Massive Stars Near and Far
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A SITELLE view of the Galactic Wolf-Rayet Nebulae NGC6888 and NGC2359

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Abstract. In this paper, we present a glimpse of our observations of two Wolf-Rayet (WR) nebulae, NGC2359 and NGC6888 obtained with the SITELLE imaging Fourier transform spectrograph. The data are of unprecedented spatial coverage and cover a broad wavelength range.

Keywords. ISM: bubbles, stars: Wolf-Rayet, HII regions, ISM: NGC2359, ISM: NGC6888

1. Introduction

The winds of massive stars sculpt their surrounding interstellar medium (ISM) leaving traces of the geometry, abundances and strength of the mass-loss from the star during its life. These powerful outflows create cavities with diverse morphologies and ionization structures, with which the supernova ejecta will interact. The comparison of the physical properties of the surrounding ISM with evolutionary models helps to shed light on some unanswered questions of massive-star evolution. The WR phase is critical as it is thought to immediately precede the supernova and follow either a Red Supergiant or Luminous Blue Variable phase, depending on its initial mass. Here we present preliminary results for two such nebula, NGC2359 and NGC6888 from data of unprecedented spatial coverage using the SITELLE instrument on the Canada-France-Hawaii Telescope (CFHT).

2. The observations

We obtained several data cubes using different filters of NGC2359 and NGC6888 with SITELLE. With a field-of-view of $11'' \times 11''$, this instruments provides spectra with a spectral resolution selected by the observer for each $0.32''$ pixel of the image. The many filters available cover all main transitions that are used to determine the physical conditions of the gas (extinction, electronic densities and temperatures, abundances).

3. NGC2359

NGC2359 surrounds the very hot (T_*=112kK; Hamann et al. 2019) WN4-s star HD 56925. This nebula presents strikingly different views, depending on which line is used, revealing the ionization state of the gas that results from varying physical parameters (gas abundances, distance of the gas from the ionizing source, gas density). Fig. 1 shows a composite view with Hα in red, [NII]λ6548,6584 in green and [SII]λ6716,6731 in blue. It is clear that the bubble is nearly invisible in the two latter doublets but strong in Hα. It also emits strongly in [OIII]λ5007 presented in Fig. 2 in blue together with [OII]λ3729,3729 in yellow. This figure clearly illustrates the striking ionization contrast between the bubble and the arc feature. In Fig. 3 we show a section of a spectrum of NGC2359 encompassing

Figure 1. A composite SITELLE image of NGC2359. Hα is in red, [NII] in green and [SII] in blue.

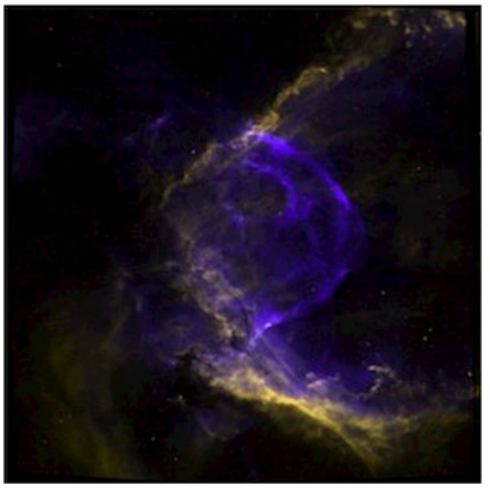

Figure 2. Change in the ionization state of the gas in NGC2359 illustrated as [OIII] in blue and [OII] in yellow.

the resolved components of the [OII] doublet, which ratio will enable the determination of the electronic temperature of the oxygen gas. The faint H9 line is also detected.

4. NGC6888

Figs. 4 and 5 show SITELLE observations of the south-western half of NGC6888 that is ionized by the WN6(h) star HD192163 in Hα and [OIII]λ5007 respectively. It is considered a prototypical wind-blown bubble with its main shell expanding at $\sim$70 km/s (Esteban & Vilchez 1992). Reyes-Pérez et al. (2015) simultaneously modelled the star and the nebula and were able to reproduce both the stellar and nebular emission-line strengths using a temperature for the star of T_*=70000K and a uniform abundance pattern throughout the gas. They found that the star and the nebula were overabundant in N and C

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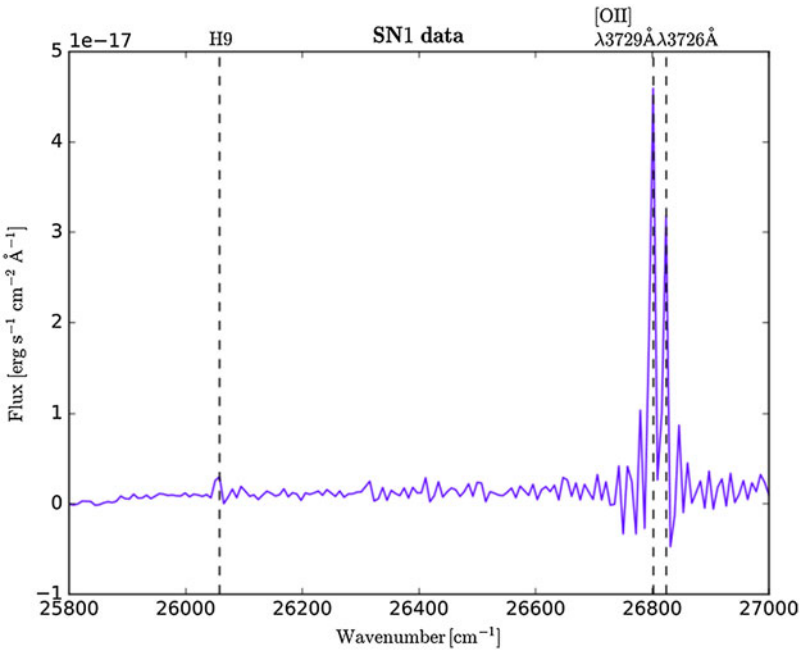

Figure 3. Part of a spectrum of NGC2359 from a section of the arc showing the resolved [OII] doublet.

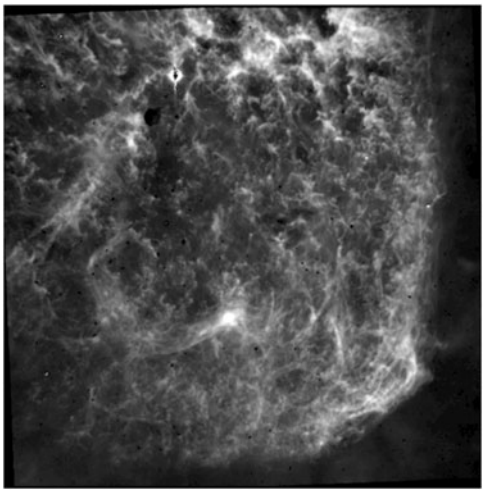

Figure 4. SITELLE image of the filamentary nature of the gas in the NGC6888 nebula as seen in Hα.

but depleted in O. The kinematics of the gas can be studied by fits to various nebular lines. In Fig. 6 we present a histogram of velocities from a two-component fit to the Hα line.

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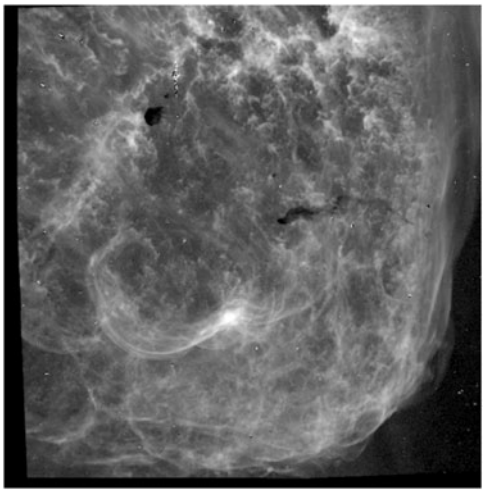

Figure 5. NGC6888 in [OIII]λ5007 highlighting the thin outer shock interacting with the ISM.

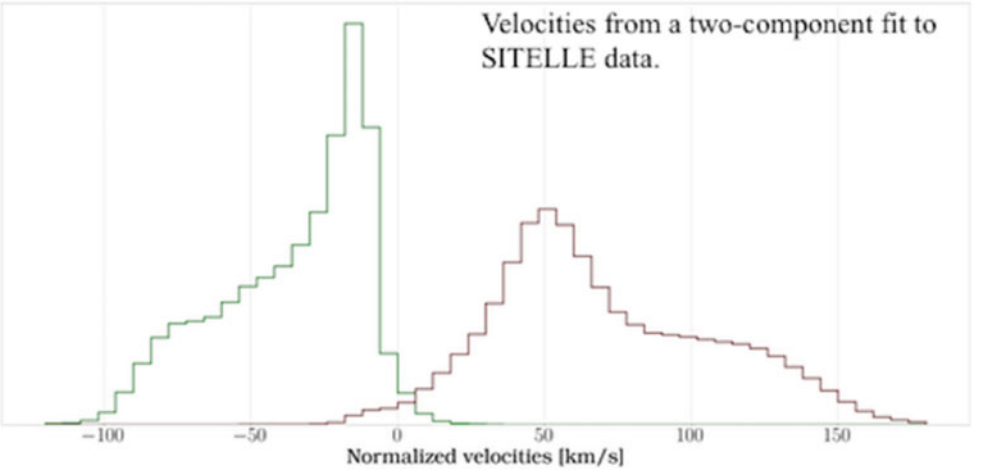

Figure 6. Histogram of velocities of the gas of NGC6888 from a two component fit of the Hα line.

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