

3D numerical model for NGC 6888 Nebula

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We present 3D numerical simulations of the NGC6888 nebula considering the proper motion and the evolution of the star, from the red supergiant (RSG) to the Wolf-Rayet (WR) phase. Our simulations reproduce the limb-brightened morphology observed in [OIII] and X-ray emission maps. The synthetic maps computed by the numerical simulations show filamentary and clumpy structures produced by instabilities triggered in the interaction between the WR wind and the RSG shell.

1 Numerical simulation

The galactic bubble NGC 6888 is produced by the WR 136 star. This bubble is a case of a limb-brightened, asymmetric structure. The limb-brightening can be caused by a bow-shock produced when the star (in this case the WR 136) moves through the ISM. The WR 136 is a runaway star with a proper motion $\sim 75 \text{ kms}^{-1}$.

Taking into account the above, we show numerical simulations which consider the interaction between the WR wind and the bow shock generated during the previous RSG phase (cf. Table 1 for a list of the parameters used in the RSG and WR stages). The emission maps are computed from the 3D numerical simulations taking the y -axis as the line of sight (thus the xz plane represents the plane of the sky). We have carried out 3D numerical simulations with the adaptive mesh refinement Yguazú code (Raga et al. 2000). A computational domain of $256 \times 256 \times 512$ pixels was considered along the x , y , and z axis respectively, with a maximum resolution of 9.7×10^{16} cm.

Tab. 1: Parameters from numerical simulations; where \dot{M} and V_w are mass loss rate and velocity wind from the star, respectively.

parameters	RSG	WR
$\dot{M}[10^{-5}M_{\odot}\text{yr}^{-1}]$	8	3
$V_w[\text{km s}^{-1}]$	75	2000

1.1 Results

- The interaction between the bow shock created by the RSG and the WR wind produce the limb-brightened observed in the NGC 6888 nebula.
- The expansion of the fast WR wind into the slow RSG wind produce the Vishniac and Rayleigh-Taylor instabilities, creating clumpy and filamentary density structures (see Fig. 1).

- The total X-ray luminosity computed from the simulations is $1.9 \times 10^{33} \text{ erg s}^{-1}$ in the $[0.4 - 2.4]$ keV range, which is in agreement with the observed one.

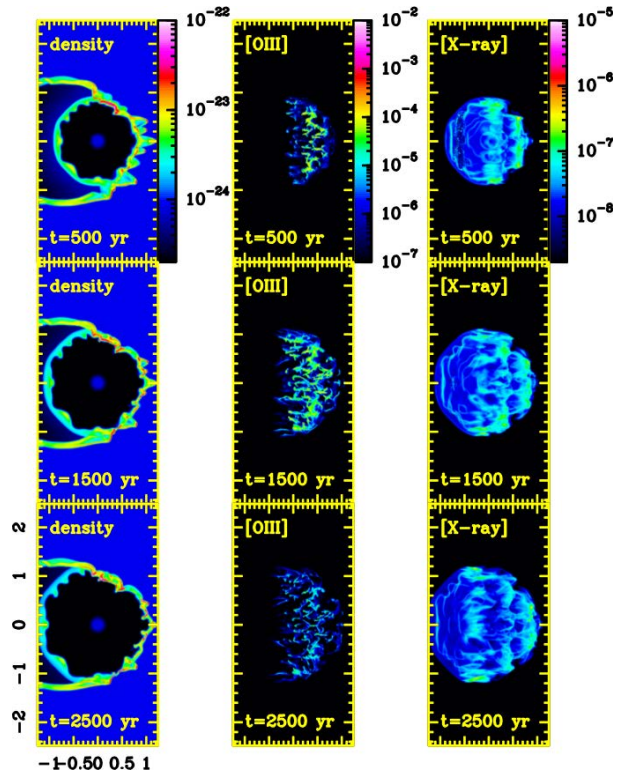


Fig. 1: From left to right (in the XZ plane): cuts of density distribution [g cm^{-3}], [OIII] and thermal X-ray [$\text{erg s}^{-1} \text{ cm}^{-2} \text{ sr}^{-1}$] synthetic maps at different evolutionary stages (from top to bottom) of the WR phase.

References

- Raga, A. C., Navarro-González, R., & Villagrán-Muniz, M. 2000, *Rev. Mexicana Astron. Astrofis.*, 36, 67