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Protoplanetary Nebula

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Keywords

Planetary nebulae; Reflection nebulae; Stellar evolution

Synonyms

Pre-planetary nebulae

Definition

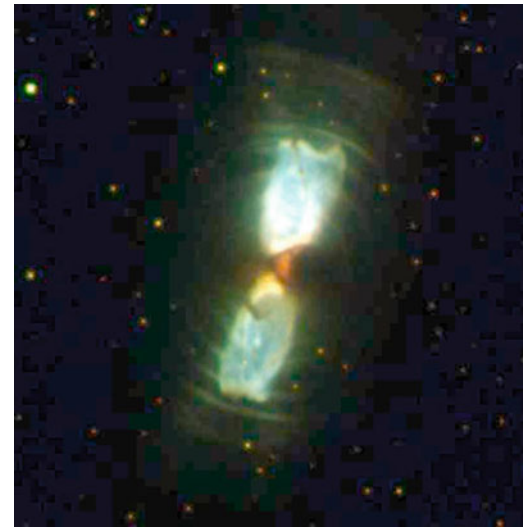
Protoplanetary nebulae (PPN) are objects in transition between the ▶ asymptotic giant branch (AGB) and the ▶ planetary nebulae (PN) phases of stellar evolution. The optical nebulosity of PPN is due to scattered light from the central star, not emission lines as in the case of PN. Observationally, PPN are defined as gaseous nebulae surrounding stars in a post-AGB phase of evolution showing no emission lines in their optical spectra.

History

Since the 1970s, PN have been known to be descendants of AGB stars, and the nebulae

represent remnants of ejecta from AGB stars. The visual brightness of PN is the result of ▶ line emission from gas photoionized by a hot central star. From models of stellar evolution, it was known that the central stars of PN need a few thousand years to evolve from the end of the AGB to a temperature hot enough to emit a significant amount of ultraviolet radiation capable of photoionizing the circumstellar gas (Schönberner 1983). However, for a long time, no such transition object was known and the phase linking AGB stars and PN represented a missing link in the late stages of stellar evolution.

The emission mechanisms responsible for the brightness of PN are primarily recombination lines and collisionally excited lines. Both are extremely efficient, making PN bright optical objects (Kwok 2000). Without ionized gas, PPN have to rely on scattered light from the central stars, making the nebulosity very faint in the visible. However, since AGB stars are known to be strong infrared sources due to dust emission, it was suspected some infrared sources discovered in the Air Force Infrared Sky Survey could be PPN (e.g., AFGL 618, Westbrook et al. 1975; AFGL 2688, Ney et al. 1975). After the Infrared Astronomical Satellite (IRAS) sky survey observed a large number of AGB stars and planetary nebulae, it was realized that PPN could be identified as objects having infrared colors intermediate between those of AGB stars and planetary nebulae (Volk and Kwok 1989). A systematic search of IRAS sources matching such color criteria has resulted in the discovery of ∼30 PPN (Kwok 1993), one of which is shown in Fig. 1.



Protoplanetary Nebula, Fig. 1 Hubble Space Telescope Wide-Field Planetary Camera 2 image of the protoplanetary nebula IRAS 17150-3224 (the Cotton Candy Nebula). The visual brightness of the object is entirely due to scattered light. In addition to its bipolar morphology, multiple concentric arcs can also be seen

Overview

PPN have the following observational characteristics: (i) their central stars have spectral types intermediate between those of AGB stars and PN, usually of spectral types F, G, and K; (ii) their central stars have low surface gravity, often classified as luminosity class I or Ia; (iii) their infrared spectra are dominated by thermal continuum emission from warm dust; (iv) molecular emission lines can be seen in their mm/submm spectra; (v) their spectral energy distributions show evidence of detached dust envelopes; and (vi) their optical nebulosity is due to scattered light.

Imaging observations by the *Hubble Space Telescope* have shown that many PPN show bipolar morphology, suggesting that the transformation from spherical to bipolar morphology has already taken place during the post-AGB phase of evolution (Balick and Frank 2002). Some PPN have binary central stars (Van Winckel 2003), which may play a role in the creation of the nebular bipolar morphology.

Most interestingly, spectral signatures of aromatic and aliphatic organics first appear during the PPN stage, suggesting that the synthesis of complex organics can occur in the circumstellar environment (Kwok et al. 1999).

See Also

- ▶ Asymptotic Giant Branch Star
- ▶ Stellar Evolution
- ▶ Unidentified Infrared Emission Bands

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Protoplasmic Theory of Life

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Definition

During the second part of the nineteenth century, the British biologist, Thomas Huxley (1825–1895), claimed that, inside the cell, the protoplasm was essentially composed of albuminoidal bodies and would be the place of the physical basis of life. This theory led some biologists, as the German Ernst Haeckel (1834–1919), to assume that origin of life could correspond to the formation of free protoplasm.

See Also

▶ Abiogenesis
▶ Cellular Theory, History of
▶ Huxley's Conception on Origins of Life

Protoplast

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Synonyms

Spheroplast

Definition

A protoplast is a bacterial, fungal, or plant cell that has had its cell wall completely or partially removed using either enzymatic or mechanical means. ▶ Cell walls are made of a variety of polysaccharides (▶ peptidoglycan, chitin, cellulose). Protoplasts are generally prepared by degrading cell walls with a mixture of appropriate polysaccharide-degrading enzymes. In the case of gram-positive ▶ bacteria, lysozyme, an enzyme that breaks the bonds that maintain the structure of the peptidoglycan, is used. To prepare plant cell protoplasts, a mixture of hydrolyzing enzymes (cellulose, proteinase, and xylanase) is required. In the case of fungal protoplast, chitinase is the enzyme of choice. During and subsequent to digestion of the cell wall, the protoplast becomes very sensitive to osmotic stress. This means that cell wall digestion and protoplast storage must be carried out in an isotonic solution to prevent the disruption of the plasma membrane. Protoplasts are useful for genetic recombination experiments, because the absence of a cell wall facilitates the transport of DNA molecules to the cytoplasm. Protoplasts are normal cells, their growth allows the generation of cells with cell walls. Although most prokaryotes