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ORIGINAL ARTICLE

A detailed study of the high-mass clump interacting with the bubble N10

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Abstract We performed a detailed study of the high-mass clump interacting with bubble N10 based on the spectral lines ^{12}CO(3–2), HCO$^+$(4–3), N_2H^+(4–3) and $CH_3OH(7(0,7)–6(0,6))$ and continuum emission data at 450 μm and 850 μm released by CADC and Spitzer. A blue-shifted optically thick line ^{12}CO(3–2) seems to indicate that the outer envelope of the high-mass clump is still falling toward the center. Detection of $CH_3OH(7(0,7)–6(0,6))$ suggests that a hot core has formed around YSO N10-7. The position–velocity diagram of N_2H^+(4–3) indicates that the cold dense core of the clump has not been destroyed by the star formation activities. The mass of N10-7 is about 27.44 $M_\odot$. The ratio HCO$^+$(4–3)/N_2H^+(4–3) in the outer part of the clump is larger than that in the inner part of it. The reason may be that the CO abundance relative to N_2H^+(4–3) is increased in the outer part of the high-mass clump, and more N_2H^+(4–3) were converted into HCO$^+$(4–3).

Keywords HII regions–ISM · Clouds–stars · Formation

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1 Introduction

The expansion of the HII regions is of extreme interest for studies of star formation as their expansion may trigger formation of new generations of star within the molecular material surrounding the bubbles (Thompson et al. 2012). Evidence of triggering has been reported by many authors (e.g. Deharveng et al. 2010; Zavagno et al. 2010; Kang et al. 2009). It should be noted that the majority of observational studies into triggered star formation near SNR or HII regions take a phenomenological approach; the evidence of triggered star formation is not very conclusive (Kendrew et al. 2012). The statistical approach may address the uncertainties inherent in observations of individual HII regions. One detailed statistical study of massive star formation in the environment of 322 Spitzer mid-infrared bubbles by using the Red MSX source survey for massive young stellar objects (YSOs) suggests that the fraction of massive stars in the Milky Way formed by triggering could be between 14 and 30 per cent (Thompson et al. 2012). Kendrew et al. (2012) made a similar statistical study with 5106 infrared bubbles, and they estimated that approximately 22 per cent of massive young stellar stars may have formed as a result of feedback from expanding HII regions. Therefore, the infrared dust bubbles could be good sites to find high-mass YSOs and study the process of high-mass star formation.

N10 is a bright mid-infrared and radio continuum bubble with an elliptical or slightly cometary shape with an opening southeast of the bubble (Watson et al. 2008). Its kinematic distance is about 4.6 kpc (Deharveng et al. 2010). The bubble is bordered on two sides by infrared dark clouds (IRDCs), and they are interacting with the HII regions (Deharveng et al. 2010). Especially for the IRDC in which one medium-to-high mass YSO has been found by Watson et al. (2008), the YSO is coincident with a single very dense dust