BOOK REVIEW

Novae And Related Stars

Proc. of an Intnl. Conf, held by the Inst. d"Ap., Paris, France, 7 - 9 Sept. 1976. Ed., M. Friedjung, Reidel, 1977, $29.50, 231 pp.

Last December, a newspaper told of new evidence (from ancient Chinese and Korean historical records) that the Christmas Star was a nova outburst, and explanation that has received much less consideration recently than the idea of a conjunction of two or more bright planets. This rekindled my interest in novae and made me doubly pleased to review this book, volume 65 of Astrophysics and Space Science Library, a collection of 53 papers presented at a conference in Paris attended by 61 astronomers from 17 different countries.

What is a nova? Laying down this book, I conclude that novae represent, without question, one of the most complex phenomena in astronomy. In this book we encounter virtually every domain of theoretical and observational astronomy: photoelectric and photographic photometry, high dispersion and objective prism spectroscopy, ultraviolet and x-ray satellite observations, polarimetry, magnetic fields, stellar atmospheres, formation of dust grains, binary star evolutions, white dwarf structure, celestial mechanics, dynamical instabilities, hydrodynamics, nuclear reactions, and synthesis of elements. Only cosmology, black holes, and the solar system did not appear on stage.

A complete and coherent description of the nova event is not what this book offers. It is, however, a highly significant benchmark in our understanding of novae. The last international conference devoted to novae was held in 1963. Then, and until recently, the observers and the theoreticians were talking mostly to themselves and not to each other. This book makes it clear that now they have joined hands and the battle is well underway. In fact, in my opinion, the battle is much more than half over, but the dust has not settled and it is difficult to perceive the outcome. Let me begin with a thumbnail sketch of the nova event as I gleaned it, with difficulty, from this book. Then let me describe a few highlights of the book.

Novae occur only in close binaries where one star is overflowing its Roche lobe and is pouring hydrogen-rich gas down into its partner, a hydrogen-depleted degenerate white dwarf. The accretion energy (energy of falling and subsequent impact) heats the hydrogen gas hotter and hotter until eventually runaway thermonuclear fusion ($4H \longrightarrow He$) is triggered. This sudden production of energy and its release into the outer layers (the "envelope") of the white dwarf heaves the envelope up and out. Part of the envelope, driven by a "pressure wave" and preceded sometimes by a "shock wave", escapes from the binary system. The rest of the envelope (the "remnant envelope") contracts from its maximum size of something like 250 R_O, increasing in temperature as it contracts. At this point, there is still so much luminous energy that radiation pressure expels most of the remnant envelope gradually over an interval of months. The source of this energy is either ongoing nuclear fusion in the remnant envelope, or gravitational stirring as the binary continues to orbit <u>inside</u> the remnant envelope, or accretion back onto the white dwarf, or perhaps all three successively, in that order.

The moment the remnant envelope begins contracting coincides with the peak of the visual light curve and also with the moment when the "pre-maximum absorption spectrum" vanishes and is replaced by the "principle absorption spectrum". The "transition region" in the visual light curve occurs when the radius of the remnant envelope has contracted to the dimensions of the binary orbit and is disrupted by it.

We learn from Waltraut Seitter that the amplitude of a nova outburst is large if the pre-nova was faint, and theoretical considerations and inferences from observations tell us that a relatively faint pre-nova has longer to wait for its next outburst. Presumably,this occurs because more mass transfer and accretion is needed to heat the hydrogen-rich envelope to the critical temperature.

We learn from Warren Sparks, Sumner Starrfield, and James Truran that their sophisticated computer program follows the detailed behavior of the gas at various depths, second by second rather than in giant steps of millions of years as is usually done in models of stellar evolution. One example of their output is a series of intriguing 3-D plots, with time on one axis, velocity on another, and depth into the white dwarf envelope on another. (One such plot resembles a plaster cast of the Rock of Gibraltar.) Most significant, is their predicted visual light curve, which reproduces with remarkable fidelity the rapid initial rise, the pre-maximum halt, the final rise to maximum, and the beginning of the long gradual decline.

An important recent discovery is that the bolometric luminosity (the total energy output at all wavelengths) does not begin to decline right after the peak in the visual light curve. Rather, it stays pretty much constant for a month or more, whereas the light in the visual has decreased by then to 1/100 of its peak value. Satellite ultraviolet and ground-based infrared observations of Nova Serpentis 1970 made this discovery possible.

Nova Cygni 1975 was the subject of one entire session of the conference. The comprehensive review by Yvette Andrillat was, unfortunately for most Americans, in French. But it is very clearly written French and anyone with two years of high school French could probably sight-read it surprisingly well. From her review we learn that eight independent estimates yield an average distance of 1300 parsecs, that (at $m_V = 1^m.7 \pm 0^m.5$) it was the brightest nova since Nova Puppis 1942, and that it was invisible on the pre-discovery Palomar Sky Survey photographs, implying a total amplitude of 19 magnitudes or more, the largest known amplitude for a nova in our galaxy.

A major question was touched on by some contributors but was not fully answered, namely: What is the relation between the classical novae (both fast and slow), the recurrent novae, the dwarf novae (including the Z Cam and SU UMa sub-types), the symbiotic variables, the binary X-ray sources like Sco X-1 and Cyg X-2, the transient x-ray sources, and the various nova-like variables? It is known now that accretion energy alone, rather than thermonuclear runaway, powers the dwarf nova outbursts. We hope the rest of the answer will be found when theoreticians systematically alter crucial parameters such as: (1) the mass or radius of the white dwarf or other compact object, (2) the accumulated mass of the hydrogen-rich envelope, (3) the orbital period, a measure of the overall dimensions of the binary system, and (4) the rate of mass transfer and subsequent accretion.

The book is divided into five parts, corresponding to the five conference sessions. Each began with a couple of introductory reviews, followed with a half-dozen short contributions, and ended with a session summary. The final part summarized a discussion of future work. Here, the participants were modest and they stressed gaps and deficiencies in our understanding of novae, rather than merely summarizing what we have learned. In my opinion, we have learned very much in the last 10 or 15 years.

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