Bulletin de la Société Royale des Sciences de Liège, Vol. 80, 2011, p. 251 - 254

A very young massive star-forming region in the Small Magellanic Cloud

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Abstract: We present a study of the compact H II region N 66A in the SMC starburst region N 66/NGC 346. This analysis is based on our ESO NTT observations coupled with archive HST ACS data. We obtain a number of physical characteristics of this compact H II region. Moreover we derive the spectral classification of the main exciting star of N 66A for the first time using spectroscopy. This compact object belongs to a rare class of H II regions in the Magellanic Clouds, called High-Excitation Blobs (HEBs). N 66A most probably represents a very young massive star formation event in the N 66 complex.

1 Introduction

N 66 is the most luminous H II region in the Small Magellanic Cloud (SMC). It is also the most active star-forming region in this neighboring galaxy. Indeed the star cluster NGC 346 located at its center hosts 33 O-type stars (Massey, Parker & Garmany 1989). Moreover it contains a large population of low-mass, pre-main-sequence stars (Gouliermis et al. 2006; Sabbi et al. 2007; Hennekemper et al. 2008).

N 66 displays an arc of dust that runs over some 60 pc from north-west to south-east below NGC 346, as can be seen on the high-resolution images of the region taken with HST/ACS (Nota et al. 2006). A bright and compact H II region, called N 66A, lies to the south-eastern end of the absorption lane. Our work was mainly focused on a detailed study of this compact H II region. We show that N 66A represents the youngest episode of massive star formation in the N 66 complex.

2 Results

2.1 The compact H II region N 66A

Figure 1 presents a high-resolution composite image of the compact H II region N 66A. It is $\sim 10''$ in diameter, corresponding to ~ 3 pc and is marked by a strong absorption lane. Interestingly, two bright stars are located towards the central part of the region, above the dust lane. Separated by $0\farcs7$ (~ 0.2 pc), they are the main exciting stars of the H II region (see also Sect. 2.2). The most extincted part of the region is the dust lane where $A_V = 1.7$ mag, as deduced from the optical $\mathrm{H}\alpha\,/\,\mathrm{H}\beta$ ratio. Elsewhere the ratio is smaller, with an average value of 3.7 corresponding to $A_V = 0.8$ mag. N 66A also presents

▪ "The multi-wavelength view of hot, massive stars"; 39$^{\mathrm{th}}$ Liège Int. Astroph. Coll., 12-16 July 2010 ▪

a high degree of excitation, particularly at the north-eastern border where the [O III] λ 5007/Hβ ratio reaches its highest value of 5 (Heydari-Malayeri & Selier 2010).

Figure 1: A composite three-color image of SMC N 66A created using the *HST* ACS images in Hα (red), filter *I* (green), and filter *V* (blue). Field size : 26″ x 26″ ($\sim$ 7.5 $\times$ 7.5 pc). From Heydari-Malayeri & Selier (2010).

2.2 Stellar content

Figure 2 shows the spectrum of the main exciting star of N 66A, called N 66A-1. Spectral classification was performed using the criteria of Walborn & Fitzpatrick (1990). The spectral features used are the high absorption of He II λ 4686, and the predominance of He II λ 4541 over He I λ 4471. We classified N 66A-1 as O8 V (Heydari-Malayeri & Selier 2010).

We also evaluated the ionizing flux of the exciting star. First we calculated the total Hβ flux emitted by N 66A. Then we computed the reddening corrected Hβ intensity. It corresponds to a Lyman continuum flux of 3.4 x 10^{48} photons.s^{-1}, assuming that the H II region is ionization bounded (Heydari-Malayeri & Selier 2010). The exciting star needed to provide this flux is of spectral type about O7.5 V according to stellar atmosphere model results (Martins, Schaerer & Hillier 2005). This estimate agrees well with the spectral classification given above.

Note that the derived value of the stellar Lyman continuum is probably an underestimate. Indeed the H II region is not fully ionization-bounded, a part of the ionizing photons escape into the interstellar medium. Thus, the spectral classification based on spectroscopy is also an underestimate. This

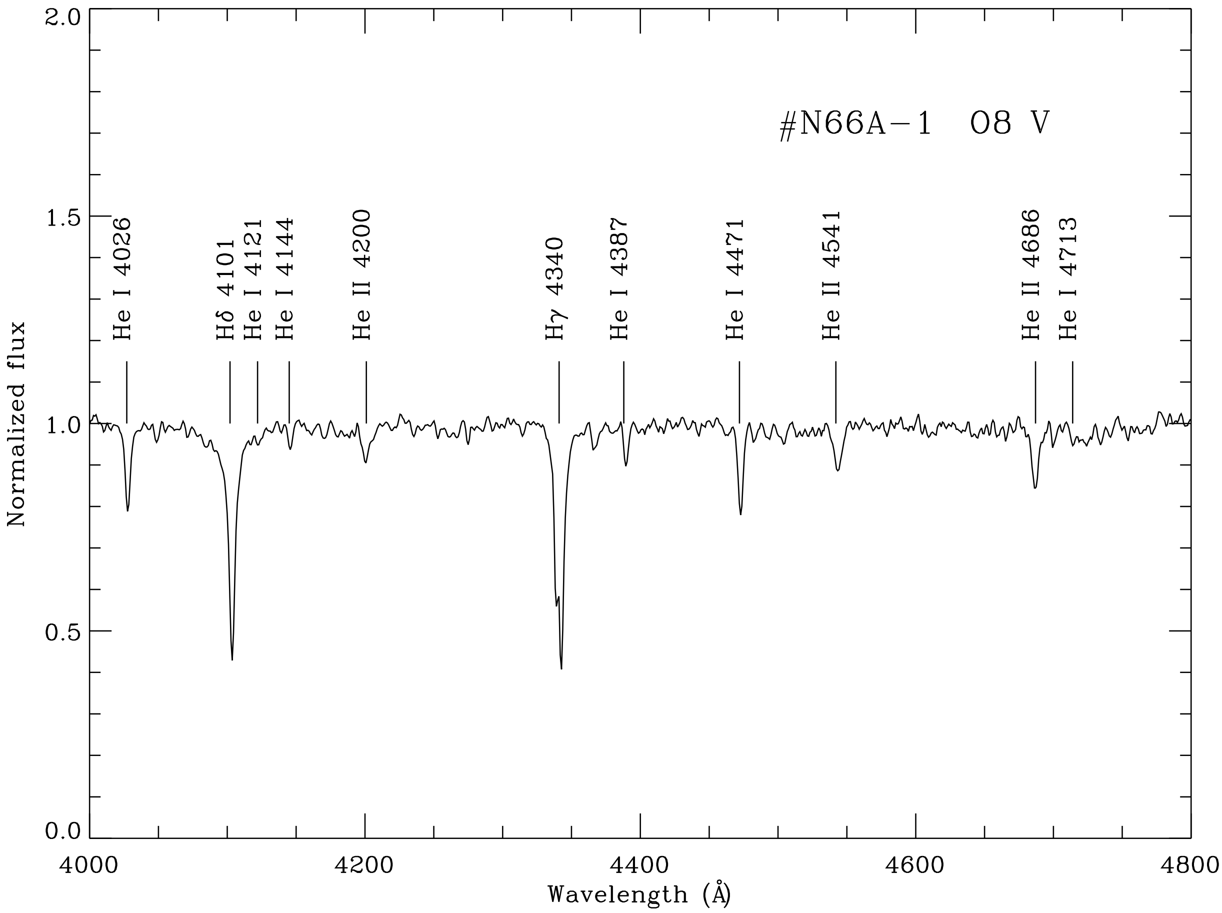

Figure 2: Spectrogram of N 66A-1 obtained with the spectrograph EMMI on the ESO NTT telescope (adapted from Heydari-Malayeri & Selier 2010).

is probably because the spectrum of N 66A-1 is contaminated by the closest neighboring star, called N 66A-2. If star #2 were of later type than star #1 the latter would be earlier than O8 V.

3 Discussion

The compact H II region N 66A is powered by a couple of massive stars, which represent a relatively younger generation in the N 66 complex. N 66A is associated with a compressed ionized front and an absorption lane. These observations suggest that its formation results from triggering by a previous generation of massive stars in the complex (Heydari-Malayeri & Selier 2010). This suggestion of a younger age for the exciting stars of N 66A agrees perfectly with other studies of this region. For example Gouliermis et al. (2008) note that the whole N 66 region may host younger star formation events induced from the east. Interestingly N 66A lies on this triggered formation arc.

N 66A is the most compact H II region of the N 66 complex in the optical. Moreover it presents a high excitation ratio and is marked by a prominent absorption lane of local dust (Sect. 2.1). These properties classify N 66A as a member of a rare class of H II regions in the Magellanic Clouds (MCs) called High-Excitation Blobs (HEBs). The two other known examples of HEBs in the SMC are N 88A and N 81 (Heydari-Malayeri et al. 1999a, b, 2002). These objects are very dense and small regions usually 5 to 10″in diameter ($\sim$ 1.5 to 3 pc) in contrast to the typical H II regions in the MCs. They are characterized by a higher degree of excitation and are heavily affected by local dust. Although the formation mechanisms of these objects are not yet well understood, it seems sure that they represent the youngest massive stars reachable through IR and optical techniques. Therefore they offer a good compromise between massive stars "at birth", embedded in ultra-compact H II regions, and those in evolved, classical H II regions.

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