The Nature of the Herschel Clump Sources in the M16 Region and Ongoing Star Formation

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Abstract:

We present the results of point source extraction and analysis of multi-wavelength far-infrared imaging encompassing the M16 region using the PACS and SPIsRE instrument on board the Herschel Space Observatory. This has been done as part of the HOBYS Key Project (Motte et al, 2010) which used Herschel to image all OB-star forming areas within 3kpc of the Sun. Our analysis allows us to identify and characterize the earliest phases of intermediate and high-mass star formation and assess the importance of star formation triggers in regions containing high-mass star formation which include the famous "Fingers of God" pillars, the tips of which show cold cores. More detailed analysis of cold cores in the region is presented which show several hundred class 0 to class I sources. These are generally distinct from the kinds of sources observed by Spitzer with an age range going to down to the youngest sources and with a markedly different spatial distribution.
Emission clumps are seen both on and (more occasionally) off the large-scale filamentary structure seen throughout the region.

Introduction:

- ***Iconic star formation region with apparently induced star formation and strong pillars at approx. 2kpc distance.***
- ***Large-scale Herschel view previously studied by Hill et al (2012).***
- ***Class I sources identified by GLIMPSE/Spitzer studies of Indebetouw et al (2007) associated mainly with stellar cluster NGC 6611 which is in a cavity seen in both Spitzer 8μm and Herschel PACS/SPIRE images.***
- ***In this poster we present the results from the extraction of clump sources identified in the region in the submm bands of SPIRE. These are (generally) the coldest point sources and are expected to be associated with the youngest objects in the field.***
- ***We are able to to characterize the nature of the sources and provide specific modelling for sources found at the tips of the pillars.***
- ***We examine evidence for induced star formation and its characteristics.***

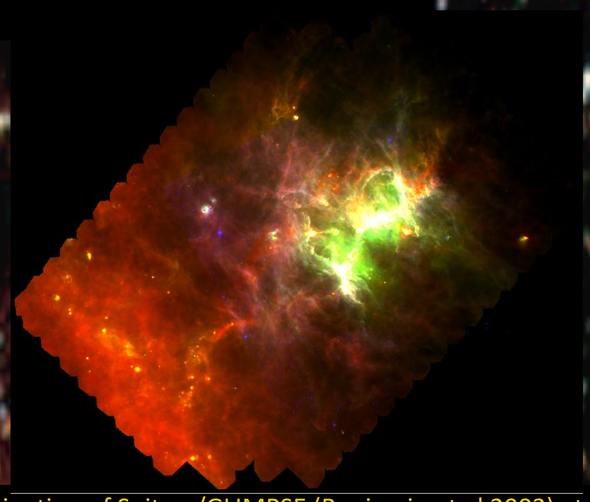

Fig. 1: Combination of Spitzer/GLIMPSE (Benjamin et al 2003) at 8 μm (blue), Herschel/PACS 70 μm (green) and Herschel/SPIRE 250μm (red). The 8 μm point bright sources are scattered across the field. Hot dust is noted in the cavity area around the cluster NGC6611 (also see Flagey et al 2011).

Fig. 2 – Distribution of Spitzer identified YSOs of class I and reddened class II sources (blue) and submm Herschel sources (green) – identified by the *getSources* program (Men'shchikov et al, 2012) – overlaid on Herschel 160μm image (from Hill et al 2012). Clear difference in distribution with class I sources interspersed within the NGC6611 stellar cluster. Herschel sources are confined more to the more filamentary structures seen in the field.

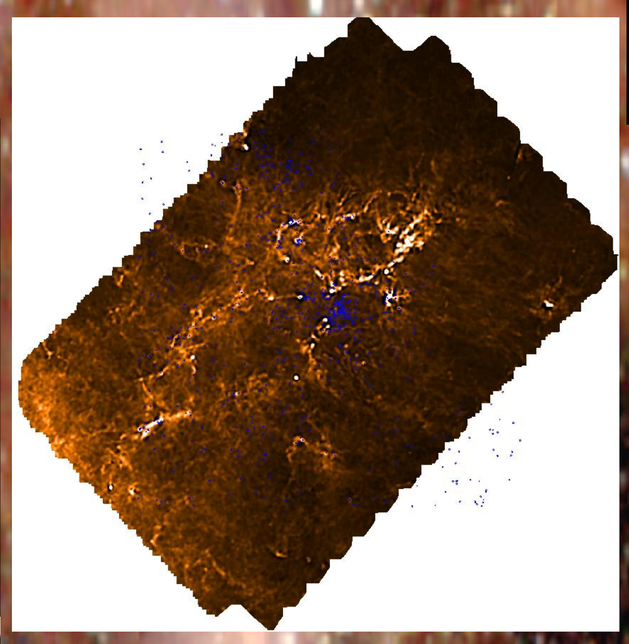

Fig. 3: The positions of class I and reddened class II YSOs (in blue) from GLIMPSE catalog data overlaid on an unsharp masked image of the column density image produced in Hill et al (2012). Colour criteria were taken from Megeath et al (2004).

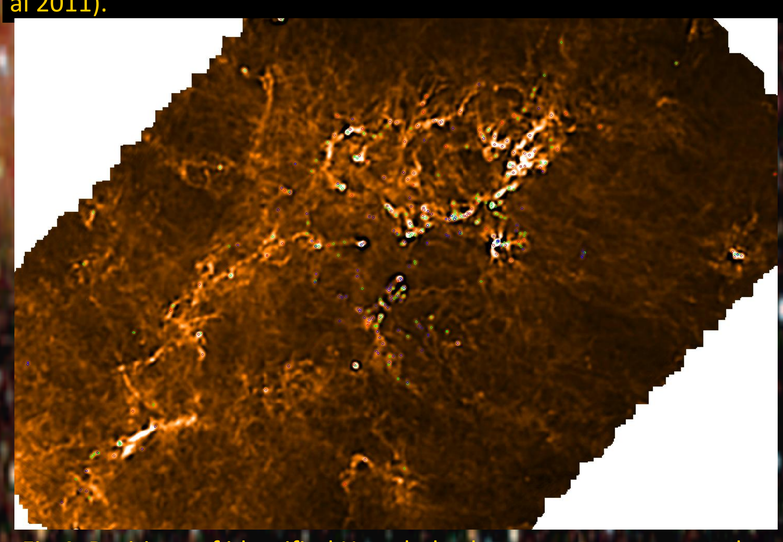

Fig 4: Positions of identified Herschel submm sources separated by class. Class 0 sources are shown in green ($L_{sub} > 0.03\ L_{bol}$), class 0/I sources are shown in blue ($0.01L_{bol} < L_{sub} < 0.03L_{bol}$) while class I sources are shown in red ($L_{sub} < 0.01L_{bol}$) – following Motte et al (2010). Where L_{sub} is the submm luminosity beyond 350μm and L_{bol} is the bolometric luminosity.

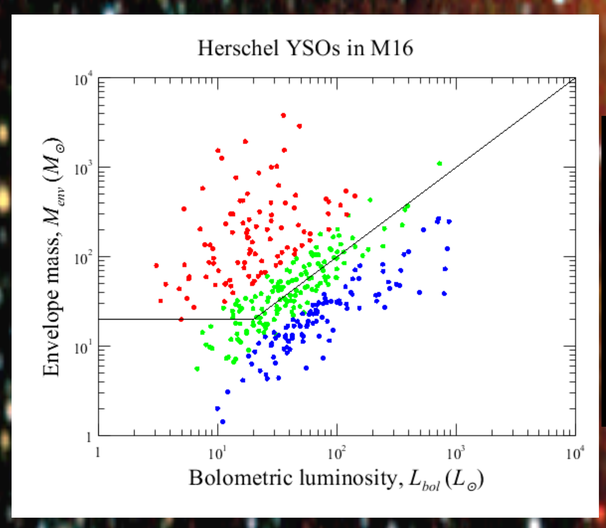

Fig.5: Figure showing the Luminosity versus envelope mass for the 366 detected sources based on the integrated luminosity of a 5-colour PACS-SPIRE SED single dust dust temperature fit. Class 0 sources (red; $L_{sub} > 0.03L_{bol}$), Class 0/I sources (green; $0.01L_{bol} < L_{sub} < 0.03L_{bol}$) and Class I sources (blue; $L_{sub} < 0.01L_{bol}$). The points in the upper left hand corner above the two solid lines correspond to sources as defined by Reid et al. (2010) as massive cold cores ($M > 20\ M_\odot$) having $L/M < 1$

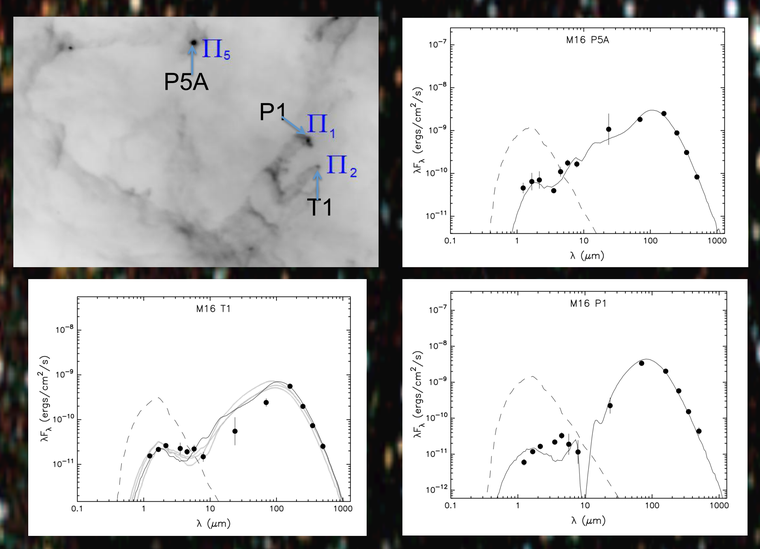

Fig. 6: Grayscale showing the 70μm image of the M16 pillars region. Strong sources are noted in all bands at the peaks of the pillars Π_1, Π_2 and Π_5. Source fits using the models of Robitaille et al (2007) provide.SEDs that are dominated by envelopes (best fits [solid lines] P1; $M_{env} = 62M_\odot$ and luminosity = 646 $L_\odot$ – P5A; $M_{env} = 461M_\odot$ and luminosity = 441 $L_\odot$ -- T1; $M_{env} = 100M_\odot$ and luminosity 202 $L_\odot$ – dotted lines show unobscured stellar photosphere. Source nomenclature from Indebetouw et al, 2007).

Results and Preliminary Conclusions:

- **366 sources found with strong confidence in SPIRE submm data for M16. Sources distinctly different in nature and position form Spitzer detected YSOs in the region.**
- **Sources are class 0 to I. All class 0 sources are within density filaments. More dispersion away from filamentary structure in going to class I sources.**
- **Timeline evident with NGC6611 cluster sources in cavity, around which are younger objects forming within the filaments formulated by the cluster winds.**
- **Strong sources at the tips of the pillars of M16 show SEDs of class 0/I and class I sources suggesting they are intermediate between NGC6611 sources and filament sources – SF has passed by. Likely still accreting and suggest already 5-8 $M_\odot$ central stars.**

References:

Benjamin, R., et al, 2003, PASP, 115, 953; Flagey, N., et al, 2011, A&A, 531, 51; Hill, T., et al, 2012, A&A, 542, 114; Indebetouw et al, 2007, ApJ, 666, 321; Megeath, T. et al, 2004, ApJS, 154, 367; Men'shcikov, A., et al, 2012, A&A, 542, 81; Motte, F., et al, 2010, A&A, 518, L77; Reid, M., et al, 2010, ApJ, 719, 561; Robitaille, T., et al, 2007, AJ, 134, 2099