Massive stars' nebulae, as seen through Herschel's eyes

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Introduction

Mass-loss rates recently decreased because of clumping considerations. In this context, short episodes of strong mass ejection, such as LBVs, appear more crucial than ever in the life of massive stars. We have examined a sample of ejection nebulae using Herschel Space Observatory. These detailed far-IR observations enable us to investigate the physical characteristics of these objects, with the aim of a better understanding of the mass ejection episodes.

These data were acquired within the MESS (Mass-loss from Evolved StarS) guaranteed time and cover 6 LBVs or LBV candidates (AG Car, HR Car, WRAY 15-751, G79.29+0.46, Hen 3-519, HD168625), two WRs (M1-67, NGC6888) and one O-star (HD148937). Here we will present results on WRAY 15-751.
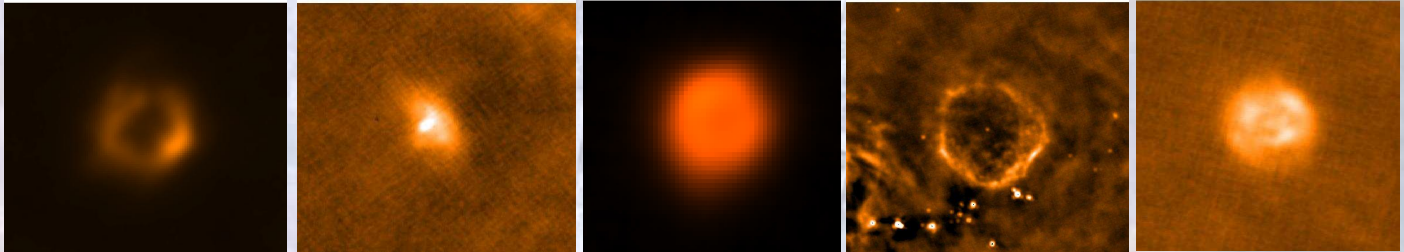

Fig. 1: Some LBV nebulae seen by Herschel at 100µm : AG Car, HR Car, WRAY 15-751, G79.29+0.46, Hen 3-519

A test case: WRAY 15-751 - Morphology

The MCS deconvolution technique was applied to the Herschel data. It reveals that the nebula around WRAY 15-751 has a ring shape, of 18" average radius and 12" width. The NE part being the brightest one.

To search for extended emission, we use the MADmap algorithm of the Herschel data reduction package. A faint, cool ellipsoidal shell, about 2' in size, is detected for the first time.
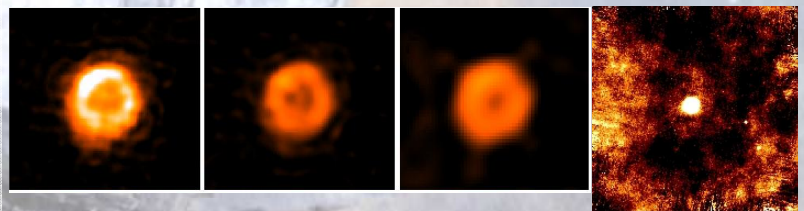

The environment of WRAY 15-751:

-3 panels to the left: deconvolved images at 70, 100 and 160µm (each image is 1' on each side)

- panel to the right: result from MADmap (image is 10' on each side)

A test case: WRAY 15-751 - Dust

Aperture photometry was performed on the PACS data, to get a good measurement of the nebular flux. We complemented these measurements by data taken with AKARI, ISO, and IRAS. We then fit the whole dataset using 2-Dust. At the time of AKARI and Herschel observations, the star was cooler and larger (320 Rsol, 9000K) than at the time of IRAS and ISO observations (80 Rsol, 18000K).

The dust emission can be well reproduced for both epochs if constant luminosity is assumed and Fe-rich dust grains (size 0.2-0.5µm) are assumed. The total dust mass in the nebula amounts to 0.045±0.005 Msol, and its temperature varies from 95K at the inner radius (7") to 66K at the outer radius (21"). For the outer shell, we find 0.03 Msol, assuming a similar dust model.
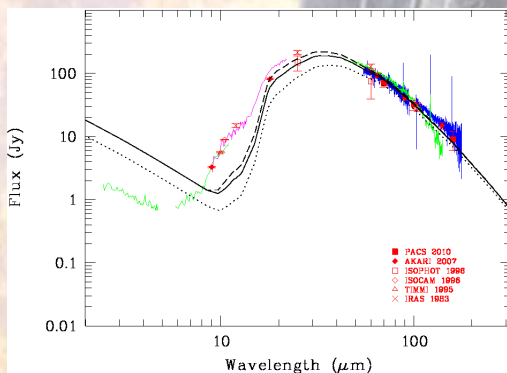
IR spectrum of WRAY 15-751 with the best fit to AKARI/Herschel data.

A test case: WRAY 15-751 - Gas spectrum

• gas density from [NII]122/205µm: n∼200/cm³

• ionizing flux: Q∼9 10^{46} ph/s

• strong EUV flux

• N/O = 1.0 ±0.3 (or 0.14 solar)

• 12+log(N/H)=8.5 ±0.9

• M(ionized gas) = 1.6-2.1 Msol
          for n(He)/n(H)=0.2-0.9 (Lamers et al. 2001)

• M(PDR)=0.05 Msol (using [CII] flux, solar carbon abundance, and the method of Goicoechea et al. 2004)
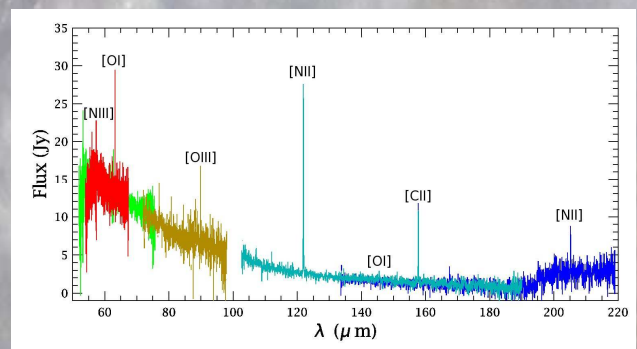
The emission lines from the HII region and the PDR are clearly seen in this PACS spectrum (central spaxel) of the WRAY 15-751 nebula.