SU Ursae Majoris-type Stars—The Most Interesting Dwarf Novae

I. Semeniuk

Dr. Irena Semeniuk is a senior lecturer at the Astronomical Observatory of the Warsaw University, Poland, and joined the ESO Scientific Group in October 1977 with a one-year fellowship. She is interested in extragalactic astronomy (distribution of galaxies in clusters) as well as in cataclysmic variables. She recently observed at La Silla and was very happy to catch one of these stars in a "superburst".

Among the large variety of cataclysmic variables there is a subgroup called SU Ursae Majoris-type stars. Although this group of variables owes its name to a star in the northern sky, our contemporary knowledge about these stars results mainly from observations of southern members of this class. Similar to the U Geminorum-type stars—with which the reader is probably more familiar, as they attracted the attention of observers much earlier than the SU UMa-type stars—the SU UMa-type stars also show quasi-periodic recurrent rapid outbursts during which the stars' brightness increases by a few magnitudes during a night. The rapid rise to maximum is then followed by a slower decline to minimum light. But the SU UMa-type stars differ from the ordinary U Gem stars in demonstrating two essentially different types of maxima. The first type of maxima, so-called *normal* maxima, occur most frequently and are characterized by rather steep rise and quick decline to minimum light. The second kind of maxima are so-called *flat* maxima or supermaxima. They are on average 1 magnitude brighter than normal maxima and they last 4–5 times longer than normal ones. Like the normal maxima they also occur quasi regularly with the recurrence periods much longer than those between the normal maxima.

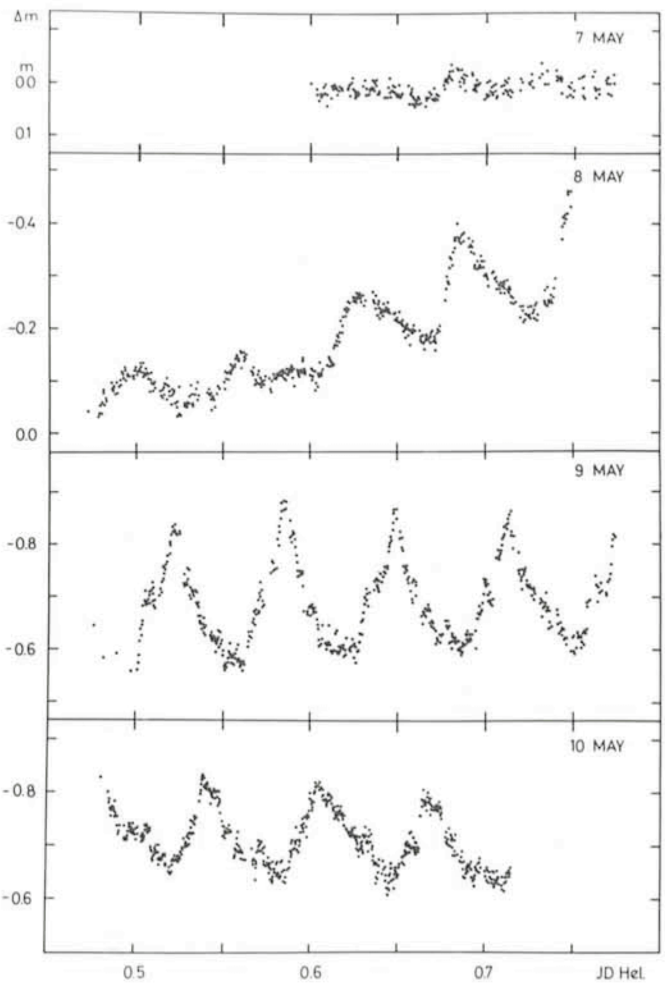
The members of the Variable Stars Section of the R.A.S. of New Zealand, directed by F. Bateson, play an important role in observing SU UMa stars. Their extensive visual observations make it possible to distinguish between the types of observed maxima, to classify a star of the SU UMa type, and to determine the mean recurrence period of outbursts or superoutbursts. Sometimes they alert astronomers having better observational facilities at their disposal that a superoutburst has begun and thus make it possible to obtain precise photometry or spectroscopy during this interesting phase.

VW Hyi

One of the brightest and the most investigated SU UMa stars is VW Hyi. It was observed by N. Vogt and B. Warner during minimum and during outbursts and it is the best example to demonstrate the behaviour of the SU UMa stars. The light curve of the star during minimum light shows a hump of amplitude between 0.4–0.9 mag which repeats periodically with a period equal to 107 min (0^{d}07427). This is the orbital period of the binary system. As is generally known, all dwarf novae are binary systems of which one component is a white dwarf and the second is a late-type star filling its Roche lobe and losing mass through the inner Lagrangian point. This stream of matter is responsible for an accretion disc surrounding the white dwarf component of the system. This stream impacts onto the disc creating a hot spot on its outer edge. Under advantageous orbital inclination conditions this hot spot manifests itself as a hump on the light curve seen during half the orbital period of the system. As a result of inhomogeneities in the impacting stream of matter the hot spot changes its luminosity and this exhibits itself as a rapid and irregular flickering observed in the light curves of dwarf novae. Observations seem to indicate that the origin of outbursts is connected either with the outer layers of the white dwarf or with the central region of the disc.

In the case of VW Hyi, normal eruptions occur in 80 per cent of all observed cases. During the normal maxima the system increases its brightness by 3.9 magnitude on average. The duration of normal maxima is about 4 days and they repeat with a mean interval between them of 29 days. During the normal maxima no hump is observed. This is not surprising, since one can easily imagine that during the outburst the system brightens so much that the source of radiation responsible for the periodically repeated hump is negligible.

The supermaxima occur in VW Hyi with an average interval between them of 179 days. Their mean duration is 17 days, i.e. they last about 4 times longer than the normal



Observations of V 436 Cen in blue light during the superoutburst in May, 1978. A star of magnitude B = 12.4 was used as comparison.

maxima and their mean amplitude is 4.8 magnitude, i.e. about 1 magnitude greater than that of the normal maxima. A naïve expectation would predict that no hump should be observed during supermaxima as it is not observed during the normal maxima. But in spite of this naïve expectation—and it is the most curious thing—not only a hump but even a *superhump* is observed during the supermaxima of VW Hyi. It is called the superhump because its amplitude in intensity units is much greater than what is observed at minimum light. Moreover, what makes the phenomenon still more curious is that the mean period of the superhump of VW Hyi is 110 min ($0^{d}.07676$), i.e. it is by about 3 per cent larger than the orbital period observed at minimum light, and even more, the superhump period is decreasing during the supermaxima. The same behaviour was observed with WX Hyi, another southern star of SU UMa type. In its case the mean period of superhump is also greater by about 4 per cent than the orbital period of the system as obtained from humps at minimum light.

Interpretation?

What is the real nature of such behaviour of SU UMa-type stars? Are the superhumps connected with appearance of a "superspot" on the disc surrounding the white dwarfs? Is the observed superhump period change related to the period change observed in Nova V 1500 Cyg? Is it indeed so that with all SU UMa stars no hump is observed during the normal maxima, but only during the supermaxima? Are the physical processes responsible for the two types of outbursts completely different?

Observations on La Silla

All these questions motivated the author to place some SU UMa stars in her observational programme for La Silla. Most of these stars at minimum light are below the threshold of visibility of the 60 cm Bochum telescope which was available. But every night the author started her observations by checking whether or not any of the stars had exploded. The chance was rather small during the author's short stay at La Silla. Thus she was very pleasantly surprised when on the night of May 7, while making her nightly survey, she perceived a star in one of the previously empty fields. It was V 436 Cen which had just exploded and was by then about 3 magnitudes brighter than the limiting magnitude of the Bochum telescope. The author's excitement was so great that she could not believe that this was the correct star. Only after measuring colours of the star she was sure there was no misidentification. The star showed a great ultraviolet excess as is usually observed with dwarf novae. The star was then monitored in blue light almost until the moment it was on the horizon.

It was not obvious after the observations of the first night whether or not the star was in a normal maximum or in one of the rare supermaxima. According to the New Zealand observers it was known that the normal maxima of V 436 Cen last only about 2 days. On the following night the star increased again in brightness and as it kept this high brightness during the next two nights it became clear that it was a *supermaximum!* In the course of the observations a hump which only started to develop on the first night increased its amplitude to the value of 0.3 magnitude so that it was clearly seen from the counts displayed on the monitor screen.

Unfortunately cirrus clouds which often cover the sky above La Silla at this time of the year interrupted these exciting observations. But when after an 8-day break, the author again began the observations (due to the kindness of N. Vogt and J. Breysacher who offered her their nights), the star was only about 1 magnitude fainter, and the hump was still visible although its amplitude had decreased. On the following night the hump merged into a rapid flickering. But the star was visible in the telescope even 16 days after the beginning of the outburst, giving strong evidence that it was indeed a long-lasting supermaximum. The reader may see some of the observations of the star in the figure. The observations are not yet fully reduced. Perhaps their further careful analysis will make some contribution to the better understanding of the most interesting dwarf novae.

Observation of the M87 Jet with the International Ultraviolet Explorer

M. Tarenghi, ESO, Geneva
G.C. Perola, Istituto di Fisica, Milano, Italy

During the past months, astronomers have been busy at the IUE ground station near Madrid. Dr. Massimo Tarenghi was the first ESO astronomer to use this unique ultraviolet satellite to observe extragalactic objects. This is the first, brief report about his exciting observations, together with Dr. Perola from Milan. We expect to bring further news about the IUE in the next issue of the Messenger.

The International Ultraviolet Explorer (IUE), a joint project of NASA, the United Kingdom, and the European Space Agency, is the first satellite designed for use by the general astronomical community which does not require a special knowledge of space techniques on the part of the observer. IUE is a geosynchronous satellite equipped with a 45 cm Cassegrain telescope for spectroscopic studies in the wavelength range 1000–3000 Å. It is kept under control at two operation centres, one located at the Goddard Space Flight Center in Greenbelt, Maryland, USA, the other at the ESA Tracking Station in Villafranca del Castillo near Madrid, Spain.

The telescope field of view is seen by a television camera in the satellite and can be displayed on a TV screen at the ground station to allow the observer to identify his target. The situation is like with a normal ground telescope: just imagine to observe with the ESO 3.6 m telescope, where the astronomer sits in the control room. With IUE the control room for the European astronomers is at the Villafranca station, the telescope is only a bit further than the other side of the window . . . !

The telescope is a Ritchey Chrétien of 45 cm aperture, with focal ratio f/15, an image quality of 1 arcsec and an acquisition field of 10 arcmin in diameter. At the focal plane there is an echelle spectrograph with two SEC vidicon cameras, one for the range 1150–2000 Å, the other for the range 1800–3200 Å. One can choose between a high-dispersion mode (resolving power $\sim 10^4$) and a low-dispersion mode (resolution ~ 6 Å).

The scientific aims of the IUE mission can be summarized as follows: