Origin of Hot Bubble in NGC 6822 Hubble V Star-Forming Region

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Abstract. We observed a bright H\textsc{ii} complex, Hubble V in NGC 6822, using the high-resolution near-infrared spectrograph IGRINS (R = 45,000) attached on the 2.7 m telescope at the McDonald Observatory. We carried out a spectral mapping over a 15\arcsec \times 18\arcsec region in the H and K bands using a slit-scanning technique. The emission lines Br\textgreek{g} and He\textgreek{i} from ionized regions as well as molecular hydrogen lines from photo-dissociation regions (PDRs), were detected. We show three-dimensional maps of the emission lines and discuss the possibility of an expanding hot bubble structure within which many ionized components are around the central stellar cluster.

Keywords. galaxies: dwarf, galaxies: irregular, galaxies: kinematics and dynamics, galaxies: Local Group, infrared: galaxies, instrumentation: spectrographs

1. NGC 6822 Hubble V Observation

NGC 6822 is a member of the Local Group and a metal poor irregular dwarf galaxy whose star-forming environment is free of dynamical driving effects (Lee \textit{et al}. 2005). We can spatially resolve molecular clouds or star-forming regions clearly down to parsec scales at a distance of 474 \pm 13 kpc (Rich \textit{et al}. 2014). This galaxy has a bar dominated by an irregular distribution of OB associations and H\textsc{ii} regions (Israel 1997). Based on X-ray observation results, some of the bright H\textsc{ii} regions of NGC 6822 have bubbles (Kong \textit{et al}. 2004; Tennant 2006).

Hubble V is one of the brightest H\textsc{ii} region complexes in this galaxy (RA = 19h 44m 52.85, Dec = –14\degr 43’ 12.8”, J2000). The star cluster inside Hubble V has about 80 OB stars massive star candidates brighter than m\textsubscript{NUV} of 22.5 mag (Hodge 1980; Wilson 1992; Bianchi & Efremova 2006; Schruba \textit{et al}. 2017).

We obtained a spectral map toward Hubble V using Immersion GRating INfrared Spectrometer (IGRINS) attached on the 2.7 m telescope at the McDonald Observatory in 2016 May and July. IGRINS covers the whole infrared H and K bands with resolving...
power of 45,000. Using a slit-scanning technique, we mapped $15'' \times 18''$ ($35 \times 17$ pc) area over Hubble V. The obtained emission lines are Br$\gamma \lambda 2.1661$ µm, He I $\lambda 2.0587$ µm from ionized regions, and molecular hydrogen lines of 1-0 S(1) $\lambda 2.1218$ µm, 2-1 S(1) $\lambda 2.2477$ µm, and 1-0 S(0) $\lambda 2.2227$ µm from PDRs.

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**Figure 1.** Integrated intensity maps (left) and the 3D cube data (right) of Br$\gamma$ and H$_2$ 1-0 S(1) emission lines. The molecular clouds surround the ionized region (halo) that extends towards the northwest.

**Figure 2.** Sample Spectra with Gaussian Fitting. The FWHM difference of mean velocity dispersion between Br$\gamma$ emission and H$_2$ 1-0 S(1) line is about 14 kms$^{-1}$.
2. Result and Discussion

We confirmed the structure suggested by Lee et al. (2005) through the integrated intensity maps and the 3D cube data of Br\(\gamma\) and H\(_2\) 1-0 S(1). The molecular clouds surround the ionized region that extends towards the northwest (Fig. 1).

Bubbles and superbubbles have been detected in the Galaxy and nearby galaxies (Camps-Fariña et al. 2017). Bubbles blown by massive stars contain fast stellar winds (\(T > 10^6\) K) which emits diffuse X-rays and a swept-up dense shell (Chu et al. 2006).

We suggest that NGC 6822 Hubble V has a hot bubble with surrounding clumpy molecular clouds. The coronal gas and H \(\text{II}\) regions are also influenced by stellar winds from embedded stars. In spite of the expected hot bubble structure, X-ray emission has not been detected in Hubble V.

The mean velocity dispersion obtained from Full Width at Half Maximum (FWHM) of Br\(\gamma\) emission line in NGC 6822 Hubble V is \(\approx 28\) km\(s^{-1}\), while that of H\(_2\) 1-0 S(1) line is \(\approx 13\) km\(s^{-1}\) (Fig. 2). Considering the line width of \(7\) km\(s^{-1}\) in the IGRINS instrument profile, our result implies that the Br\(\gamma\) emission line profile does show neither double-peaked nor multiple-peaked emission components. From this highly dispersed emission, we argue that embedded H \(\text{II}\) regions or inside hot gas have a random motion.

References