Modeling the wind-shaped CSM of a blue supergiant: Sher 25

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observation

HST image of the bi-polar circumstellar nebula around B1.5Iab supergiant Sher 25, from [2].

model

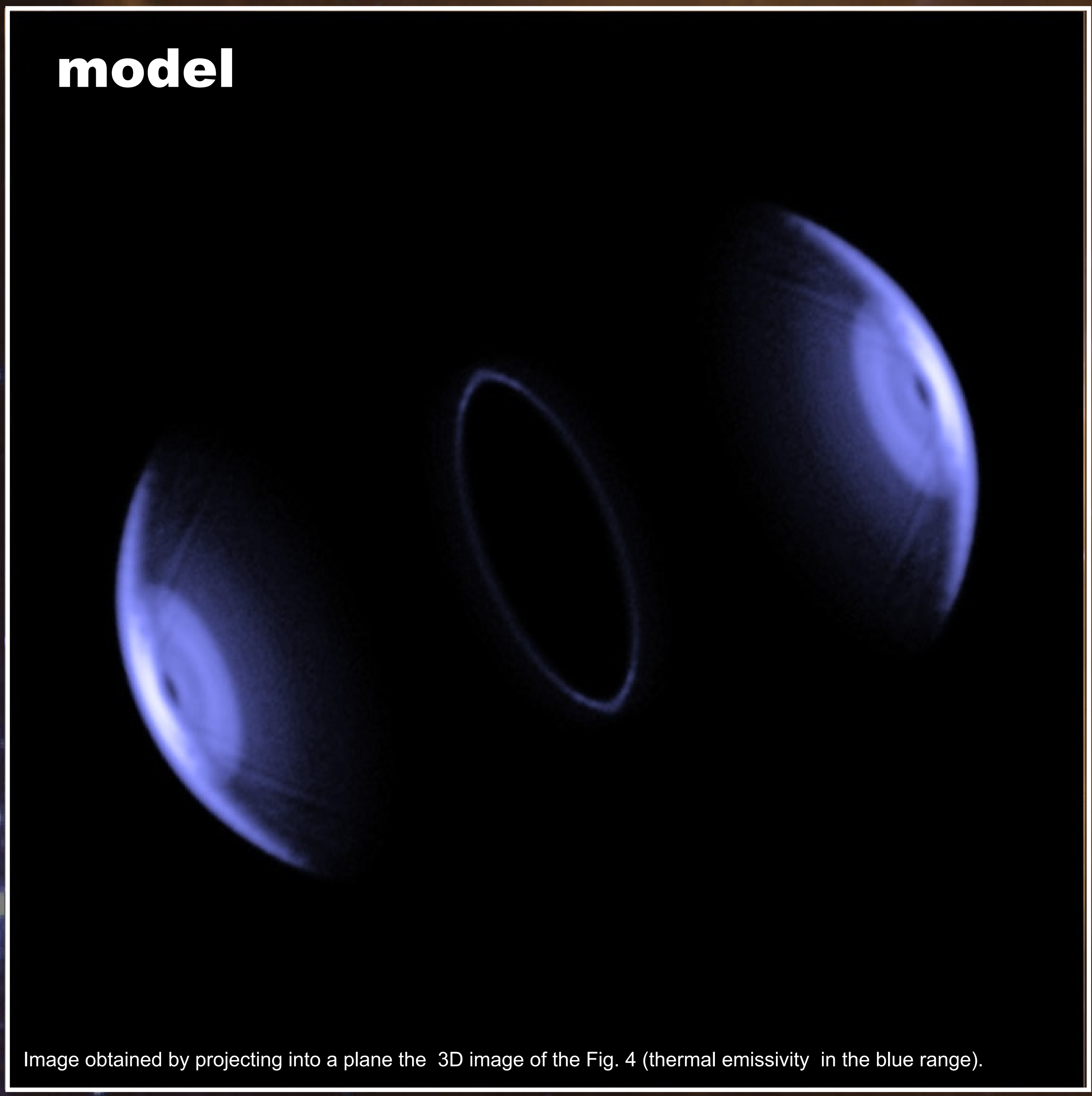

Image obtained by projecting into a plane the 3D image of the Fig. 4 (thermal emissivity in the blue range).

Complex circumstellar structures as seen in Sher 25 are the natural by-product of a red-to-blue evolution.

Stellar and wind evolution: Rotation and asymmetric winds

Massive stars between 10-20 solar masses after their main sequence, are expected to expand twice into red supergiants (RSGs), with an intermediate blue supergiant (BSG) phase before exploding as supernova.

Throughout its life, a massive star emits winds with mass-loss rate and wind velocity varying with time. During the BSG phase the star rotates so rapidly that the wind becomes highly aspherical with mass-loss rate and wind velocity beeing affected by rotation (see[4]).

The interaction of a fast wind with a slow preceding wind but also that of a slow wind the hot bubble created by a fast preceding wind give rise to the formation of circumstellar shells (see [5]).

We use a simple version of the wind compresion model to describe stellar wind anisotropies induced by rotation (see [1] and [5]). The stellar and wind parameters, as function of time from our stellar evolution models, are used as input for the hydrodynamic circumstellar matter, which we compute with ZEUS-3D (see [6]).

Comparison with Sher 25

The hour-glass shape of the blue supergiant shell in our circumstellar model (Fig.2) give rise to form structures as observed around the B1.5Iab supergiant Sher 25 (see [2]).

The symmetry axis through the polar lobes at 1.4 pc is perpendicular to the equatorial ring of 0.5 pc in diameter. The mass in the polar caps in our model is approx 0.0043 solar masses (see [3]).

The morphology of the circumstellar matter as seen in Fig.2 and Fig.3 together with the density emisivities in different photon energy regimes as seen in Fig.4, extracted from the hydrodynamical models, confirm the similarity with Sher 25.

The short lifetime of such structures in our circumstellar models is consistent with their rare occurrence in nature.

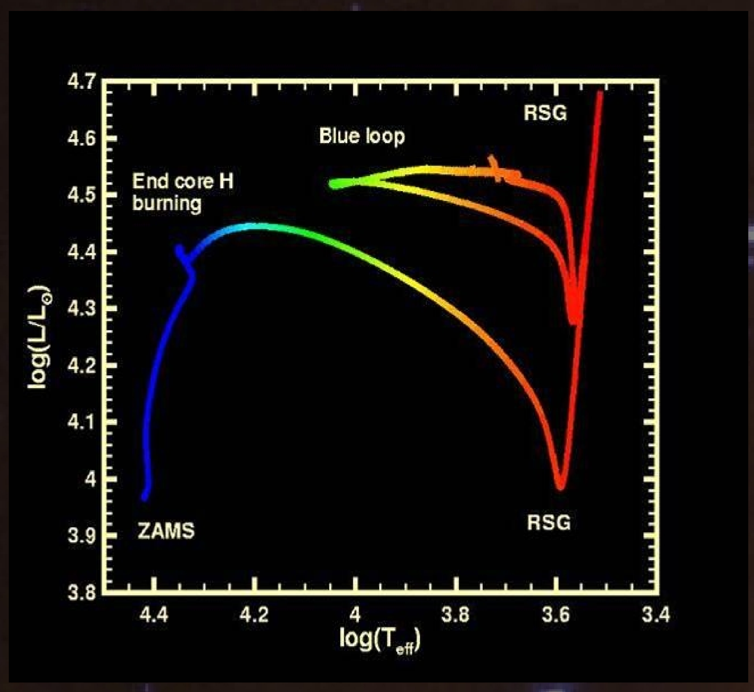

Figure 1 Evolution of a 12 solar masses star in the Hertzprung-Russell diagram (see[4]).

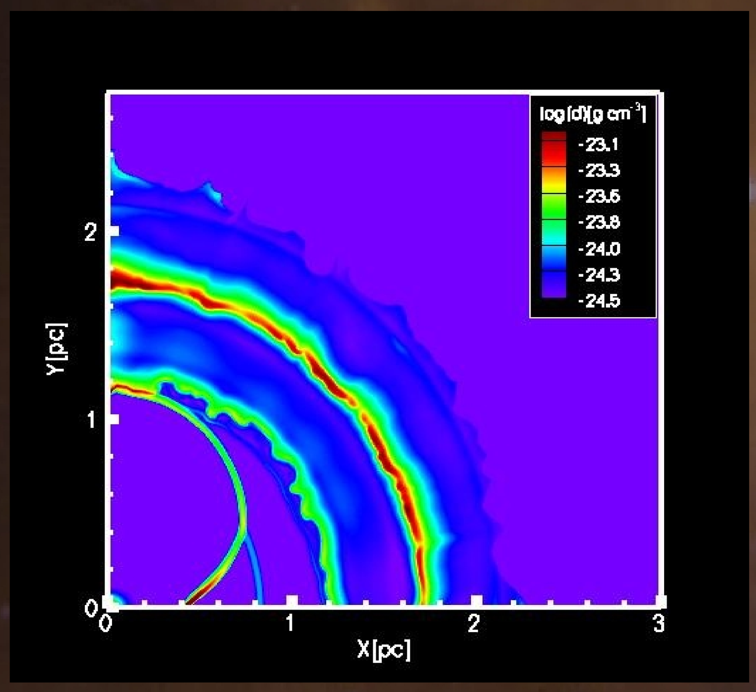

Figure 2 Density distribution of the circumstellar material around our 12 solar masses model after its first post red-supergiant stage (RSG) and at the beginning of the blue supergiant stage (BSG). The fast, anisotropic BSG wind sweeps up the preceding RSG wind into an asymmetric shell, (situated at 0.5 pc in the equatorial plane and 1.2pc on the polar axes) which after approx 10000 yrs, collides with the older spherical symmetric RSG shell situated (1.2-2.0 pc).

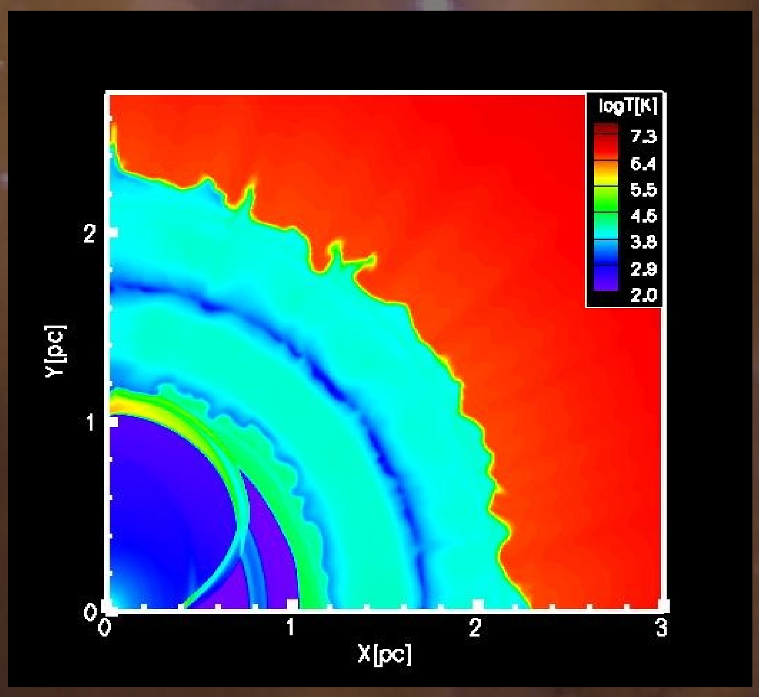

Figure 3 Temperature of the circumstellar material at the same time as Fig.1. The blue supergiant shell collides with the cold dense spherical red supergiant shell.

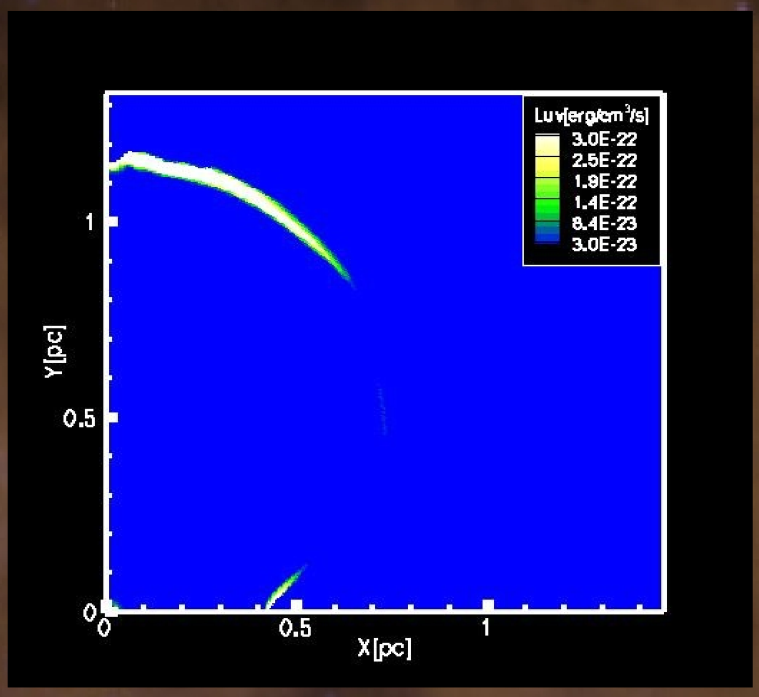

Figure 4 Emissivity, as a function of density and temperature from our models, calculated for the entire ultra-violet wavelength range at the same time as Fig.1. The blue supergiant aspherical shell, at the polar axes and equatorial plane, is visible into the UV regime when it collides with the red supergiant shell.

References:

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