# FILAMENTS OF THE HELIX NEBULA

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Thirty years ago Baade discovered in the Helix Nebula extremely thin radial filaments, but since then their existence has been neglected. Data presented below were obtained by studying a copy of a plate obtained in 1954 in the light of Hα with the 200-inch telescope. Our goal is to draw attention to these filaments, which are of great importance for the understanding of planetary nebulae in general.

The thickness of the filaments is approximately 1″ of arc, and their extension is about 30″ of arc. The regular linear filaments point exactly at the nucleus of the nebula, and are best seen against the dark background inside the ring. Hundreds of filaments can be individually resolved, and thousands of fainter filaments must also be present. Apparently the bright ring of NGC 7293 is formed entirely of coalesced filaments. As a rule, each filament has a bright condensation at its inner end. The brightness of filaments can be from 19 mag to 20 mag. Adopting a distance for NGC 7293 of 100 parsec, the length of the filaments is 3000 AU and their width is 150 AU. Neither short filaments nor their condensations can be seen in the central part of the nebula. Thus the filaments and the ring they form actually are a kind of a thick toroid.

It is very improbable that the filaments represent gaseous streams directed from the envelope to the nucleus of the nebula. Instead, they must be formed by corpuscular currents ejected by the nucleus, or by tracks of an unknown agent. The absence of the filaments nearer to the nucleus than about 90″ even in the plane of the ring is enigmatic. The filaments are reminiscent of solar corpuscular streams, both being nearly cylindrical in cross-section. A thin column of ionized dense gas, ejected from the nucleus, probably first loses its luminescence and then becomes luminous again by the Zanstra mechanism just in the vicinity of the ring. It is difficult to explain the condensations in the gas, or the luminosity at the end of a filament, which faces the nucleus.

From the velocity of ejection of about 1000 km/sec, observed in Wolf-Rayet stars, one can easily calculate that the gas from the nucleus will reach the ring in some 70 years. Such motions are easy to detect from already existing plates. After penetrating into the expanding ring the corpuscular streams slow down and dissipate. The ejection from the nucleus can be recurrent and its duration can be variable. If the value of electron density in the filaments is of the same order of magnitude as that found in

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FIG. 1. *Part of NGC 7293, 200-inch plate taken in* $H\alpha + [N\,\text{II}]$, *showing filaments and condensations.*

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other ring-shaped planetary nebulae, say $n_e = 500\ \text{cm}^{-3}$, the mass of a single filament is $5 \times 10^{25}$ gm; 1000 filaments have a mass $10^{-5}\ M_{\odot}$, equal to the mass loss by a Wolf-Rayet star during 1 year. The creation of the nebular envelope would require $10^2$–$10^3$ years of such activity by the nucleus.

The structure and origin of the nebular envelope of the Helix Nebula must be typical at least for all ring planetary nebulae.

## DISCUSSION

*Mathews:* The instabilities in NGC 7293 could result from a Rayleigh-Taylor instability at the shock front where a stellar wind from the central star interacts with the bulk of the nebular matter.

*Liller:* We have measured the angular radial motion of three of the bright condensations within the ring of NGC 7293 on 100-inch Newtonian plates, the earliest of which was Baade's discovery plate. The mean radial motion of these condensations is $+1\overset{''}{.}0 \pm 0\overset{''}{.}4$ of arc per century, at a mean distance of 176″ of arc from the central star. If we assume the distance to be 200 parsec, this motion corresponds to a linear velocity of about 10 km/sec, considerably less than the velocities mentioned by Vorontsov-Velyaminov.