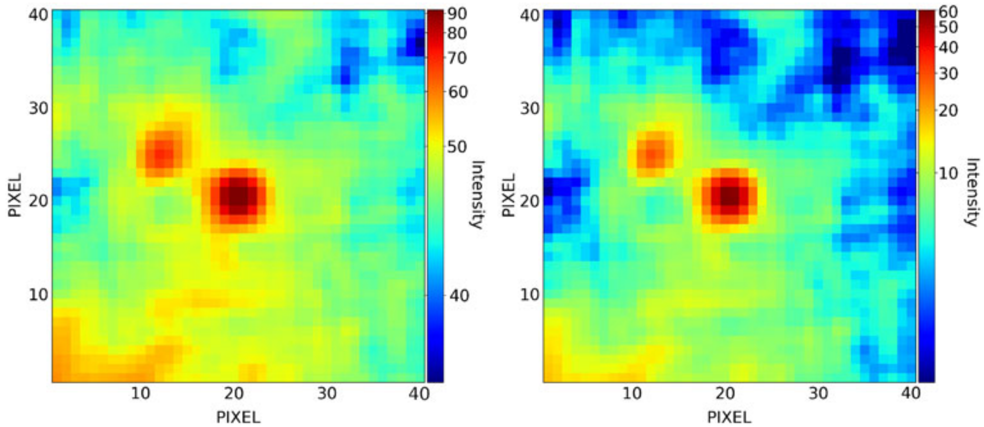

Figure 1. Left: PACS 160 μm stack of LMC Evolved stars from Jones *et al.* (2015); Right: same as left with a background annulus subtracted. The bright central source is our stacked emission. The bright source centred at pixel (12,25) to the top left of our source is a bright background emission source found in a few frames.

of sources we reduce the noise by $\sim\sqrt{No.\,of Observation}$, allowing us to detect fainter emission as the contrast improves. This method is more commonly used in extragalactic observations, and will allow us to improve the signal-to-noise of the cold dust emission. We divide the sample into sub-categories based on multiple parameters which can then be individually co-added and stacked. The stacks can be divided into subcategories, e.g. chemistry (C-rich, O-rich, S-type), mass-loss rates, initial mass (AGB, RSG), evolutionary state (E-AGB, TP-AGB, X-AGB).

The mean photometric fluxes derived from the co-added stack of each parameter will then be compared to the co-added fluxes predicted by GRAMS in order to identify the presence of the cold historic mass-loss component.

3. Preliminary Results and Future Work

Initial experiments have shown that confusion with background emission is currently the limiting part of the analysis. Co-addition of the 28 high mass-losing sources identified by Jones *et al.* (2015) show that while we enhance the source we also enhance the ISM background emission, which in the case of the LMC has significant structure (see Fig. 1, left). Subtracting using backgrounds estimated in an annulus centered at the source enhances the source significantly, however, there is still bright background structure, which affects the signal of the stacked source (see Fig. 1, right). Therefore we require a more complex background subtraction method such as polynomial subtraction to help remove the large scale structure.

Once we are able to successfully separate the stacked source from the background we will then be able to obtain accurate fluxes and hence refine the dust budget estimates determined for the sample by Riebel *et al.* (2012) and Srinivasan *et al.* (2016). The derived SED of the cold dust component can then be applied to analyse and adjust the average DPRs in the sample and thus the Magellanic clouds as a whole.

References

Boyer, M. L., Srinivasan, S., Riebel, D., *et al.* 2012, *ApJ*, 748, 40
Jones, O. C., Meixner, M., Sargent, *et al.* 2015, *ApJ*, 811, 145
Meixner, M., Panuzzo, P., Roman-Duval, J., *et al.* 2013, *AJ*, 146, 62
Riebel, D., Srinivasan, S., Sargent, B., and Meixner, M. 2012, *ApJ*, 753, 71
Srinivasan, S., Boyer, M. L., Kemper, F., *et al.* 2016, *MNRAS*, 457, 2814