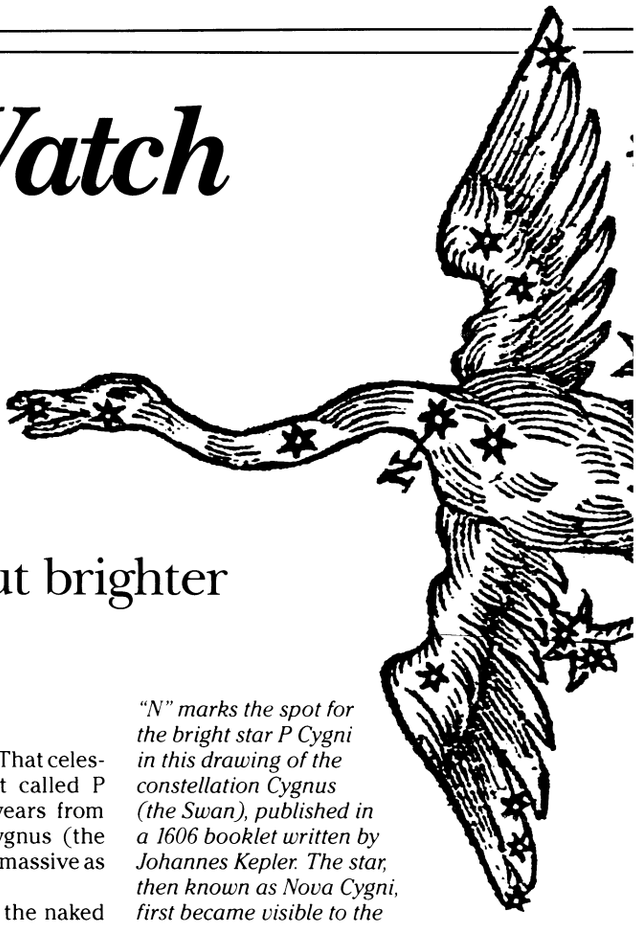
Astronomers Watch a Star Age



A blue supergiant grows older, but brighter

By RON COWEN

"N" marks the spot for the bright star P Cygni in this drawing of the constellation Cygnus (the Swan), published in a 1606 booklet written by Johannes Kepler. The star, then known as Nova Cygni, first became visible to the naked eye in 1600.

From William Shakespeare to Cole Porter, poets and songwriters have hailed stars as a constant in nature. Wishes may be ephemeral, but the star you wish upon remains unchanged.

In analyzing recent and historical observations of a star called P Cygni, however, scientists have found that this Milky Way resident has increased steadily in brightness over the past 300 years — indicating it has aged significantly in the twinkling of an astronomical eye.

Astronomers have seen stars die violently in supernova explosions and have watched as rapidly spinning stars called pulsars slow their rate of rotation. But they have had only limited opportunities to observe long-term changes in stellar luminosity. "No one has seen a star age in this way before," asserts Mart J.H. de Groot of the Armagh Observatory in Northern Ireland.

To undergo rapid aging, says de Groot, a star must meet two criteria: It must have a mass more than 25 times that of the sun, and it must already have lived some 500,000 to 2 million years — roughly half its lifetime. A massive star generally evolves hundreds of times more rapidly than a lower-mass star, such as the sun, he notes. But an older heavyweight possesses a special advantage: It has already burned all the hydrogen in its core and converted the material to helium, a property that enables the star to cool down significantly — and alter its luminosity in visible light — over a mere few hundred years.

Countless stars fill the bill for such rapid evolution, says de Groot. But so far, he notes, astronomers have observed only one such star long enough to have detected age-related changes. That celestial object, a blue supergiant called P Cygni, lies some 6,000 light-years from Earth in the constellation Cygnus (the Swan) and is about 30 times as massive as the sun.

P Cygni has been visible to the naked eye ever since Dutch cartographer Willem Janszoon Blaeu first spotted it on Aug. 18, 1600. While mapping the stars in Cygnus on a celestial globe, Blaeu suddenly noticed an extra star in the constellation, near the neck of the swan. A search soon revealed that the star did not appear in any catalog of that region of the heavens.

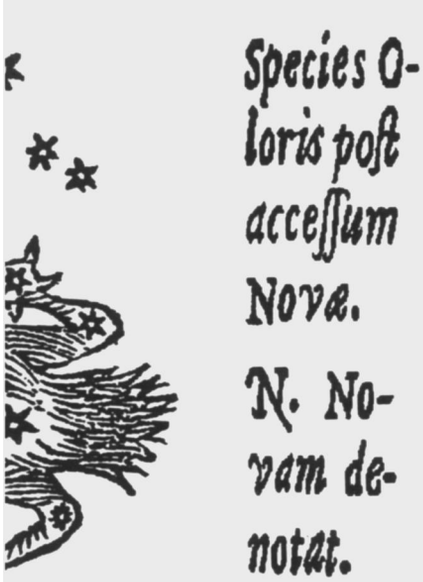
Blaeu's initial sighting commanded plenty of attention, because it seemed that a star visible to the naked eye had debuted suddenly in Cygnus. In fact, the star had been there all along, too dim to be detected in this pretelescope era until it burst into view as the result of an explosive brightening in the summer of 1600.

Johannes Kepler hailed the "new star," then known as Nova Cygni, in a 1606 treatise. And a slew of other scientists, a veritable Who's Who of astronomy, joined the watch after P Cygni underwent a second, less explosive brightening in 1655. William Herschel, the discoverer of Uranus, observed P Cygni eight times in the late 1700s, and his son John followed suit a few decades later. Heinrich Olbers, famous for his paradox about the night sky, viewed the massive star during the first half of the 19th century, as did Nicolas Flammarion, the great French popularizer of astronomy. And at the turn of this century, German researchers studied the star at the Potsdam Astrophysical Observatory. Though none of these scientists ever caught P Cygni in the act of exploding, they did keep careful records of its luminosity.

Those records, many of them compiled by the Potsdam research group, now prove invaluable. De Groot and Henny J.G.L.M. Lamers of the Astronomical Institute of the State University of Utrecht in the Netherlands recently compared modern measurements of P Cygni's brightness in visible light with 30 archival measurements made between 1700 and 1917.

The researchers excluded data gathered before 1700, because the star's sudden — and temporary — brightening during that era would have confounded observations. By 1700, short-term brightening had died down, revealing any underlying, gradual brightening that could be attributed to age. Reducing the possibility for errors in historical data by averaging several of the older measurements, de Groot and Lamers found that the star has steadily brightened over the past 300 years and glows 51 percent more brightly in visible light now than in 1700. They present their analysis in the Jan. 30 NATURE.

"Because there have been very few



massive stars that have been observed really well, we never realized how fast they could evolve — until we saw one doing it and then checked it against the theory," de Groot says.

Nonetheless, a star that *increases* in brightness wouldn't seem to be growing older. But P Cygni's added luminosity in visible light is actually tied to a *decrease* in its surface temperature, de Groot says. Due to its hot temperature, three to four times greater than that of the sun, this star actually radiates mainly at ultraviolet wavelengths, which carry more energy than visible light. As its helium-rich, hydrogen-depleted core contracts, its atmosphere expands in order to maintain equilibrium. The expansion cools the atmosphere, slightly shifting emissions from the hotter, ultraviolet spectra to the cooler, visible-light wavelengths, de Groot explains. The increase in visible-light emissions — coupled with a corresponding decrease in ultraviolet emissions — indicates that the star's surface cools by about 6 percent per century, a sign that the star is indeed aging, he asserts.

"Stellar evolution theory has taken enormous strides in the last 20 years," says de Groot. "But it hasn't always been very easy to check those calculations against what really happens in space. To have a star that lends itself in a superb way to comparison with the theory is a bonus."

"The theory predicts something very close to what we actually saw," he concludes.

Small discrepancies do exist between theoretical models and the observations, however. Theory predicts that a star as massive and as old as P Cygni should have cooled half as slowly — and thus brightened somewhat less — over the past 300 years, de Groot notes.

One explanation, he says, is that P Cygni may have a slightly lower mass than estimated. (A somewhat smaller, less massive star would undergo a little less cooling when its core collapsed.) Another possibility is that the theory needs some revision.

In a commentary accompanying the NATURE article, Achim Weiss of the Max Planck Institute for Astrophysics in Garching, Germany, writes: "The most important point . . . is that the timescale [for aging] is indeed of the order of 100, and not 100,0000, years or more, as is typical for other phases in the evolution of massive stars."

To further test the theory, de Groot has begun searching for long-term records of other massive stars. But that search won't be easy.

"There are just not that many stars that have attracted the attention of astronomers for a long enough time," he laments. □