Herschel Observations of V838 Mon

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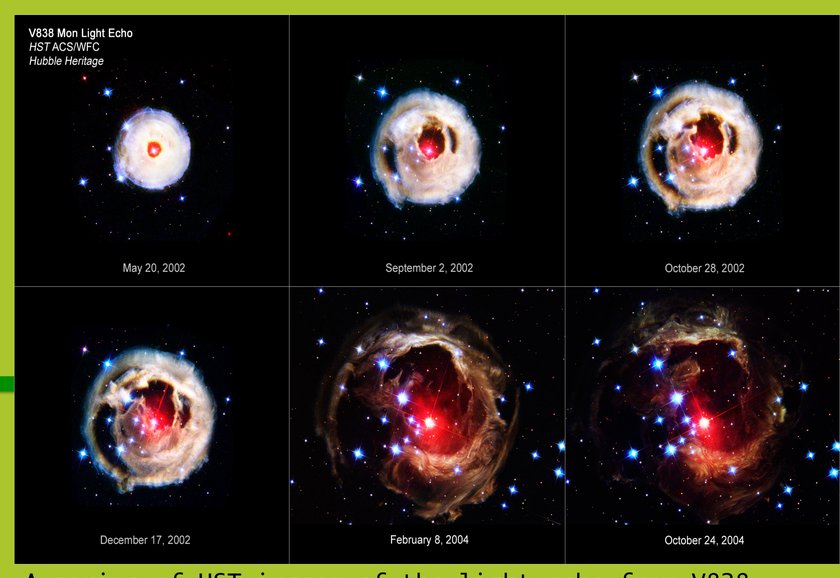
Background

V838 Mon is an enigmatic star indeed. It underwent a powerful eruptive outburst in 2002, increasing in luminosity by a factor of 100 over 3 months and changing spectral type: F...G...K...to a very cool M-giant and even an L-type supergiant. A spectacular evolving light echo was formed from the outburst light reflecting off the surrounding dust; this has been followed by the HST (see figure).

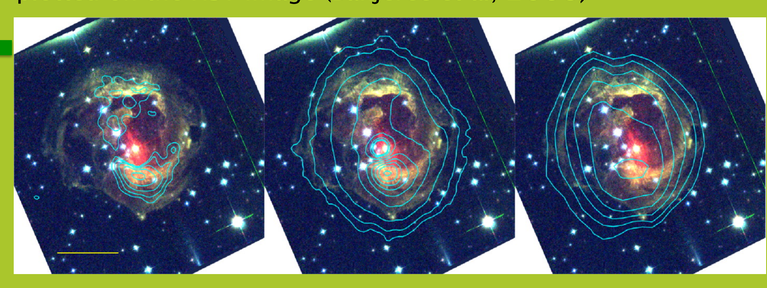
The exact nature of the outburst is unresolved: two prominent theories are a giant star engulfing a planetary system or a stellar merger (Retter & Maron '03; Soker & Tylenda, '03). The HST images show a very chaotic region; suggesting that outburst may not have been an isolated event (Bond et al, '03), although most estimates of the mass of dust exceed several $M_\odot$. But we still lack much basic knowledge of the origin and the physics from before, during and after the outburst. Kinematics from atomic and molecular lines show that the star has an outflow/wind, and also mass infall and may have developed a jet (Tylenda et al, '09). Did the stellar envelope expanded after the merger event and is now beginning to contract (Geballe et al, '07)? An increase in the IR magnitudes in 2007 indicate new dust was created--condensing out of the outflow around the star (Wisniewski et al, '08)? An IR "thermal" echo, spatially correlated with the HST light echo (see figure), is also seen: its dust mass is about $1M_\odot$ (Banjeree et al, '06).

We used Herschel to study the IR thermal echo, the newly created dust arising from the star itself, and the expanding/contracting stellar atmosphere. We obtained spectra from HIFI, PACS and SPIRE, and images from PACS and SPIRE. Here we present our work on some of these data.



A series of HST images of the light echo from V838 Mon

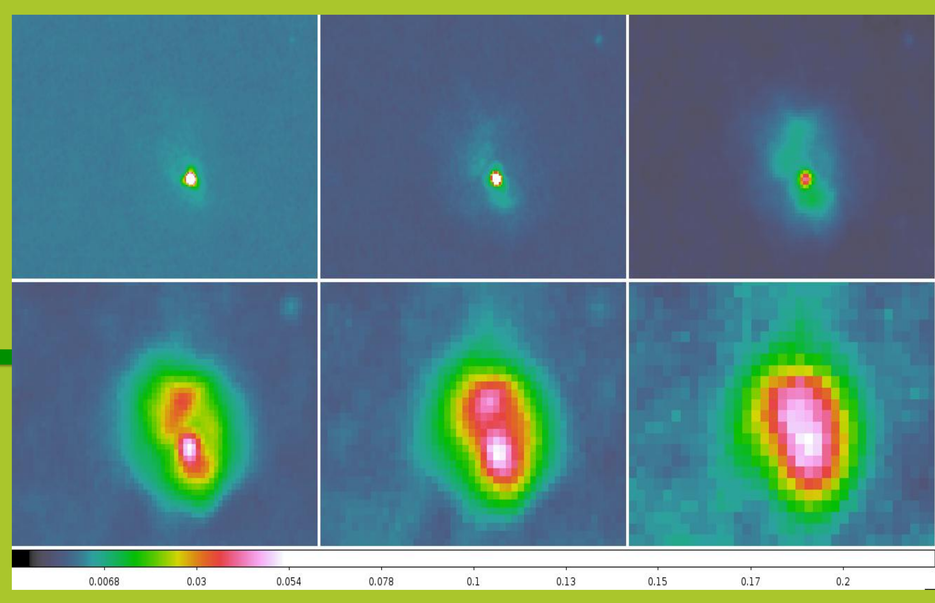
Spitzer 24, 70, and 160 μm (l to r) images in contour plotted on the HST image (Banjeree et al, 2006)



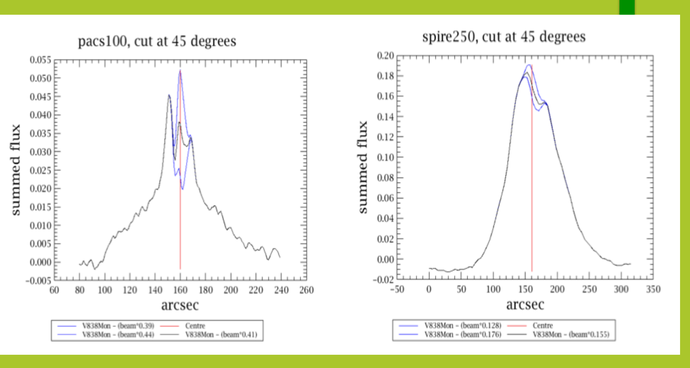
The PACS and SPIRE Images

We have 3 PACS and 3 SPIRE maps (see figure on right) showing a bright spot where the point source is located and extended emission which becomes increasingly significant with wavelength. In fact, the extended emission and the point source are so heavily blended in the SPIRE maps that separating the two is not a simple task. Point source subtraction, using a scaled beam, has been attempted but the results are still not satisfactory (see figure below). With this first attempt at point source subtraction we have estimated the fluxes of the point source and extended sources separately and fit the SEDs with a simple blackbody, finding a temperature of 56K and 20K for the star and for the extended emission respectively, and masses of 0.01 $M_\odot$ and $3M_\odot$.

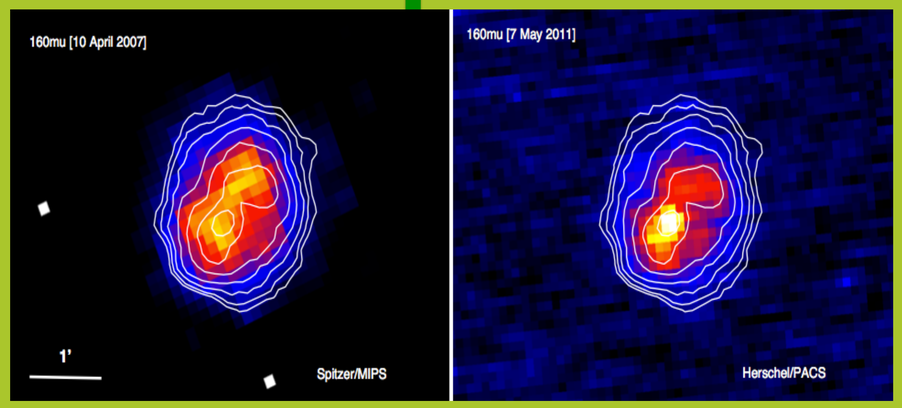
We can compare (figure lower right) our maps to those from Spitzer (PIs K. Su and N. Ashok): a cursory examination shows that the point source is relatively brighter at 160μm in 2011 (PACS) than in 2007 (Spitzer).



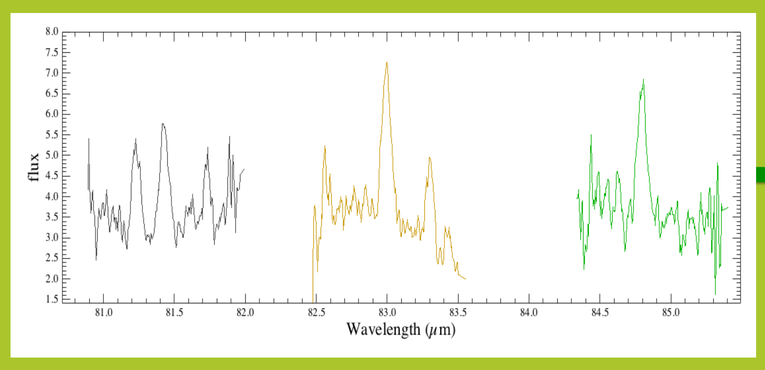
The PACS and SPIRE maps: from top left in clockwise direction: 70, 100, 160, 250, 350, and 500 μm.



Subtracting the scaled beam from our maps: at what point is the SPIRE beam fully subtracted?

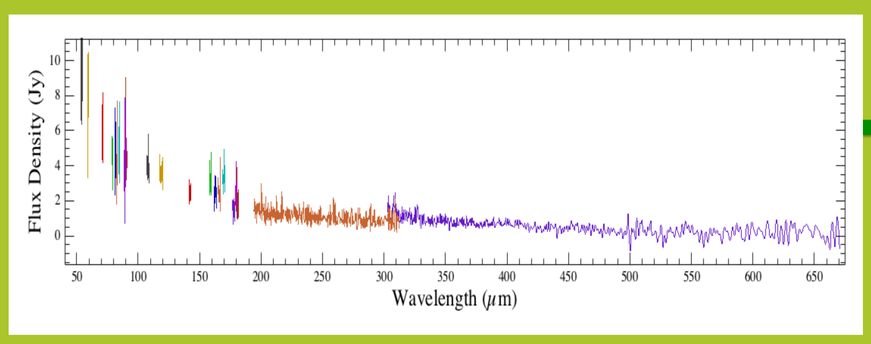


Spitzer map from 2007 at 160μm, compared to PACS map from 2011. Contours are from the SPIRE 250μm maps.



PACS spectrum. left: ^{12}CO, o-H_2O; middle: o-H_2O, p-H_2O; right o-H_2O

The PACS+SPIRE combined spectrum of V838 Mon



The PACS and SPIRE Spectra

The SPIRE spectra were taken as a single pointing on the star, in high spectral resolution mode. The PACS spectra were also taken as a single pointing, so we have a field-of-view of 45sq. arcsec covered by 25 spaxels, and we observed 20 spectral regions. For both sets of spectra, continuum from the extended emission around V838 Mon is probably present, but it is too faint to study. Continuum from the stellar source is also present, and in the PACS spectra emission lines of ortho and para water and CO are also detected. We extracted the point source spectra from the re-reduced SPIRE Level 2 product (testing the background subtraction). We reduced the PACS data with the background normalisation pipeline and modified the point-source flux-correction task to work for V838 Mon (due to the star not being located in the centre of the field-of-view, the standard task will not work on our data). These spectra are presented in the figure to the left.

In conclusion: more work to do, more results to come!