The massive young cluster in Mon R2

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Using data from the Herschel PACS and SPIRE instruments, we study the reflection nebulae association Monoceros R2. At the core of the region, we find a young massive (300–500 $M_\odot$) cluster in the process of formation within a dense hub of filamentary structures. High-resolution temperature and column density maps of the region are used to study the structure, while protostars and potential prestellar cores are identified and compared, leading to the conclusion that those within the central core form a separate population to those outside.

The Mon R2 Region

- An association of reflection nebulae.
- Lies about 830 pc away, midway between Canis Major OB1 and the Orion complex.
- Forms a chain, running east–west for about two degrees from tip to tip, with a shorter chain leading north from the western tip.
- The western tip itself contains the brightest reflection nebulae, and often the name “Mon R2” will refer to this region alone.

Herschel Observations

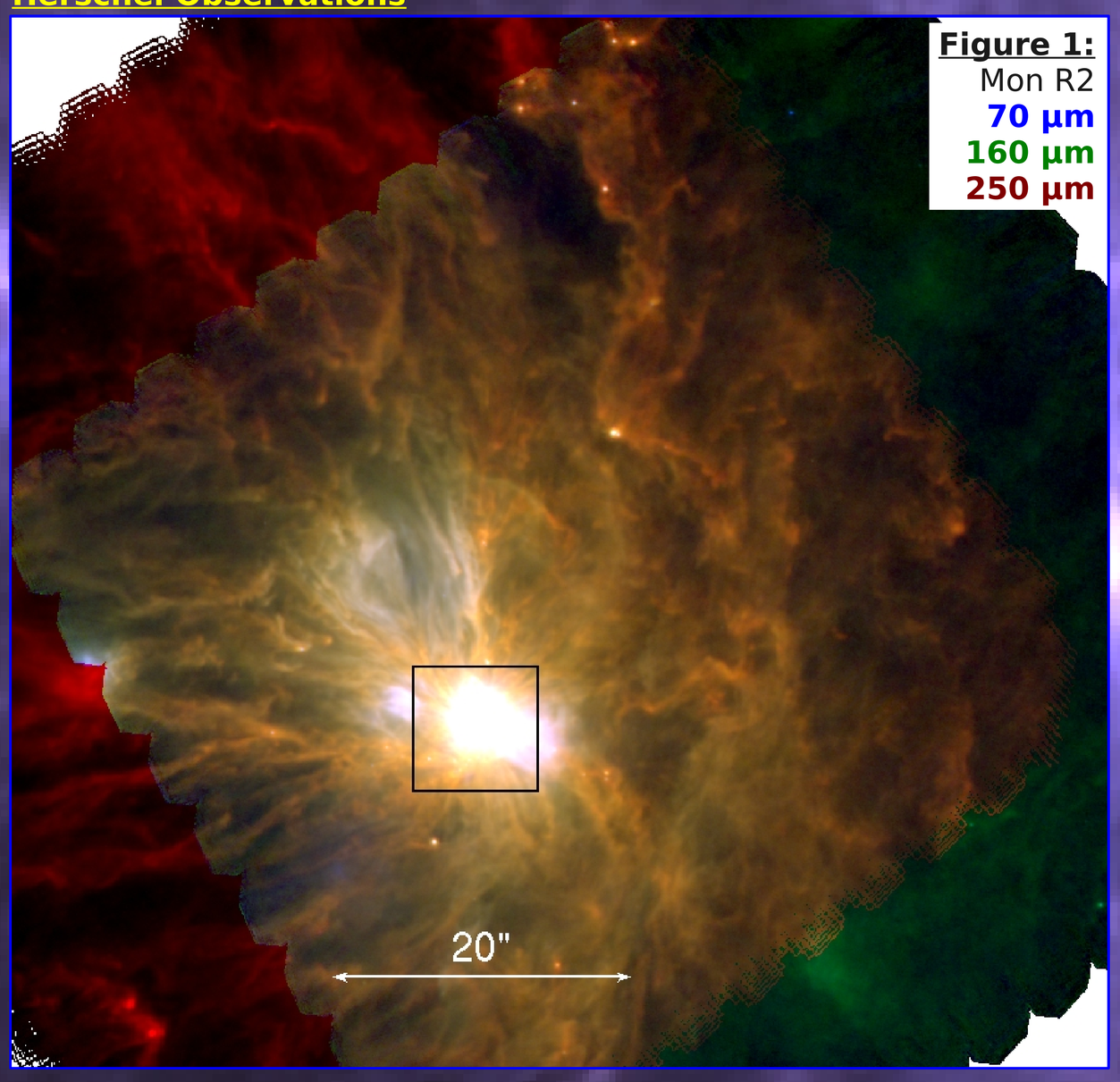

Figure 1: Mon R2
70 µm
160 µm
250 µm

- The western tip of Mon R2 contains a bright central core at the hub of several long filaments
- Several emitting sources exist outside the core, generally associated with the filaments
- A close-up of the central core (the region within the black box) is shown in Figure 2
- The central core exhibits great internal structure.
- The structure can be seen better in the column density and temperature maps, shown in Figure 3.
- These maps were made using the Herschel 160, 250, 350 and 500 µm observations, and show the same region as shown in Figure 2.
- While the column density map shows a similar structure as the flux maps, the temperature map shows a peak that is almost spherically symmetric.
- The combined shapes suggest a hotter, inner region, surrounded by a denser shell of material, probably a forming HII region.

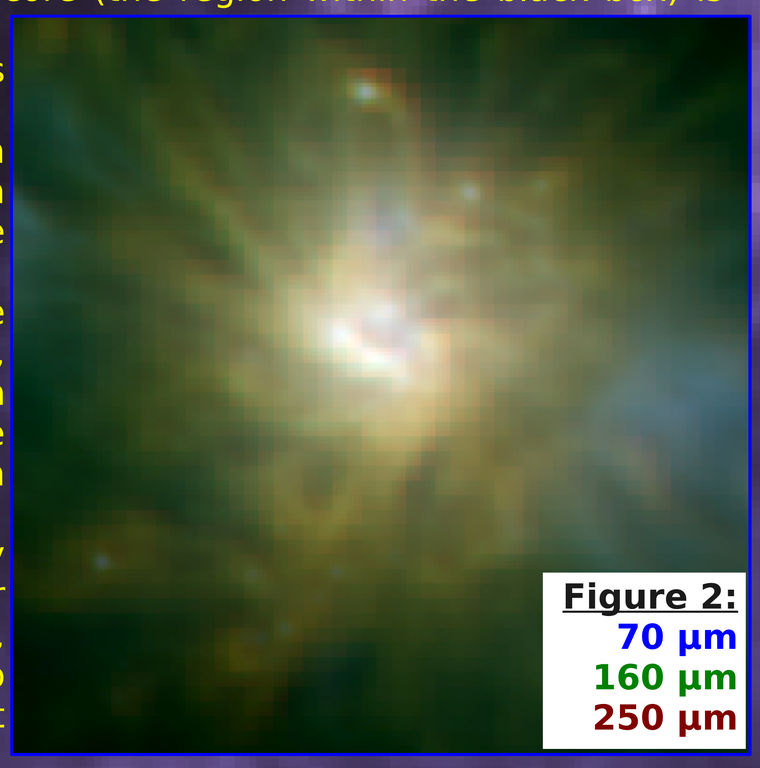

Figure 2:
70 µm
160 µm
250 µm

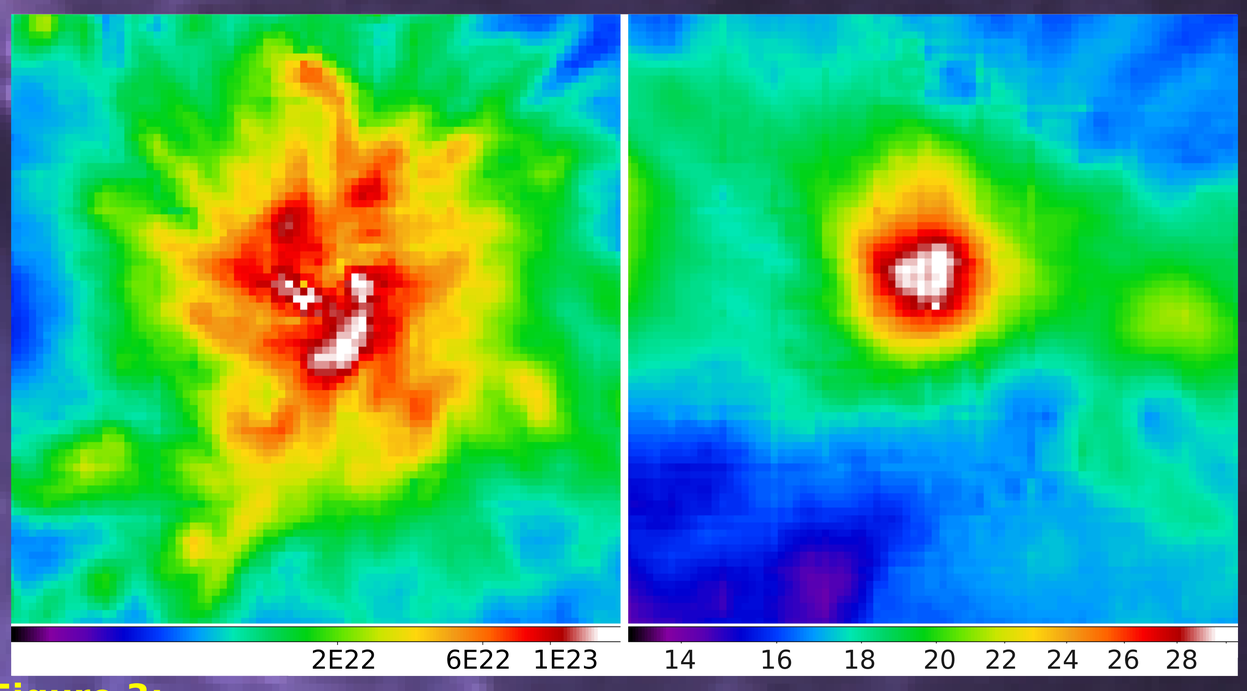

Figure 3:
- Mon R2 central core column density (left; in cm^{-2}) and temperature (right; in K) maps.

Source-finding

- Individual sources were detected using the getsources routine (see Men'shchikov et al. 2012).
- About 300 sources are detected in total, 100 in the central core.
- The sources have a mean temperature of 24 K and a mean mass of 6.0 $M_\odot$.
- The total mass of the cluster is between 300 and 600 $M_\odot$.
- Compared with those outside, the sources that are inside the central core are more luminous, so they are likely more fully evolved.

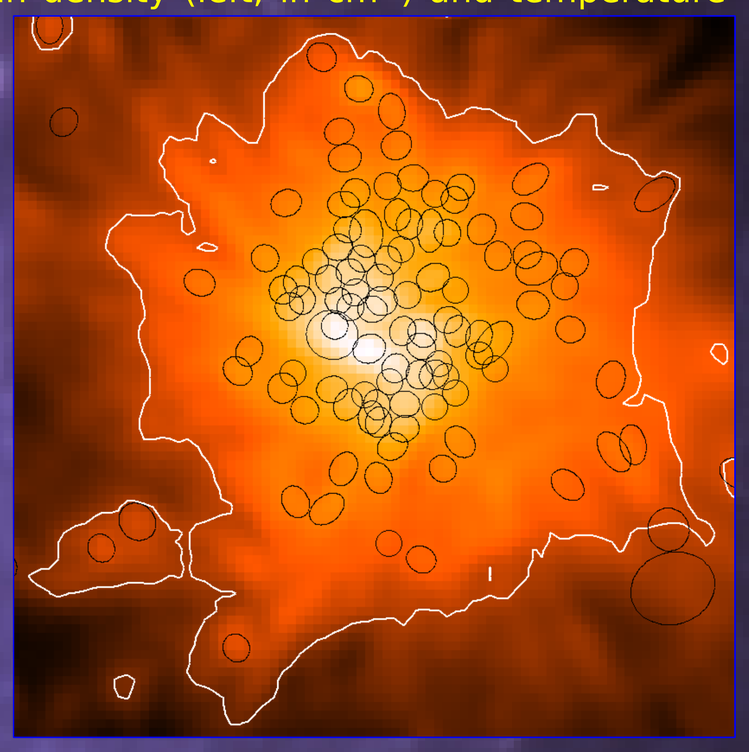

Figure 4:
Mon R2 central core with getsources source detections. The “central core” is the area within the central white contour.

Conclusions

- A bright submillimetre cluster of young and forming stars.
- The presence of a hot central region inside a denser shell is indicative of an HII region, and means that the cluster is likely to break free soon.
- About one hundred of the cluster's pre- and proto-stars are discernible (albeit only barely), with a total mass of up to 600 $M_\odot$.
- The central core sources form a separate population to those sources outside the core, having a much higher average luminosity for their mass.
- It is likely that more–highly-resolved millimetre or submillimetre images of the region (from, for example, ALMA) will be needed to better understand the cluster.
- In addition, the structure of the region suggests that the filaments are accreting mass onto the central core, a possibility that could be investigated using kinematic data from molecular line observations.

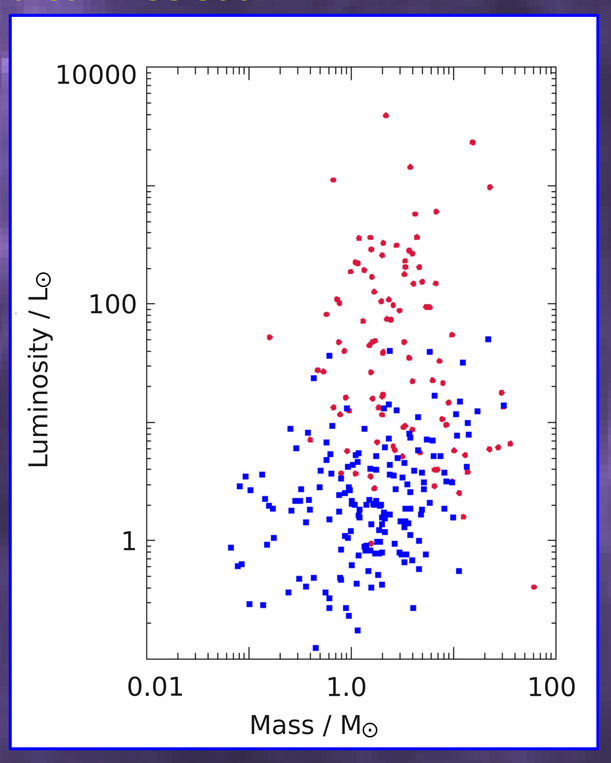

Figure 5:
Mon R2 Luminosity / Mass diagram. Central core sources are in red, outer sources are in blue. The sources appear to form two distinct populations.