

The isolated embedded cluster IRAS 17136-3617 (GM24) revisited

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We present new infrared observations of the very young embedded cluster GM 24, which at its core (Irs 3) has a proto-trapezium stellar system, IRAS 17136-3617. Images in the wavelength range 1.2 to 20 μm are analysed. In an area of $111'' \times 111''$, a total of 619 sources were detected in *K*, 296 in *HK* and 119 in *JHK*. Of these, 54 were also measured at 3.6 and 4.5 μm and only 10 at 5.8 μm . By means of source counts, a circle of radius $38''$ was found to contain most of the cluster. The number of sources belonging to the cluster is found to decrease abruptly at $K > 14.5$, corresponding to a $2 M_{\odot}$ ZAMS, although the completeness limit of the survey is two magnitudes fainter. Only Irs 3 and Irs 27 and, marginally Irs 17, were measurable in the ground-based mid-infrared images. The Class I source Irs 3, which dominates the emission at $\lambda > 8$ and is responsible for the ionization of the associated compact H II region, is found to be composed of at least four near-infrared components within a $3''$ circle. Its luminosity and number of UV photons imply the presence of at least one late O-type star. Irs 17 appears to be an extended spherical mid-IR source with a near-infrared bipolar reflection nebula. A long bar of diffuse emission seen at wavelengths 2.2 to 8.9 μm near the centre of the cluster may be a photodissociation front. The considerable fraction of stars with infrared excess, including two Class I objects associated with a compact radio H II region and the presence of an H₂O maser source with a faint mid-IR counterpart, provide evidence of the extreme youth of the isolated cluster, with age probably $< 10^5$ years.

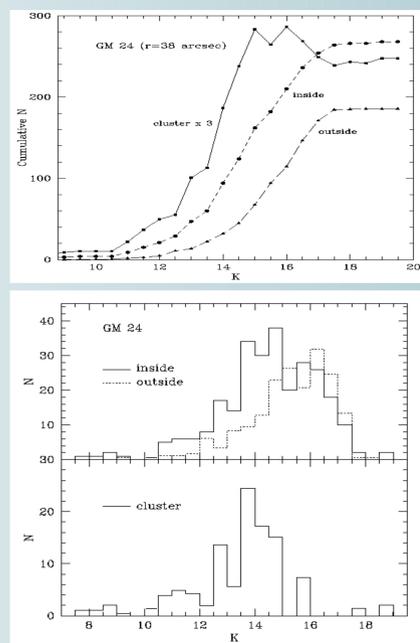


Figure 2: Cumulative *K*-band counts and luminosity function of the sources in the field. "Inside" and "outside" refer to a circle of radius $38''$ centred at (J2000) $\alpha = 17^{\text{h}} 17^{\text{m}} 1.4^{\text{s}}$ and $\delta = -36^{\circ} 21' 2''$ that marks the boundaries of the embedded cluster. All numbers have been normalized to the area of the circle. The cluster population is considered to be represented by the subtraction of the number of sources "inside" minus "outside". Note that the cluster population decays drastically at $K > 14.5$, (corresponding to $\sim 2 M_{\odot}$), two magnitudes brighter than the limiting magnitude of the survey.

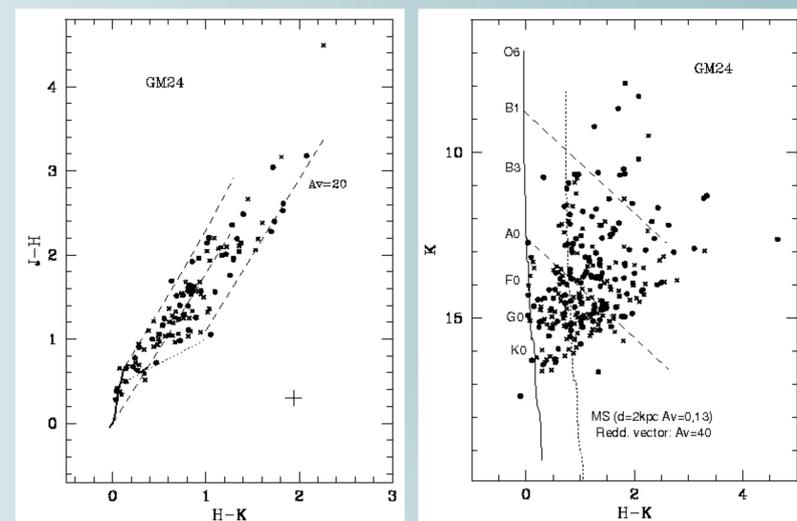


Figure 4, left panel: *J-H* vs. *H-Ks* diagram of the sources detected in *JHK*. The solid line marks the locus of the main sequence, while the dotted line represents the location occupied by of T Tauri stars. The dashed lines define the standard reddening vectors for late and early and T Tauri stars. **Right panel:** *Ks* vs. *H-Ks* diagram of all sources detected in these bands. The solid line marks the locus of the main sequence at $d = 2.0$ kpc and $A_V = 0.13$, the dotted line, for $A_V = 40$. Solid circles are sources located inside the $r = 38''$ boundary of the cluster. Crosses are for sources outside, considered to be representative of the field. The dashed lines represent the standard reddening vectors and the crosses mark the typical photometric errors.

Table 1. Log of new imaging observations

Telescope	Date	Instrument	Wavelengths
SPM 2.1 m	2000 Sept. 2003 Oct.	CID	8.9,9.9,12.7,18.7 μm
Clay 6.5 m	2003 May	PANIC	<i>JHK</i>
<i>Spitzer</i>	2005 Sept.	IRAC (archive GLIMPSE)	3.6,4.5,5.8 μm

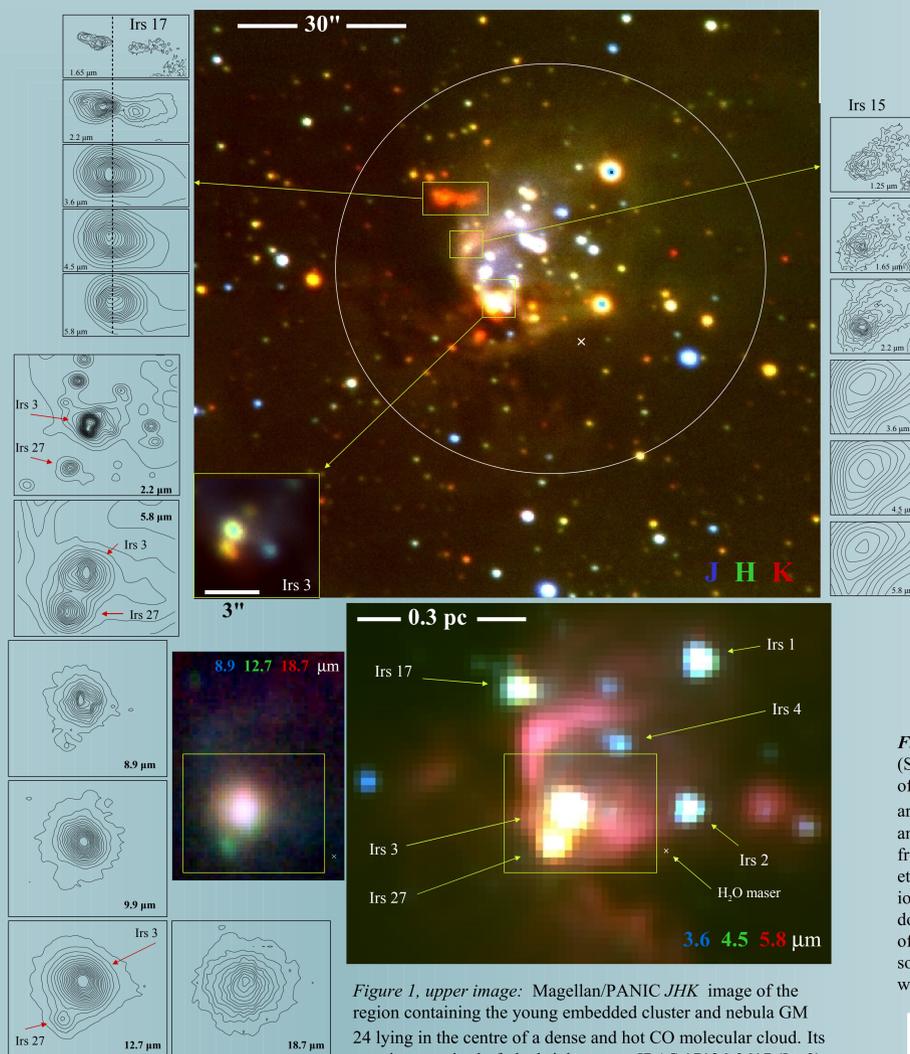


Figure 1, upper image: Magellan/PANIC *JHK* image of the region containing the young embedded cluster and nebula GM 24 lying in the centre of a dense and hot CO molecular cloud. Its core is comprised of the bright source IRAS 17136-3617 (Irs 3), a deeply embedded ($A_V \sim 50$) Class I trapezium-type stellar system, shown enlarged in the insert. Contour plots at several wavelengths of two very red, extended and conspicuous sources. Note that the position of Irs 17, exhibited in the left panels, lies, in the longer wavelengths, midway between the two lobes of reflected light seen in the shorter wavelengths. In contrast with Irs 15, shown in the right panels, where the point source is detected only at the shorter wavelengths. The circle of radius $38''$ delineates the size of the cluster. **Lower right image:** *Spitzer*/*IRAC* colour-coded image constructed from the GLIMPSE survey at 3.6, 4.5 and 5.8 μm . The brightest and reddest sources are indicated. **Lower left image:** San Pedro Mártir/CID mid-infrared (8.9, 12.7 and 18.7 μm ; Salas et al. 2006) composite colour image of the central part of GM24. Contour plots of the core region (marked by a square) at several wavelengths are plotted in the left-side panels. The scale is the same for all images, the (x) sign marks the position of the H₂O maser source (Sekellis et al. 1984).

Table 2: Physical parameters of GM 24 (Distance = 2 kpc)

MOLECULAR CLOUD (Gómez et al. 1990):

$M_{\text{tot}}(\text{C}^{18}\text{O}) = 4 \times 10^3 M_{\odot}$; $M_{\text{core}}(\text{C}^{18}\text{O}) = 1.5 \times 10^3 M_{\odot}$
size (core) = 0.9×1.3 pc; $T_{\text{K}}(\text{CO}) = 35.1$ K; $A_V(\text{total}) = 89$ mag.

HII REGION (Tapia et al. 1985, Roth et al. 1988, Gómez et al. 1993):

Position (J2000): $\alpha = 17^{\text{h}} 17^{\text{m}} 02.26^{\text{s}}$, $\delta = -36^{\circ} 21' 10.0''$; $l = 350.50$ $b = 0.96$
Flux density (2 cm, 3.6 cm, 6 cm): 2.7 Jy, 4.4 Jy, 4.3 Jy,
Size ≈ 0.7 pc; $A_V(6 \text{ cm to Br}\gamma) = 51$ mag.
 $T_e = 6400$ K; $N_e = 2 \times 10^{-4} \text{ cm}^{-3}$; E.M. = $8.7 \times 10^6 \text{ pc cm}^{-6}$
 $M_{\text{HII}} = 2.7 M_{\odot}$; No. ionizing photons = $4 \times 10^{48} \text{ s}^{-1} \rightarrow 1 \text{ O9 ZAMS star}$

H₂O MASER (Sakellis et al. 1984, Gómez et al. 1993):

Position (J2000): $\alpha = 17^{\text{h}} 17^{\text{m}} 01.04^{\text{s}}$, $\delta = -36^{\circ} 21' 15.4''$
 $V_{\text{LSR}}(\text{km s}^{-1})$: -15.6, -13.0, -11.0, -9.7; Flux (Jy): 0.5, 7.1, 13.6, 15.3

EMBEDDED CLUSTER (Tapia et al. 1994, this work):

Centre of cluster (J2000): $\alpha = 17^{\text{h}} 17^{\text{m}} 01.04^{\text{s}}$, $\delta = -36^{\circ} 21' 15.4''$;
Radius of cluster: $38'' \rightarrow 0.37$ pc
No. stars (2.2 μm): ≥ 100 ; Total stellar mass (M_*): $\geq 4.5 \times 10^2 M_{\odot}$
No. stars with excess emission at $\lambda > 2 \mu\text{m}$: $\geq 30 \rightarrow \geq 30\%$
 $L_{\text{tot}}(\text{Irs 3}) \geq 4 \times 10^4 L_{\odot} \rightarrow 1 \text{ O8-9 ZAMS star}$
 $A_V(\text{from } 9.7 \mu\text{m Si feature}) = 55$ mag.

Star formation efficiency (M_*/M_{core}) $\geq 30\%$

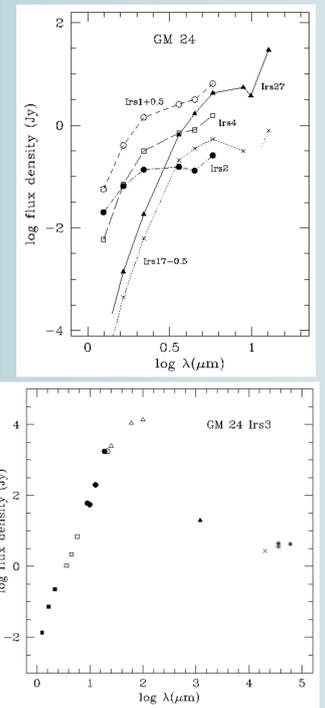


Figure 3: Lower panel: Spectral energy distribution (SED) of Irs 3, a Trapezium-type system at the core of the massive cluster GM 24. 1.25 to 18.9 μm data are from this work, 8 to 100 μm from *MSX* and *IRAS* and PSCs, 1.2 mm from Faúndez et al. (2004), 2 cm from Roth et al. (1988) and 3.6 to 6 cm from Gómez et al. (1993). The Class I object, Irs 3, is the main ionizing source of the compact HII region and dominates the emission at $\lambda > 8$. **Upper panel:** SEDs of Irs 1, 2, 4, 17 and 27, the brightest and reddest IR sources in the cluster, after Irs 3. All data from this work.

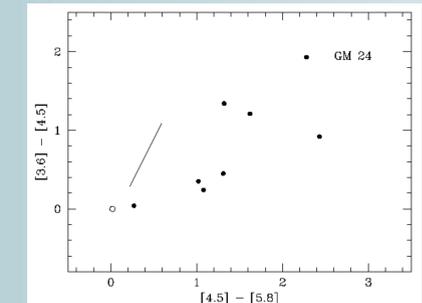
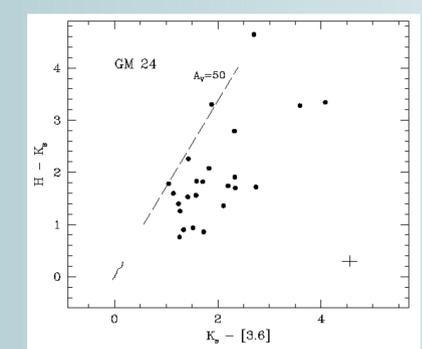


Figure 5, upper panel: *H-Ks* vs. $K_s - [3.6]$ diagram of the sources measured on the *Spitzer*/*IRAC* short wavelength image. **Lower panel:** $[3.6] - [4.5]$ vs. $[4.5] - [5.8]$ diagram of the sources measured on the three *Spitzer*/*IRAC* images. Symbols as in Figure 4.

References:

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