A KINEMATIC ANALYSIS OF THE GIANT STAR FORMING REGION OF N11

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N11 is the second largest HII region in the LMC, after the 30 Doradus nebula and consists of a huge bubble surrounded by several HII regions. Given its proximity, N11 is an ideal laboratory to analyze the kinematics of the ionized gas in a giant HII region. In this poster, we present high resolution spectra of this region, obtained with the GIRAFFE instrument on the Very Large Telescope. By using this data set, we find that most of the Halpha emission lines in this complex can be fitted by a single Gaussian. By adding all the spectra, we derive the integrated Halpha profile of this complex, which displays a width (sigma) of about 12 km s^{-1} (corrected by instrumental and thermal width). As can be expected, this width is lower than the value presented by the giant-star forming region of 30 Doradus. Given its evolutionary stage, a comparison of the kinematics of the ionized gas in N11 and 30 Doradus can provide important insights to the understanding of the stellar feedback process in giant star-forming regions.

Introduction

One of the main characteristic of giant HII regions (GHR) is the supersonic width of their integrated emission lines (Smith & Weedman 1972). Several energy sources are invoked to maintain these supersonic motions: Stellar winds, supernovae explosions, gravity and stellar radiation. In addition to the formation of supersonic line widths, the energy sources listed above are responsible for shaping wind-blown cavities in GHR (Weaver et al. 1977). Despite several efforts that have been done to understand the kinematics of GHR, the main physical process producing supersonic velocity dispersion and super bubbles in GHR is still an open question. In order to address the question listed above, we have obtained new high resolution spectroscopic data for the GHR of N11, located in the Large Magellanic Cloud (LMC).

Observations

Observations of N11 were carried out using the FLAMES/GIRAFFE instrument (MEDUSA) at the Very Large Telescope (VLT) under high resolution mode (HR14A). This configuration allow us to derived an optical spectroscopic data cube of N11. The instrumental resolution of the observations (FWHM) is 18 km s^{-1} ($sigma_{inst}$=7.8 km s^{-1}).

The Halpha data cube

In Fig. 1, the Halpha profile of each MEDUSA fiber is overlaid on an Halpha image of N11. The most intense and narrow Halpha profiles are associated with a ring of star-forming regions (e.g. N11A, N11B, and N11C, see Fig. 1). At the center of this ring we found multiple profiles, which are consistent with an expanding bubble. We note that the kinematics of the central region can be dominated by the stellar winds and/or the supernova explosions of massive stars belonging to LH9, however, the internal kinematics of the young HII regions N11A, N11B, and N11C could be mostly affected by their own new-born massive stars.

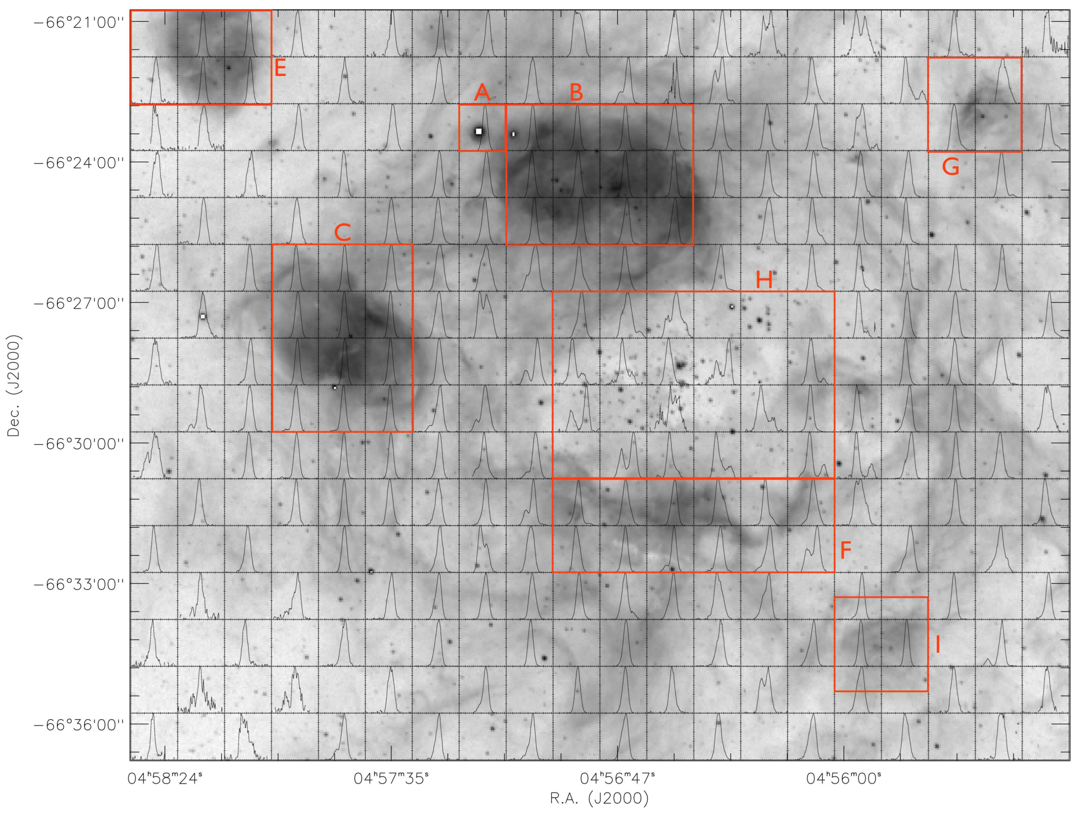

Fig. 1. Halpha image of N11, where we have overplotted the Halpha profiles obtained with MEDUSA. The most important regions are highlighted with red boxes. Each region has been labelled following Rosado et al. (1996).

The integrated Halpha profile

In Figure 2 we show the integrated Halpha profile of N11, obtained from adding all the data cube profiles (black solid line), with its corresponding single Gaussian fit (red dashed line). From this fit, we can note the presence of remaining wings in the observed profile of N11. In order to remove these wings, we have fitted a second Gaussian component to the observed profile (bottom panel of Fig. 1). The origin of this broad-low intensity component is still uncertain.

In both panels, we list the measured widths ($sigma_{obs}$) derived from the Gaussian fits. We found that N11 displays a smaller $sigma_{obs}$ than the GHR of 30 Doradus ($sigma_{obs}$ ~29 km s^{-1}, see Torres-Flores et al. 2013). This fact may be linked with the evolutionary stage of each GHR.

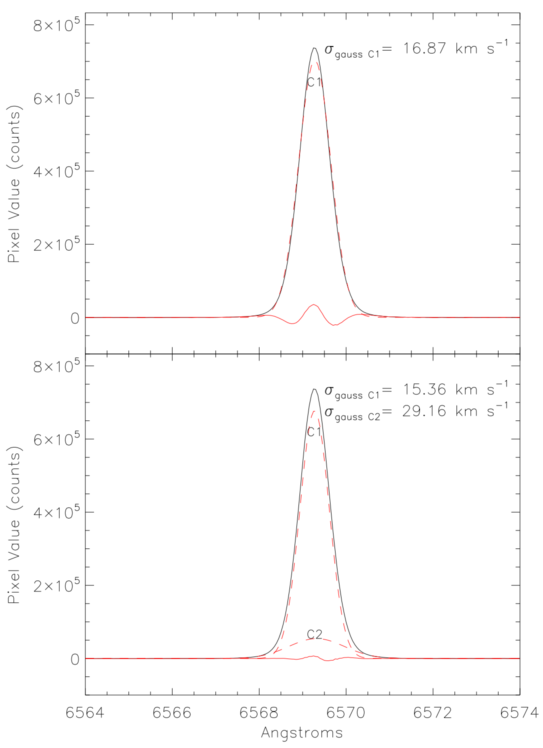

Fig. 2. Top panel: Integrated Halpha profile for the whole observed data cube. Red lines shown a single Gaussian fit, and its corresponding residual. Bottom panel: Same analysis, but including a second Gaussian.

The central expanding bubble

In Figure 3 we show the integrated Halpha profile of the central region of N11 (region H in Figure 1). Inspecting this figure we see a double peaked Halpha profile. In order to search for the individual components, we have fitted four Gaussians on this integrated profile (red dashed lines). The two most intense Gaussians can be associated with the expansion of this region. The velocity difference between these components is 45.7 km s^{-1}, which corresponds to an expanding velocity of 22.9 km s^{-1}. This value is lower than the expanding velocity reported by Rosado et al. (1996). This fact should be linked with the different spatial resolution of both studies.

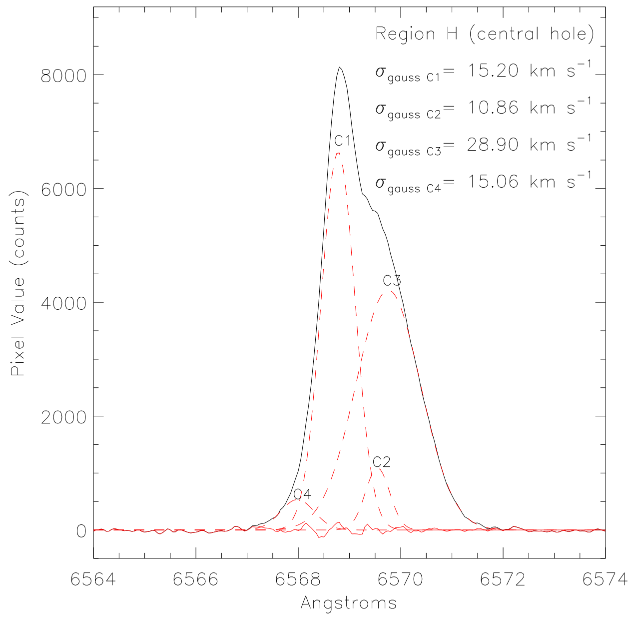

Fig. 3. Integrated Halpha profile for the central region of N11 (region H, in Figure 1). Red lines show a multiple Gaussian fitting analysis.

X-rays, CO and Halpha emission

In Figure 4 we plot the regions of soft X-ray emission detected by Nazé et al. (2004) through the analysis of XMM-Newton data (violet circles and ellipses), the X-ray contours shown in Maddox et al. (2009, blue contours) which were obtained from observations carried out by the Suzaku telescope and we also included the CO(2-1) emission shown in Herrera et al. (2013, red contours). This figure shows that the central X-ray emission in N11 is confined by the CO(2- 1). Inspecting the Halpha profiles, we found that several high-velocity components can be found overlapping the soft X-ray emission. In order to show some examples, in Figure 3 we have highlighted with a yellow colour three regions that display clear high velocity components (regions a, b and c). The connection between Halpha high-velocity components and soft X-ray emission has been found in other GHR (e.g 30 Dor, Chu & Kennicutt 1994) and is linked with shocks produced by strong stellar winds. All these findings show the kinematic richness of GHR.

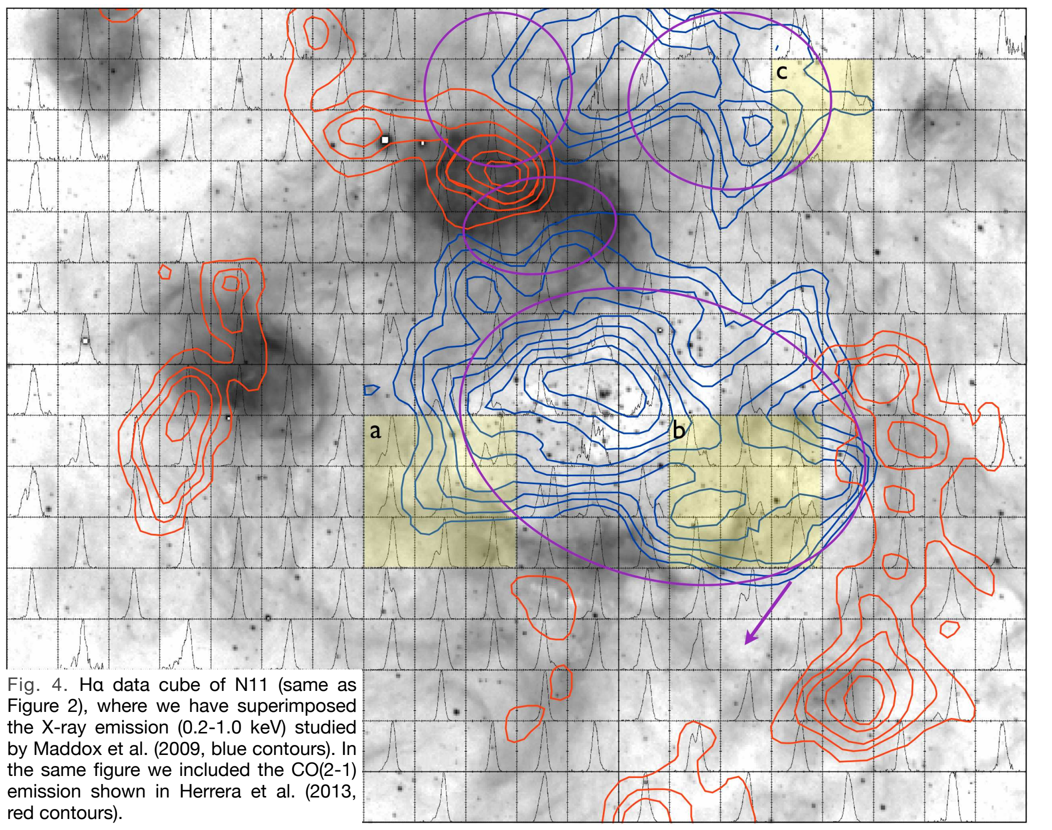

Fig. 4. Hα data cube of N11 (same as Figure 2), where we have superimposed the X-ray emission (0.2-1.0 keV) studied by Maddox et al. (2009, blue contours). In the same figure we included the CO(2-1) emission shown in Herrera et al. (2013, red contours).

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