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INDUCED STAR FORMATION IN THE HII REGION SH2-54

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RESUMEN

En este trabajo presentamos un estudio multifrecuencia del medio interstelar en el entorno de la región HII Sh2-54. El gas molecular y el polvo se han analizado y descripto por medio de las observaciones milimétricas e infrarrojas, respectivamente. La emisión en 8.0 μm de *Spitzer*-IRAC presenta una compleja estructura filamentaria de gas fotodisociado, evidenciando la interacción entre la región HII y el gas molecular. Numerosos candidatos a objetos estelares jóvenes se encuentran proyectados sobre Sh2-54 y sus alrededores. Analizamos si la presencia de estos objetos puede ser explicada dentro de un escenario de formación estelar inducida.

ABSTRACT

We present a multiwavelength study of the interstellar medium around the HII region Sh2-54. The millimetric and infrared data allow us to analyze and characterize the molecular gas and dust components, respectively. The emision at 8.0 μm of *Spitzer*-IRAC shows a complex filamentary structure of photodissociated gas, revealing the interaction between the HII region and the molecular material. Several young stellar object (YSO) candidates have been detected projected towards Sh2-54 and its surroundings. We analyze if the presence of these YSO candidates can be explained by a triggered star formation scenario.

Key Words: HII regions — ISM: individual (Sh2-54) — stars: formation

1. GENERAL

The expansion of HII regions over molecular clouds generates potential sites of star formation. There are two main mechanisms that explain the induced star formation process on the edge of HII regions. The "collect and collapse" process (Elmegreen 1998) proposes the formation of massive stars, while the "radiatively driven implossion" model ("RDI", Lefloch & Lazareff 1994) focusses on the formation of low and intermediate mass stars, based on the compression of original overdensity regions. We can find in the literature a large number of star forming regions that can be explained by any of these two processes, e.g. *RCW 120* (Deharveng et al. 2009), *Gum 31* (Cappa et al. 2008), *SF 79* (Urquhart et al. 2004).

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2. SH2-54

Sh2-54 is an HII region of $\sim$6 arcmin in size, centered at (α, δ)(J2000)$\simeq$(18:17:50.0, –11:44:00.0), which is being ionized by several OB type stars. An DSS2 R image of the region is shown in the upper panel of Figure 1. It can be seen that the northwestern side of the nebula is surrounded by a high extinction region. The lower panel of Figure 1 shows the IRAC emission distribution at 8.0 μm with the integrated ^{12}CO(1-0) emission distribution (NANTEN data, HPBW = 2.7$'$ and 1 km s^{-1} velocity resolution), within the velocity range from +22 to +36 km s^{-1} (green contours) and the radio continuum emission distribution at 1465 MHz (VLA DnC conf. with a synthesized beam of 39.8×22.6 arcsec) indicated by blue contours. Both, the spectrophotometric and kinematical distances suggest for Sh2-54 a distance of $d = 2.0 \pm 0.5$ kpc. Based on the radio continuum and the millimetric emissions the main physical parameters of the ionized and molecular gas were estimated adopting an spherical geometry for the region (see Table 1).

3. STELLAR FORMATION

Based on the Allen et al.'s (2004) criteria, several YSO candidates projected onto the molecular emission were selected from the *Spitzer*-IRAC point source catalogue. The morphology of the phodissociation region (PDR) observed at 8 μm (see the lower

TABLE 1

MAIN PHYSICAL PARAMETERS OF THE IONIZED AND MOLECULAR GAS

d (kpc)	2.0 ± 0.5
ν (GHz)	1.465
S_ν (Jy)	7.4
Size ($'$, pc)	3.8, 1.63
n_e (cm^{-3})	120
$M_{\rm HII}$ ($M_\odot$)	60
Δv (km s^{-1})	22–36
$N_{\rm H_2}$ (cm^{-2})	2.40×10^{21}
$M_{\rm H_2}$ ($M_\odot$)	2300

panel of Figure 1), suggests that the expansion of Sh2-54 has perturbed the molecular gas. However, the angular resolution of our CO data do not allow us to identify clumps in the cloud. Thus, better angular resolution data are needed to detect the molecular clumps linked to the YSO candidates.

The ambient density derived by distributing the ionized and molecular masses over a sphere of r = 1.63 pc in radius is $n_0 = 5200 \pm 3200$ cm^{-3}.

Considering the simple expansion model for an HII region in a uniform medium given by Dyson & Williams (1997), we estimate a dynamical age $t_{\rm dyn} = 1.3 \pm 0.4$ Myr for Sh2-54. The "collect and collapse" mechanism predicts a fragmentation time given by $t_{\rm frag} = v^{7/11}\ N_{\rm lym}^{-1/11}\ n_0^{-5/11}$ (Whitworth et al. 1994), where v is the sound velocity and $N_{\rm lym}$ is the number of Lyman photons emitted by the ionizing stars. To discern if this mechanism could have been triggered the YSOs in the region, we estimate the lowest ambient density value for the fragmentation process to take place. Adopting $v = 0.2$ km s^{-1}, and log $N_{\rm lym} = 48.3$ (which is the minimum number of ionizing photons needed to keep a region with $S_{1.465\ \rm GHz}$ = 7.4 Jy ionized), an ambient density larger than 3500 cm^{-3}, is required for $t_{\rm frag}$ to be lower than $t_{\rm dyn}$. Taking into account that our estimation for n_0 is about 5200 cm^{-3}, we suggest that the fragmentation of the molecular cloud could have been occured. In this case, a scenario where the stellar formation activity was triggered by the expansion of Sh2-54 is plausible.

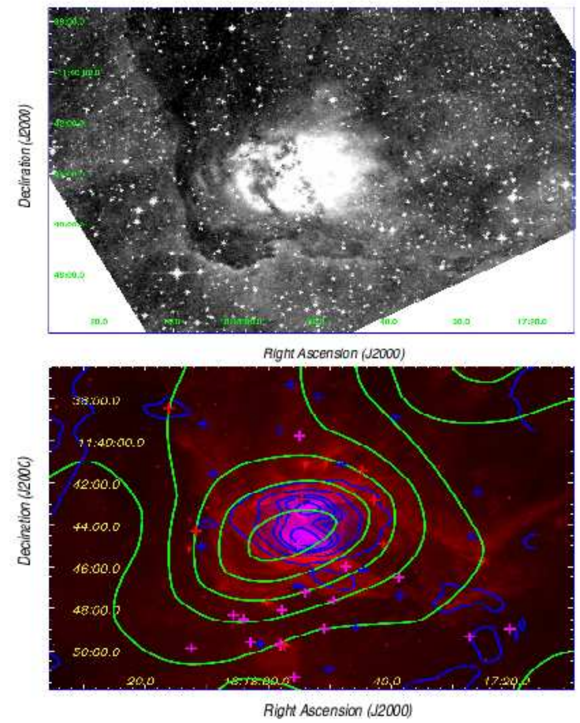

Fig. 1. Upper panel: DSS2 R image of Sh2-54. Lower panel: Mid-IR emission distribution at 8.0 μm overlaid with the radio continuum at 1465 MHz (blue contours), and the averaged ^{12}CO(J=1-0) emission (green contours). The crosses indicate the position of the YSO candidates.

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