PROCEEDINGS OF SCIENCE

Multi-band observations of the extended green object (EGO) G45.47+0.13

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A preliminary study of the extended green object (EGO) G45.47+0.13 including new near-IR images in $JHKs$ broad-band filters, H_2 and Kc narrow band filters, and mid-IR images at 8.9, 9.9, 12.7, and 18.7 μm is presented. From the analysis of the data , a detailed spectral energy distribution (SED) of the source is derived. In addition the presence of a young embedded stellar cluster around G45.47+0.13 is found.

Multifrequency Behaviour of High Energy Cosmic Sources XIV (MULTIF2023)
12-17 June 2023
Palermo, Italy

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PoS(MULTIF2023)026

1. Introduction

Extended Green Objects (EGOs) are a new class of star-forming regions. In the Spitzer images at 3.6, 4.5, and 8μm,(blue, green, and red, respectively), EGOs show extended emission in the green channel which could be due to excesses in the 4.5μm band. It is suggested that this emission may arise from H_2(u= 0-0, S(9, 10, 11)) and/ or CO (u = 1-0), excited by shocks from outflows. A catalog of more than 300 EGOs has been presented by[1].The majority of EGOs are associated with infrared dark clouds (IRDCs), and where high-resolution 6.7 GHz CH3OH maser surveys overlap the GLIMPSE coverage, EGOs and 6.7 GHz CH3OH masers are strongly correlated.This suggests that the extended 4.5μm, emission may pinpoint outflows specifically from massive protostars.
G45.47+0.13 has been identified as an EGO located at the edge of an H II region by [2]. Around the EGO source is present an extended red nebulosity . OH, water maser as well as methanol maser have been detected in G45.47.+0.13 ([3], [4]).
In order to analyze in more detail this region, we obtained new sub-arcsec resolution near-IR broad-band and narrow-band images, and mid-IR images from 8.9 to 18.7μm. These observations are compared with *Herschel* images obtained from the Herschel Infrared GALactic Plane survey (Hi-GAL, [5].). In addition, archive IRAC/*Spitzer* images are used to supplement these observations. Section 2 describes the new observations, while in Section 3 we discuss the properties of this high mass star forming regions as obtained from our observations. Finally Section 4 lists our conclusions.

2. Observations

2.1 Near-IR images

Near-infrared images through narrow-band H_2 (λo = 2.122 μm, $\Delta\lambda$ = 0.032μm) Kcont (λo = 2.270 μm, $\Delta\lambda$ = 0.034μm) filters, as well as through standard broad-band JHKs filters, were collected on the night of 2008 July 14 using the Near-Infrared Camera Spectrometer (NICS) attached to the 3.58 m Telescopio Nazionale Galileo (TNG) at the Observatorio del Roque de los Muchachos on La Palma island. The camera has a HgCdTe Hawaii 1024 × 1024 array and was used in the SF (small-field) configuration that provides a scale of 0.13 arcsec/pixel.
The color composite JHKs image of the region is showed in Fig.1 (Right panel). As shown by a comparison between JHKs and Spitzer image (Left panel), G45.47+0.13 is extended also in the near-IR. In addition in the north-east part of the image is present a red nebulosity observed also at 8μm. $JHKs$ photometry was obtained in an area of 30arcsec×30arcsec centered on G45.47+0.13, using DAOPHOT [6] within IRAF in the standard way, with an aperture of 1 arcsec. The results relative to the photometry will be discussed in the next sections.
No H_2 emission is found in the continuum-subtracted H_2 image as shown in Fig.2 (Left panel) in agreement with the observations of [2].

2.2 Mid-IR images

Mid-infrared images at 8.9, 9.9, 12.7, and 18.7μm, of G45.47+0.13 were taken on the night of 2007 November 10 with the mid-infrared camera CID [7] on the 2.1 m telescope of the Observatorio Astronomico Nacional at San Pedro Martir, Baja California(Mexico). This camera is equipped

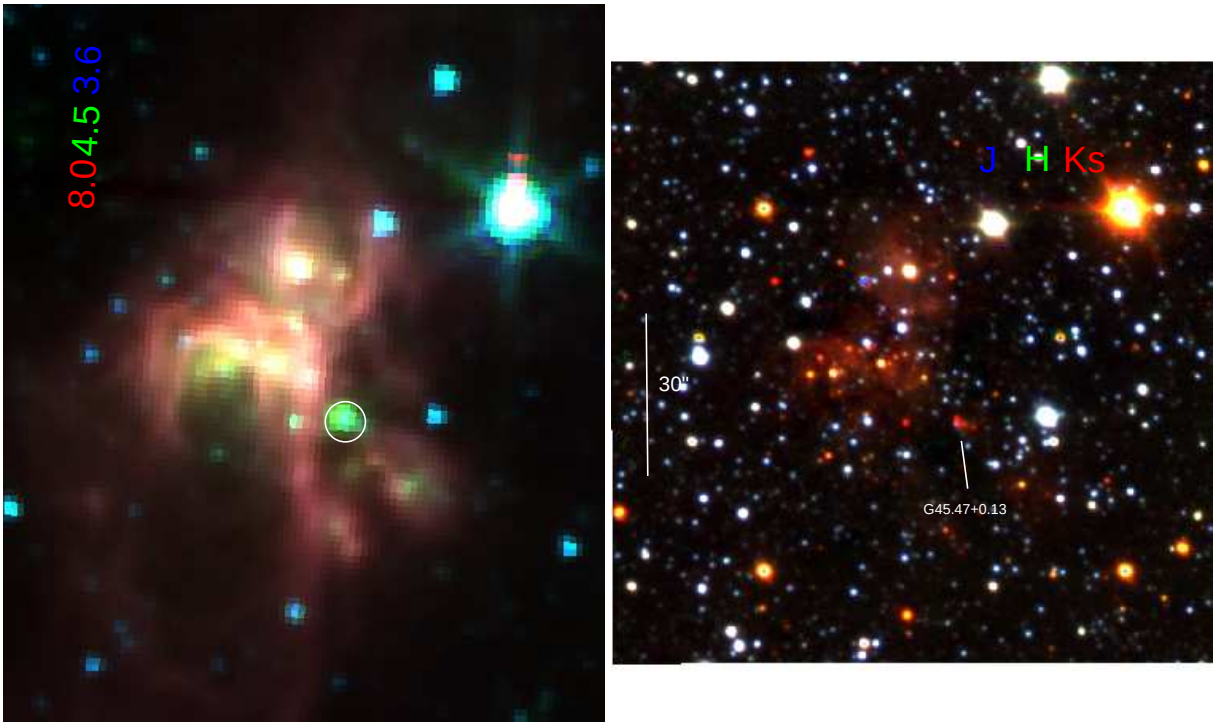

Figure 1: *Left panel:*Color-composed Spitzer image obtained with the 3.6 (blu), 4.5(green) and 8.0 ,(red)μm. The circle show the position of G45.47+0.13.*Right panel:* Color-Composed JHKs image of 2'×2' centerd at $\alpha(2000) = 19^{h}\ 14^{m}\ 08^{s}$, $\delta(2000) = +11^{\circ}\ 12'\ 26.''5$.

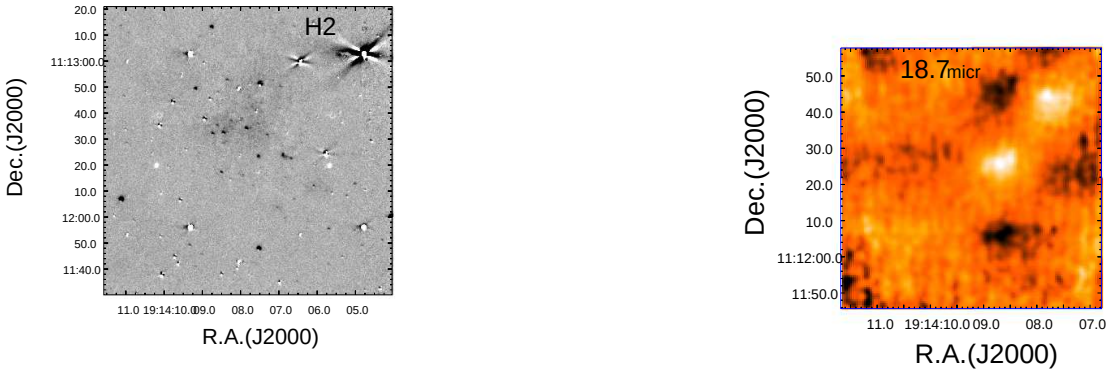

Figure 2: *Left panel:* H_2 subtracted image of G45.47+0.13.*Right panel:* CID image at 18.7μm of G45.47+0.13

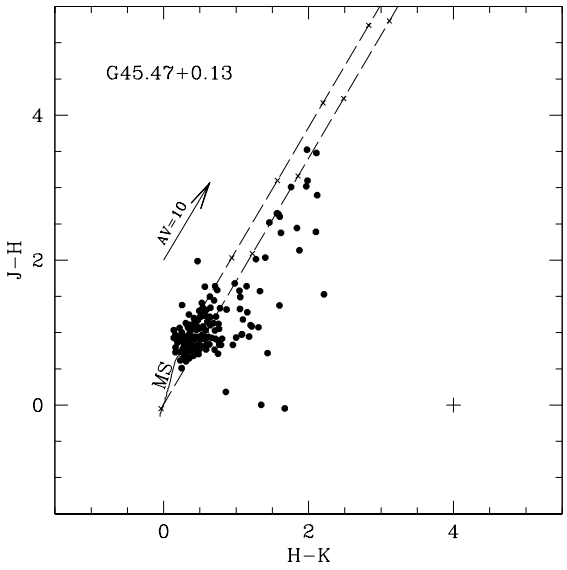

Figure 3: J-H versus H-Ks diagram of all sources measured in JHKs with uncertainties less than 0.15mag in each filter.

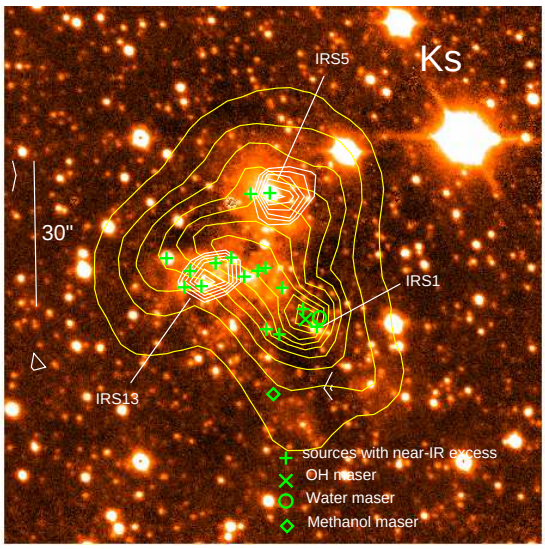

Figure 4: Ks image of the area around G45.47+0.13. The yellow contour correspond to the Hi-GAL 70μm emission, and the white contours indicate the positions of the two sources observed at 18.7 μm

with a Rockwell 128 × 128 pixel Si:As BIB detector array that delivers an effective scale of 0.55 pixel.

As shown in Fig.2 (Right panel), no mid-IR emission is detected at the position of G45.47+0.13, but in the northwest part of the field two sources are detected at 12.7 and 18.7 μmin agreement with the observations reported by [8] .

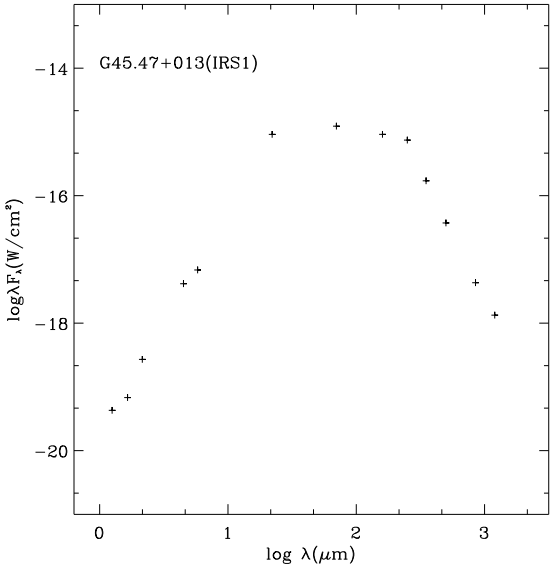

Figure 5: Spectral energy distribution (SED) of G45.47+0.13

Table 1: Physical parameters of source G45.47+0.13 derived from model [10].

Parameters	
Stellar Mass (M_{sun})	16
Stellar Temperature (K)	17000
Envelope Accretion Rate (M_{sun}/yr)	6.7 10^{-3}
Disk Mass (M_{sun})	0.15
A_V	59
Dist (Kpc)	6.9
$L_{\rm bol}$ (L_{sun})	308

2.3 Discussion

From the near-IR photometry of the region, we have found 16 sources with IR excess as shown from the J-H vs H-K s diagram of Fig.3. The positions of these sources are shown with the symbol (+) in in the Ks image of Fig.4.

The source IRS1 in the Fig.4 is G45.47+0.13, while the sources with IR excess IRS5 and IRS13 match to the two mid-IR sources indicate with the white contours in the figure. Mostly of the source with IR excess are located within the red nebulosity and indicate the presence of a young embedded cluster around G45.47+0.13. This source is reported in the HI-GAL catalogue of [9] and the yellow contour in the figure indicate the 70μm emission.

Combining the observations at different wavelengths from near -IR to millimeter, we have obtained a detailed spectral energy distribution (SED) of G45.47+0.13 (IRS1) illustrated in Fig.5. The SED has been fitted using the star/disc/envelope model of [10]. The derived parameters reported in Table1 suggest that G45.47+0.13 is an high mass young stellar objet at a very early stage of evolution.

2.4 Conclusion

From a partial analysis of our observations compared with the Herschel, Spitzer and millimeter data we can derive the following conclusions:
1) The EGO source G45.47+0.13 is an high mass young stellar objet at a very early stage of evolution
2) A young embedded stellar cluster is observed around G45.47+0.13, and a red nebulosity is present in the region.

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