Amateur Astronomers and Dwarf Novae

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1. Introduction

On December 15, 1855 the English astronomer John Russell Hind (1823–1895) was searching for new minor planets in the constellation of Gemini. During this search he found a new star at approximately 9th magnitude. A new asteroid? He observed the star for several days and found that it didn't move – thus not an asteroid! The next few days the star became fainter and fainter and it was soon invisible in Hinds telescope. He thus classified the star as a faint nova. But a few months later in March 1856 the star was seen again, this time by another English astronomer Norman Robert Pogson (1829–1891). From this moment the star was monitored more systematically and more outbursts were observed. The period between the outbursts was calculated at approximately 100 days. A nova with numerous outbursts was a new phenomenon, so the first member, U Geminorum, of a new class of variable stars, dwarf novae, was discovered! 40 years passed before the next member of this class, SS Cygni, was discovered in 1896. Since then a few hundred dwarf novae or possible dwarf novae ([Downes and Shara, 1993] list 349) have been discovered. Most of these are faint and have only been observed very infrequently. In several cases the classification of dwarf novae is based on very few observations.

The observation of dwarf novae (and other cataclysmic variables) is one of the few fields of astronomy in which amateur astronomers still can deliver substantial contributions to the work of professional astronomers. The unpredictable behaviour of most cataclysmic variables makes it very difficult for professional astronomers to monitor these variables systematically. Our current knowledge and understanding of the physical processes, that form the basis of the dwarf novae outburst mechanism, are still subject to a lot of controversy. In this article the work of a world-wide network of amateur dwarf novae observers is described. We present some examples of the important results achieved by these observers. Moreover we describe the instruments, the charts and the observational methods used.

2. Dwarf Novae

Dwarf novae are associated with a special type of interacting binary stars – the cataclysmic binaries. In a cataclysmic binary a mass-losing secondary (often a late main-sequence dwarf) is in close orbit with a white dwarf primary. The orbit is so close that the secondary star fills its Roche-volume and hence it loses material through the inner Lagrange point L1. The lost gas is accumulated in an accretion disk around the white dwarf. This material then accretes onto the surface of the white dwarf from the disk. At the point where the stream of gas from the secondary impacts the disk, a shock front is formed which results in a hot spot. The luminosity of the disk and the hot spot accounts for most of the luminosity of the entire system. The orbital periods of cataclysmic binaries are very short, a little over 1 hour to about 15 hours. As the orbital periods indicate, cataclysmic binaries are very small systems, and often the dimensions are comparable with solar diameter. Dwarf novae are cataclysmic binaries exhibiting quasi-periodic eruptions of several magnitudes (2–8). Most of the time they stay in a minimum state, but now and again this state is interrupted by abrupt outbursts. The outbursts last from a few days to about 14 days. The time between the outbursts, the recurrence time, ranges from 10 days to months, and in some cases several years. The recurrence time for an individual dwarf nova is not at all constant. It is only possible to indicate an average recurrence time, e.g. the recurrence time for SS Cyg ranges from 15 to 95 days with 50 being the average. The same unpredictability holds for other dwarf nova characteristics as outburst amplitude and outburst duration.

Dwarf novae are divided into 4 subclasses according to their specific behaviour.

SS Cyg type (UGSS): This class contains the classical dwarf novae, i.e., stars like U Gem and SS Cyg.

Z Cam type (UGZ): In addition to the behaviour shown by the SS Cyg subtype, stars of the Z Cam type are characterised by standstills in their light curves. The eruption light curve is occasionally interrupted by periods of standstill lasting from days to several years. During the standstills the star remains at a brightness between the normal maximum and minimum magnitudes.

SU UMa type (UGSU): This subtype is characterised by frequent narrow outbursts, but in addition super-outbursts occasionally occur. During a super-outburst, short-period light variations, superhumps, are observed in most SUUMa stars. The superhumps have a period of a few per cent longer than the orbital period. Thus the detection of these superhumps is very important in order to determine the orbital period of systems where this is otherwise very difficult to obtain.

WZ Sge type (UGWZ): This special type of dwarf nova has outbursts very seldom. The typical recurrence time is several decades. Clearly, the detection of all outbursts of these rare objects is extremely important.

The origin of dwarf nova outbursts is due to a brightening of the accretion disk. The mass-transfer burst model proposed in the early 1970's by Geoffrey Bath explains the outbursts by semi-periodic enhancements of the mass transfer from the secondary.

The disk-instability model proposed independently by Jozef Smak and Yoji Osaki in the mid-1970's is nowadays the most favoured model of an outburst mechanism. This model explains the dwarf nova outbursts as follows: The accretion disk can accumulate a certain amount of gas before it gets unstable. When instability is reached, the accretion of matter to the white dwarf increases dramatically. We see this as an increase in luminosity – an outburst. When the accretion disk has lost enough mass, it becomes stable again, the increased accretion stops and the system returns to minimum magnitude. The disk is now ready for a new fill-up and a new outburst cycle can begin.

The classical novae (N) and the recurrent novae (RN) are also cataclysmic variables. The outburst of classical novae as well as some recurrent novae are generated by thermonuclear runaway reactions at the surface of the white dwarf, following long periods of accretion from the secondary. The outburst of classical novae are always accompanied by an expulsion of a shell of material, whereas for the recurrent ones this seems not to be the case. A more thorough and comprehensive review of dwarf novae and other cataclysmic variables can be found in [Patterson 1984] and the references therein.

3. The Observers, Their Instruments and Techniques

The major part of the visual dwarf novae observations are made by a few very active and enthusiastic observers.

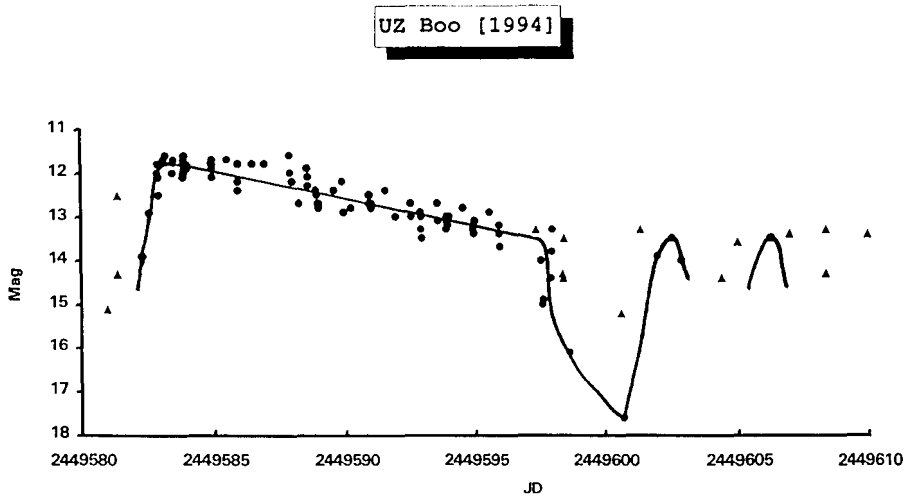

Figure 1.

Most of them are very experienced variable star observers, with proven skills in 'traditional' variable star work. Lot of practice and perseverance has turned them into well-trained amateurs, that are capable of memorising tens of star fields. On every clear night, they visually check these fields, hunting for 'new' stars. No sophisticated instruments are required: an alt-azimuth dobsonian type of reflector is quite common, with apertures in the range from 20 cm to 50 cm and more. Using this technique, some amateurs are capable of visually inspecting between 50 and 100 star fields in one single night! On such nights typically 3–10 dwarf novae are seen in outburst.

Often the magnitude of a dwarf nova in minimum is in the range magnitude 17–21. Most dwarf novae are hence only observed in maximum and naturally the observers get a lot of negative (fainter than) observations. Negative observations are often as important as the positive ones to get a continuous light curve. What makes dwarf novae hunting so challenging to amateur astronomers? There is no single answer to this question. Most amateurs are driven by the unpredictable nature of the dwarf novae: no one can anticipate the outcome of a nightly observation session. Others are attracted by the 'scientific' contribution of their observations. Variable star charts and sequences come from various organisations, such as the AAVSO (American Association of Variable Star Observers), The Astronomer and the BAAVSS (UK), RASNZ (Royal Astronomical Society of New Zealand), BVVS (Belgium Vereniging voor Sterrenkunde), and from reprints of articles in professional journals [Vogt and Bateson, 1982], [Bruch et al., 1987] and [Downes and Shara, 1993].

Monthly tables, listing all dwarf novae outburst activities are generated and distributed by organisations like the AAVSO (The AAVSO Circular). Approximately 40–50 more or less active observers contribute to the dwarf nova section of the AAVSO Circular. Often an outburst is only observed by a few observers. Nearly 400 variables are currently classified as UG stars. For many possible UG stars nearly no characteristics are known, because they are very faint even in outburst or they have very long recurrence times. Some of them have only been observed on very few occasions, for some the identification is unknown, or the subclass classification is very tentative. The task of monitoring such stars is largely taken over by amateurs, who join their efforts in worldwide networks, that in total cover over 100 peculiar objects. All over the world, only a few dozens of amateurs participate in these dwarf novae alert networks.

3. Interest from Professional Astronomers

The Astronomer organisation (UK) has set up a programme specifically to monitor poorly studied-long period dwarf novae. The Recurrent Objects Programme contains approximately 75 objects of various types, ranging from dwarf novae, recurrent and old novae, to suspected UG, UGSU and UGWZ stars. Gary Poyner has been coordinator of the programme since 1991. The main criteria in the object selection were the following:

1. The star must have an outburst period (or suspected period) of at least one year.
2. Little (if any) information on the precise cycle length or amplitude is available.

Gradually more stars were added to the list, as research uncovered many more of these long-period objects where just one or perhaps two outbursts had been recorded. Among recent successes we note the first ever visual observations of the following stars (discoverers' names following).

EF Peg: October 1991 (Schmeer, Ger)
SS UMi: August 1991 (Mitchell, UK)
HV Vir: April 1992 (Schmeer, Ger)
AK Cnc: January 1992 (Kato, Japan)
V1113 Cyg: August 1993 (Szentasko, Hungary)
V493 Lyr: October 1993 (Bortle, USA/Van Cauteren, B)
LL And: December 1 (Vanmunster, B)

Also many stars which have been monitored by observers have been reclassified after observations had shown that outburst activity wasn't quite as predicted. If a programme star is found to go in outburst frequently, it is dropped from the programme, but only after monitoring it intensely through several outbursts. This has recently happened with the UGSU star SS UMi.

Figure 1 shows an example of a light curve obtained for a programme star: UGWZ type dwarf nova UZ Bootis. The light curve documents a recent superoutburst (August 1994). The last observed outburst of UZ Boo was in 1978.

Occasionally stars which are not eruptive in nature, but were originally thought to be are revealed. Four of these rogue stars have recently been identified and dropped from the programme. Three, HN Cyg, UY Vul and UZ Vul, were in fact semi-regular type variables catalogued as possible cataclysmic stars. However, observations from the programme's observers have revealed their real nature. When activity of a suspected star is noticed, other members of the network are informed (over telephone) in order to obtain immediate confirmation. Positive identifications of outbursts result in alert calls (telegrams and electronic circulars), that are issued to amateurs all over the world and to interested professional astronomers.

Examples of such services are The Astronomer Electronic Circulars (UK) and the Cataclysmic Variables Circular (B). Photometric observations, that cover the outburst activity, are passed between professional and amateur astronomers by electronic mail, mainly through Internet and CompuServe. The availability of e-mail to many amateurs has meant that professional astronomers can be alerted to an outburst very quickly, thus making possible extremely valuable observations early in the outburst phase and in various wavelengths.This can provide valuable information into the mechanisms behind these cataclysmic events. Summarising results, complemented with contributions from professional astronomers, are published in various magazines.

4.1. *HV Virginis*

The HV Vir outburst deserves special mention here, as it proves just how valuable amateur observations can be. HV Vir was photographed by Schneller in 1929 in outburst at magnitude 11.5. Following a series of observations of it at maximum light and in decline, it was classified as a classical nova. The object was added to the recurrent objects programme in 1988 primarily because of it's high galactic latitude, and the possibility that it may be a rare type WZ Sge dwarf nova, although no other outbursts had been detected. On April 20, 1992, a German amateur, Patrick Schmeer, made his usual check of the field with his 20-cm telescope and saw HV Vir in outburst at magnitude 12. At first Schmeer thought it might be a minor planet, but following a search of minor planet positions it soon became evident that HV Vir was indeed in outburst. Observations of spectra and high-speed photometry have shown that HV Vir is indeed a dwarf nova. It shares many characteristics of WZ Sge itself, and displays superhumps typical of UGSU stars.

4.2. LL Andromedae

Another major success of the TA dwarf nova network was the detection of an outburst of LL And by Belgian amateur Tonny Vanmunster on the evening of December 7, 1993 using a 35-cm dobsonian reflector. The outburst was confirmed within minutes by UK and Belgian observers. LL And was discovered photographically by astronomer Paul Wild (Bern Observatory) in September 1979 [Wild 1979], when it reached V~13th. Since then, the dwarf nova had never been seen again. Due to an alert, the December 1993 (super)outburst could also be monitored by several professional astronomers. Spectroscopic observations of the star at maximum light were obtained, as well as a photometric outburst light curve based mainly on observations contributed by amateurs. The outburst amplitude was ~ 6 magnitudes. Dr. Kato (Kyoto University, Japan) conducted CCD photometry during four nights, and detected superhumps, hence classifying the star as a UGSU dwarf nova, possibly belonging to the WZ Sge subclass.

5. Belgian Cataclysmic Variables Alert Programme

The Belgian Cataclysmic Variables Alert Programme (CVAP) was initiated in May 1994 as a dwarf nova observation programme, complementary to the TA programme. It mainly consists of poorly observed objects, for which professional astronomers have shown interest and have requested continuous monitoring. The CVAP currently includes about 13 objects, of which the identification and/or the subclass is uncertain or unknown. These objects are now monitored on a very regular basis by European variable star amateur observers. Due to the unavailability of professional search charts and sequences for these objects, the CVAP members currently are using charts based on the Guide Star Catalogue (GSC). Example CVAP objects include: AS Psc (last seen in outburst in 1963), V358 Lyr (seen in 1965) and SS LMi (seen in 1980, and classified as either N or UG).

Although the CVAP started only recently, a first result has already been obtained. The programme star IR Lyr, classified as a possible UG star, has been observed during activity in recent months. A first interpretation of photometric observations indicates that the star does probably not belong to the UG variables. Paul Van Cauteren and Tonny Vanmunster are currently the coordinators of the Belgian programme.

6. Future Perspectives

As CCD cameras become more widely available to amateur astronomers, we would like to point out the important role that these instruments can play in the observation of dwarf novae, even if they are mounted on a small telescope.

(1) Monitoring of dwarf novae at quiescence

Most amateur astronomers, even with larger instruments, obtain only limiting magnitudes around magnitude 14.5–15.5. But the majority of dwarf novae are much fainter when at quiescence. With the use of a CCD camera, however, many of these objects are within reach. This means that daily monitoring may result in observing the start of the outbursts, and early warning of interested observers is possible.

(2) Confirmation of outburst discovered by visual observers

When an outburst is reported by a visual observer, it is common practice to obtain confirmation from a second observer, before the astronomical world is informed. Confirmation via a CCD image is much more 'safe' than a second visual sighting. Having something on file/paper also makes it possible to analyse and re-check the result later on.

(3) Astrometry/photometric sequence

With CCD images an accurate position measurement may be obtained. At present, too many inaccurate charts are used, resulting in 'false' outburst-alerts or large scatter in magnitude estimates. Preparing charts with reliable comparison stars is of utmost importance.

(4) Photometry

By taking regular images of the variable star, reliable photometry may be performed. The accuracy is much higher than the visual estimates. Detecting superhumps in suspected UGSU stars is an example of useful work that can be done.

It is our impression that most astronomers do not know about the important work some amateurs do in the field of cataclysmic variables. It is our hope that this article will inspire more professional astronomers to make use of the results and observations obtained by the amateur astronomers. The different recurrent object programmes are always open for new interesting cataclysmic variables to be monitored. Naturally, it is also inspiring for the amateurs to see that their efforts can be and are used by professional researchers to gain more knowledge about the behaviour of cataclysmic binaries.

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