We present the first high resolution $\lambda$4686 images of the high excitation nebula around the WR star Brey 2 in the LMC. This nebula presents a striking morphology: a small arc-like feature some 3.6 pc in radius is particularly prominent in the $\lambda$4686 line. We further discover a previously unknown faint emission that extends over an area of $22 \times 17$ pc$^2$. An even fainter emission is apparently associated with the interstellar bubble blown by the progenitor of Brey2. The total flux corresponds to an ionizing flux of $4 \times 10^{47}$ photons s$^{-1}$.


Introduction

Except for Planetary Nebulae, high excitation features, such as nebular emission, are not expected in regions. Indeed, normal O stars do not emit enough hard UV photons to produce detectable nebular emission. However, in the last two decades, seven objects of the Local Group were found to harbour such nebular emission (Garnett et al. gar91). Wolf-Rayet (WR) stars are the ionizing sources of five of them. These stars are hot, evolved massive stars that possess strong winds, but until then they were generally believed to be unable to excite such highly ionized nebulae. Nebular emission was also discovered farther away, in star-forming galaxies (e.g. I Zw 18, see French fre) and WR stars were again thought to be responsible for it (Schaerer sch). This type of emission thus seems intimately linked to WR stars in most cases, and the analysis of these peculiar highly ionized objects can help us put tighter constraints on the poorly known extreme UV ionizing fluxes of these stars (Crowther cro). Only the nebulae of the Local Group are situated close enough to enable a detailed study.

We study here the nebula associated with Brey2 (or BAT99-2 in Breysacher et al. bat), a WN2b(h) star in the Large Magellanic Cloud (Foellmi et al. foe). This WR star has blown a small bubble whose expansion velocity reaches 16 (Chu et al. chu). Moderate chemical enrichment was detected in this bubble (Garnett & Chu gar). Using this result, Chu et al. (chu) suggested that the circumstellar bubble was probably currently merging with the interstellar bubble blown by the progenitor of the WR. Nebular emission near Brey2 was first detected by Pakull (pak). Imaging of the nebula in the lines is crucial in establishing the distribution of the emission in detail, in order to evaluate the total flux, and to better understand the origin of the ionization. To date, only low resolution, low signal/noise images exist (Melnick & Heydari-Malayeri mel). Thanks to observations made with the Very Large Telescope (VLT), we present here the first high resolution $\lambda$4686 images and a detailed spectral analysis of this peculiar highly ionized nebula.

Observations

We obtained CCD images of Brey2 and its associated nebula with the FORS instrument installed on the 8 m VLT-UT3 in 2002 January. The images were taken through seven filters (, $\lambda$5876, $\lambda$4686, plus three continuum filters centered on 4850, 5300, and 6665 ˚A) for exposure times of $3 \times 100$ s, $9 \times 400$ s, $9 \times 600$ s, $9 \times 600$ s, and $3 \times 100$ s, respectively. The seeing was $\sim$1. The data were reduced with iraf using standard methods for overscan and bias subtraction and flatfielding. Stellar sources were removed using the photometric and astrometric information obtained from the continuum images (details are reported by Nazé et al., in preparation). The few remaining faint stars were either removed individually or not considered for flux determinations. Fig. br2ha presents a three color image of the whole field; while Fig. mosaic shows a close-up on Brey2 in the four nebular filters.

During the same observing run, we also obtained long-slit spectra of Brey2 with the same instrument. We used the 600B and 600V grisms to obtain a blue spectrum covering 3700-5600 ˚A ($R \sim 800$) and a red
spectrum covering 4500-6850Å ($R \sim 1000$), respectively. The 1.3×6.8′ slit was tilted by 45° and centered on Brey2. The spatial resolution was ∼1.2 and the spectral resolution, as measured from the FWHM of the calibration lines, 7Å. The spectra were reduced and calibrated in a standard way using iraf. For flux calibration, we observed several standard stars from Oke (oke) and used the mean atmospheric extinction coefficients for CTIO reduced by 15%. Sky subtraction was done using a small region of the spectra where the nebular emission is the lowest. Only a few residuals remained for the brighter sky lines (e.g. 5577Å).

The high excitation nebula surrounding Brey2

Morphology

figure Color image of the Brey2 field. Red, green and blue correspond to continuum subtracted, , and images, respectively. The different regions used for spectral analysis are marked by a solid line. Features discussed in the text are labelled. br2ha