sequence) and cools. Hydrogen fuses to helium in a shell surrounding the core, releasing more power (energy per unit time) than on the main sequence, and the point representing the star ascends the red giant branch of the ▶ Hertzsprung-Russell diagram. The ascent stops when core temperature allows helium fusion, which takes place in the red clump (for metal-rich stars) or in the ▶ horizontal branch (for metal-poor stars). More massive stars become red supergiants, which are substantially more luminous, while *red dwarfs* are fully convective and never evolve to red giants (no differentiation occurs between core and envelope).

See Also

▶ Hertzsprung-Russell Diagram
▶ Horizontal Branch
▶ Main Sequence, Star
▶ Stellar Evolution

Red Rectangle

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Keywords

Reflection nebulae; Extended red emission; Molecular synthesis – photoluminescence; Unidentified infrared emission bands

Synonyms

AFGL 915, IRAS 06176-1036; HD 44179

Definition

The Red Rectangle (astronomical coordinates J2000 RA = 06 19 58.2, DEC = −10 38 14.7) in the constellation Monoceros is the common name given to the infrared source CRL 915 (=AFGL 915). The central star of the nebula is HD 44179 = BD–10°1476.

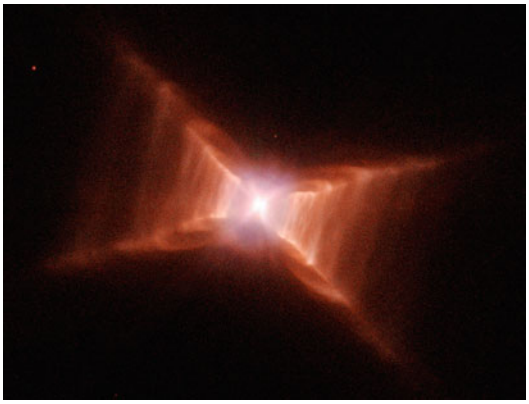
History

The Red Rectangle was discovered as the result of ground-based identification of infrared sources observed in the Air Force Cambridge Research Laboratory (AFCRL) rocket sky survey. The infrared object AFCRL 915 coincides in position with a nebulous object on the National Geographic Society-Palomar Sky Survey red print. Because of the peculiar shape of the nebula, the object was given the name "the Red Rectangle" by Martin Cohen and Mike Merrill. In November 1973, Cohen and Merrill took a picture of the object with the 4-m telescope of the *Kitt Peak National Observatory* and found it to have a set of spikes in the form of an "X." Nebular emission can be detected as far as 56 arc s from the star, giving a total angular extent of ∼2 arc min in the sky. Recent *Hubble Space Telescope* imaging reveals a biconical structure, with the edges of the cone connected by straight "ladders" (see Fig. 1). These structures have been interpreted as the result of projection effects of concentric arcs due to spherical episodic outflows (Koning et al. 2011).

Overview

The central star HD 44179 is of ▶ spectral type B9-A0 and has been identified as a spectroscopic binary system of period 319 ± 3 days (Van Winckel et al. 1995). It is deficient in iron ([Fe/H] = −3.3) and other refractory elements (Mg, Si, Ca) but has normal solar C, N, O, S, abundances.

In the infrared, the Red Rectangle shows strong ▶ unidentified infrared emission (UIE) bands (Russell et al. 1978), suggesting that it is carbon rich. However, infrared emission features attributed to crystalline silicates (olivines) are also seen (Waters et al. 1998).



Red Rectangle, Fig. 1 HST wide field planetary camera 2 image of the Red Rectangle (Photo credit: NASA/ESA Hans Van Winckel and Martin Cohen)

The astronomical extended red emission (ERE) was first discovered in the Red Rectangle (Schmidt et al. 1980). The ERE is likely to be due to photoluminescence of a carbonaceous semiconductor, but the exact chemical nature of the carrier is not known. Narrow emission features resembling those of the diffuse interstellar bands (DIB) can be seen on top of the continuum emission (Van Winckel et al. 2002).

Although the Red Rectangle is widely believed to be an object in the late stages of stellar evolution, its exact evolutionary status is not certain. The most interesting aspect is that the Red Rectangle is an active site of molecular synthesis. The fact that the DIB, ERE, and UIE unidentified emission phenomena all manifest themselves in this nebula raises the question of whether the carriers responsible for these three spectral mysteries are chemically related.

See Also

- ▶ Diffuse Interstellar Bands
- ▶ Extended Red Emission
- ▶ Stellar Evolution
- ▶ Unidentified Infrared Emission Bands

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Reddening, Interstellar

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Definition

Because the extinction by ▶ interstellar dust grains depends upon wavelength, with greater extinction at shorter wavelengths, starlight passing through the interstellar medium is reddened with respect to the light emitted by the source star. The reddening of a star is customarily quantified by astronomers through "selective extinction," defined as