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NOVAE OR TEMPORARY STARS

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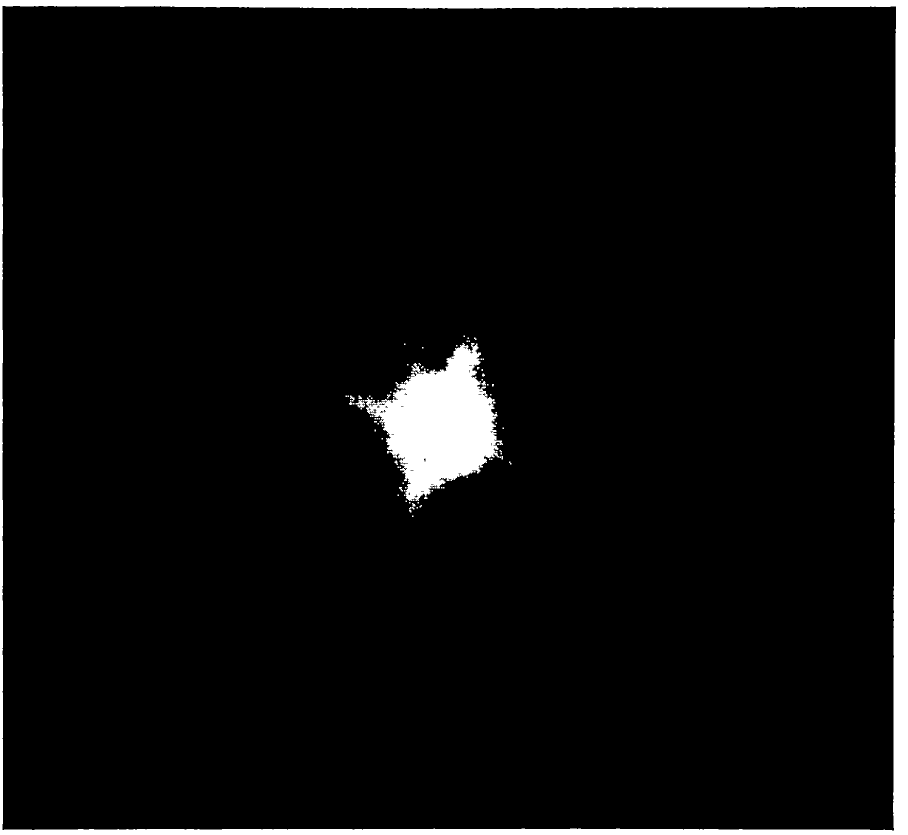

Nova Aquilae (1918) Showing Nebulous Shell 18 Seconds in Diameter. Enlarged from a photograph taken by Dr. Hubble, at Mount Wilson, April 25, 1927. Exposure, 45 minutes.

(Editor's Note: The right-angled rays are factitious and not part of the Nova, being due to diffraction from the ribs supporting the small plane "newtonian" mirror. The photograph proper shows the Nova and its shell as they were in the Eighth Century; but the rays of light bearing the message, speeding constantly through space at the rate of 186,285 miles of distance in each second of time during all the intervening 1200 years, have only recently reached us to form the picture here given. Now invisible to the naked eye, the Nova lies about ten degrees westward and eight degrees southward from Altair, the brightest star in the constellation of Aquila.)

ACCOUNTS which probably refer to bright novae or temporary stars occur from time to time in ancient annals, but it was not until 1572 that scientific observation of such phenomena was undertaken. In that year Tycho Brahe observed the famous nova in Cassiopeia which rivalled Venus in its splendour and could easily be seen in broad daylight. But brilliant novae are rare. Generations pass which never witness such an event. Records are scarce until well into the last century, and not until photography had come into general use were novae discovered in considerable numbers. Our own generation is exceptional in having witnessed four novae of the first rank—Nova Persei (1901), Nova Aquilae (1918), Nova Cygni (1920) and Nova Pictoris (1925). As for the fainter novae, Bailey has estimated that in our own stellar system an average of about ten per year reach maxima brighter than the ninth magnitude (one-sixteenth the brightness of the faintest naked eye stars). These novae appear mostly along the Milky Way, perhaps because the great majority of the stars are near that plane; and they are especially numerous in the region of Sagittarius, the direction of the center of our stellar system. Probably only a few of those occurring are actually observed; the records, in fact, contain only about fifty well observed cases.

Nova Aquilae (1918) may be described as a typical example. For 30 years prior to 1918 it appeared on occasional photographs as a normal white star of the eleventh magnitude (about 100 times fainter than the faintest naked-eye star). On June 5, 1918, its appearance was still normal; but two nights later, on June 7, it had flared up, without any warning, to naked-eye visibility and was still rising at a rate which doubled its luminosity in less than an hour. By the next night it had reached the first magnitude, brighter than Antares; and later still at magnitude —1.4, it outshone all the fixed stars save Sirius alone. In three days it had blazed out to nearly 100,000 times its original brightness—as we now know from 4 to nearly 400,000 times the luminosity of the Sun. Almost at once it began to fade, rapidly at first, then more and more slowly. Eighteen days after maximum it was at the third magnitude, one-fiftieth of its maximum luminosity; eight months later it was lost to the naked eye. Now, after several years, it has faded to its pristine faintness, with only an occasional flickering to recall its great adventure.

In two respects, however, the experience has left its

trace. First, before the outburst, the spectrum appears to have been the normal type A, with a surface temperature of about 10,000 degrees Centigrade, whereas the present spectrum indicates a much hotter surface temperature, from 20,000 to 30,000 degrees, and hence a greater surface brightness. The total luminosity, however, is about the same as before the outburst. This is a discrepancy as yet unexplained, unless we suppose that the size of the star has shrunk just enough to compensate for the increased surface brightness.

The second remaining trace of the outburst is a shell of nebulosity which surrounds the star. This represents material blown out at a velocity of more than a thousand miles per second, as shown by the displacement of lines in the spectrum. Since the shell was first observed by Barnard, some six months after the outburst, it has been expanding at a uniform rate; and in the year 1927 it appeared as a dim halo some 18 seconds in diameter. The angular rate of expansion combined with the linear radial velocity indicates a distance of about 1200 light years from the earth. The outburst, therefore, actually occurred back in the Eighth Century, although the news did not reach us until 1918.

The histories of other novae show wide variations from this particular story, yet there is sufficient uniformity to suggest insistently that one particular type of physical causes is responsible for all the outbursts. The explanation is being sought partly in the distribution of novae among the stars and, more hopefully, in the unravelling of the bewilderingly complex and changing spectra. Among the leaders in this latter field are Wright of the Lick Observatory, and Adams and Joy of Mt. Wilson.

A nova outburst has been described thus: "A star swells up and blows off its cover"—and the prevailing opinion holds that this is not entirely wrong. The star suddenly becomes unstable and some sort of explosion results; but we do not know whether the action is spontaneous or whether it arises from some external stimulus, such for instance as a collision. Novae are so frequent, however, and the lives of stars are so long that we must suppose the outbursts to be normal episodes in the histories of stars. Probably there are preliminary indications which can be observed but as yet they have not been identified. At any moment, so far as we know, any particular star may blaze out as a nova.

Studies of the spectra indicate that outbursts are nor-

mally accompanied by the ejection of nebulous material. Only occasionally, however, is the star so near or the material in such quantity that the nebulosity can be seen or photographed. Nova Aquilae (1918) was such a case and Nova Persei (1901) as well. The Crab Nebula, Messier No. 1, is possibly a third, for it is expanding rapidly and at such a rate that it must have required about 900 years to reach its present dimensions. For, in the ancient accounts of celestial phenomena only one nova has been recorded in the region of the Crab Nebula. This account is found in the Chinese annals, the position fits as closely as it can be read, and the year was 1054! The great loop in Cygnus (NGC 6960-6922) may be a fourth case, but there the expansion is so slow that about 90,000 years would have been required for the nebula to reach its present size. Novae outbursts under exceptional conditions furnish a possible explanation of planetary nebulae in general. This statement, however, is made with the reservation that once the explosion is under way and the nebulosity is receding from the star with enormous velocity, we know of no reason why it should stop and settle down to the equilibrium that is actually observed in the planetaries.

Novae as a class are about the brightest stars in our stellar system, averaging perhaps twenty thousand times the luminosity of the Sun. Could we look back upon our system from some immense distance, from which all save the brightest stars had melted into an unresolved blur, we should still see the novae as they flash out, shine for a while and then fade from sight. In Messier 31, the great spiral in Andromeda, a vast independent stellar system nearly a million light years from our own, we actually witness these very phenomena. More than eighty novae have already been observed in that system, where they seem to occur two or three times as frequently as in our own. Novae have been observed in other systems as well—four, for instance, have been found in Mesiser 33—but in none do the conditions seem to be so favorable as in Messier 31. These extra-galactic novae appear to be entirely similar to novae in our own system, and investigations of them by statistical methods supplements the more intimate study of the latter stars.