

## THE ATLANTA OBSERVER'S NOTEBOOK

- prepared for the members of the Atlanta Astronomy Club -

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### Origin of a Planetary Nebula

Planetary nebula may be recognized by their appearance, visually or photographically. Many of the brighter ones were discovered long ago by William Herschel and John Herschel by simple inspection. More recently, such searches have been made on photographs taken with filters that isolate the hydrogen-alpha line. This was the procedure used by George Abell and others with great success on plates of the Palomar 48-inch Schmidt telescope. Of course, this method works only for extended surfaces, and nebulae smaller than 15 seconds of arc are difficult to distinguish on the Palomar plates.



The famous Dumbbell nebula in Vulpecula is one of the largest and brightest planetaries in the sky. An enormous expanding cloud of highly rarefied gas, it is excited to shine by a faint but very hot central star. The author obtained this photograph on August 19, 1976, with the 14 $\frac{1}{2}$ -inch reflector at Campbellton<sup>o</sup> Observatory in Marietta. It is a 5-minute exposure on Kodak 103a-F film. The dimensions of the Dumbbell are about 8 by 5 minutes of arc, which at the object's distance of roughly 1000 light years correspond to 2.3 and 1.5 light years. Easily visible in small telescopes, the Dumbbell was discovered by Charles Messier in 1764 and is, therefore, cataloged as M27. -B.C.

Despite their great range in apparent size - from tiny objects indistinguishable from stars to faintly glowing masses several minutes of arc across - all the planetary nebulas share certain basic properties. In each instance the luminosity is derived from a hot star imbedded within the nebula. Sometimes the star is masked by the brightness of the nebular background, but this can easily be understood if we imagine a shell of ionized gas glowing from the energy of a central star whose surface temperature reaches 100,000° Kelvin or more.

In nearly all planetaries, the nebula is symmetrical around the star (unlike the diffuse nebulosities), showing that the nebula originated at the star. When internal motions can be measured, the gaseous material appears to be moving outward from the star at velocities of 10 to 30 kilometers per second. This is much slower than the expansion during a nova outburst, which is at hundreds or thousands of kilometers per second.

Planetary nebulae are not rare freaks, but represent an advanced stage in stellar evolution. Not every star evolves into a planetary nebula, but recent statistical studies by J. N. Cahn indicate that at least 25 percent may do so.

Stars shine by converting hydrogen to helium in its core. Eventually the hydrogen becomes exhausted in the central part of the star, but hydrogen burning

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continues in a thin interior shell. When this occurs, the star undergoes a profound change in structure: it becomes a giant. The outer part expands and the core contracts. This process may continue until the outer envelope becomes very large, and eventually the outer layers must escape into space while the core contracts to a white dwarf star. It is widely believed that a planetary nebula is formed as the envelope of a one-time giant star swells outward to dimensions exceeding our solar system's, its gases being excited to shine by the radiation from the intensely hot contracting core.

In the earlier stages, the gases near the central star are ionized by the ultraviolet radiation from the star, but the density is so high that ions and electrons recombine rapidly. Thus, the nebula is bright, thereby identifying itself as a new event. As the shell expands, its density decreases, and the recombination of ions and electrons is slowed. As a result, the nebula gradually grows larger and fades away. After centuries, the last observable stage is a large ghostlike disk, barely visible on the longest exposures with the largest of telescopes.

Lawrence H. Aller concluded his fine study on planetary nebulas (which appeared as a series published in Sky and Telescope during 1971) by stating the following: "Perhaps we can now answer the question of what the planetaries are, at least to a poet's satisfaction. They are wreaths placed by Nature around dying stars."

- Bob Campbell

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THE DOUGHNUT STAR

I took my brand new telescope,  
Went out to view the stars,  
I thought I might see Jupiter  
Or maybe even Mars.

I used directions carefully  
(My first time out, you see).  
I aimed the 'scope up skyward then  
Over the tallest tree.

Imagine my excitement when  
The star that came in view  
Shown big and round and beautiful  
And had a hole clean through!

I looked again and turned some dials -  
The "doughnut star" still shined!  
Shades of Shapley and Messier!  
They'd nothing on my find!

But before I called Smithsonian  
To tell my thrilling tale,  
I thought I'd better check it out,  
So I rang up Charlie Gale.

I told my story and assured him well  
This was no hocus-pocus!  
He just sighed patiently and said,  
"My dear, you're out of focus!"

-Jody Watts