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The Halloween Stellar Outburst of 2006 – A Nearby Microlens?

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Abstract

When an experienced amateur astronomer discovered that an ordinary 11th magnitude star had brightened to 7th magnitude, other amateurs immediately followed up on the discovery. Their observations proved significant in deciphering a puzzle that garnered considerable attention among professional astronomers in the ensuing days. This paper traces the events and analysis of this highly unusual event.

1. The Discovery

On Halloween, October 31, 2006, the IAU's Central Bureau for Astronomical Telegrams sent out a notice on the internet containing observations from Akihiko Tago, a very experienced observer of novae and comets from Japan, who reported the brightening of GSC 3656-1328 from 11.8 magnitude to 7.5 magnitude (Nakano, 2006). Tago noted that the star had not varied in previous images. Two hours later, another Central Bureau Electronic Telegram was issued with a more precise position and further confirmation of the eruption (Nakano, 2006). The AAVSO quickly sent out an Alert Notice on the new variable, with the designation Var Cas 06.

Krajci and Koff, two Center for Backyard Astrophysics (CBA) observers in the western US, independently began time series observations of the new variable on November 1, within hours of the announcements. Krajci observed unfiltered, while Koff used a V filter, along with several observations in a B filter to obtain colors for the variable and potential comp stars. The two observers later coordinated their selection of a comp star.

Koff expected his observations to be consistent with a cataclysmic variable, with possible superhumps and flickering. Figure 1 shows an example of what was expected, the CV SDSS J0557+68 in outburst.

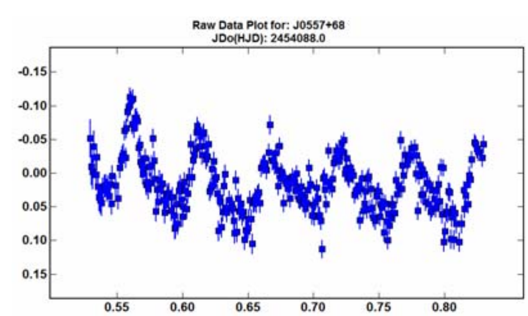

Figure 1: SDSS J0557+68 In Outburst

However, the results of the first night's time series showed a steady decline, with none of the signatures of a CV. Figure 2. The observed B-V of 0.27 was also inconsistent with a CV, which would be expected to show a B-V of close to zero. Krajci also obtained the same lightcurve results, a curve with a steadily declining magnitude of 1.5 magnitudes/day.

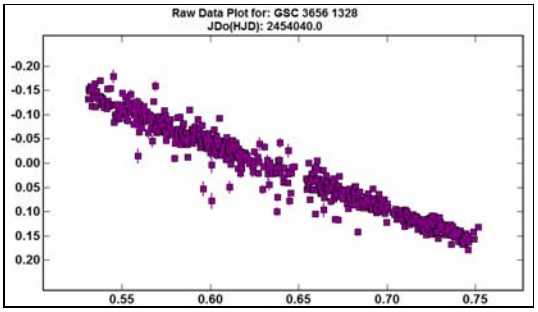

Figure 2: GSC 3656-1328, First Night of Observation

Both observers posted their findings to the CBA and AAVSO websites.

Patterson examined the observations, and noted the oddity of this variable. It did not seem to adhere to any know variable class. He sent out a notice to the CBA members on November 3 suggesting more observations of this star.

2. Observations Broaden

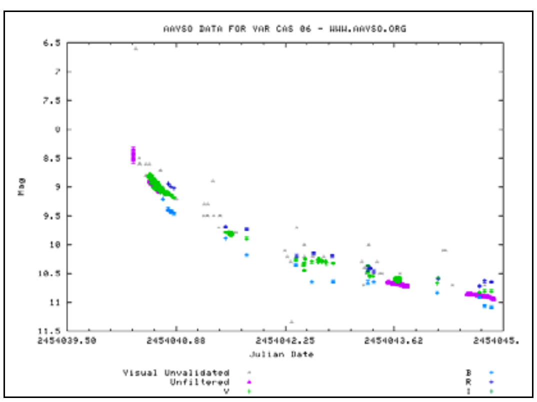

Figure 3: GSC 3656-1328, First Five Nights. www.aavso.org

By November 3, professional interest was building worldwide, as amateurs continued intensive observation. Figure 3. Patterson and his colleagues were able to schedule a target of opportunity observation from the Swift satellite, an X-ray instrument. The observations showed no detectable X-ray flux. Furthermore, Ron Remillard (MIT) reported that a search of the RXTE All-Sky Monitor showed no detectable X-ray flux before or during the outburst. This seemed to rule out a CV.

Professionals examined the available color data and arrived at a B-V value of 0.2, typical of a type A star. Such stars would not be expected to erupt like this one had. Still on November 3, Ulisse Munari of the Padova Observatory reported via another CBET that a spectrum indicated a normal A star with no indication of emission or rapid rotation (Munari, 2006).

Sergie Antipin of the Sternberg Astronomical Institute reported that a search of 400 plates from 1964 –94 showed no variation from a magnitude of 11.8, a figure that is the same as modern surveys such as Tycho, USNO, TASS, etc.

Thus, the astronomical community was left with a seemingly ordinary, constant star that had brightened four magnitudes, then begun to quickly fade. There were no x-rays, no flickering, and no apparent change in color or spectrum. In short, there was no ordinary classification for such an event.

More professional observers joined in. Images were obtained from PAIRITEL, the Peters Automated Infrared Imaging Telescope, a 1.3-meter instrument on Mt. Hopkins. The Swift satellite provided UV-band observations. Spectra were obtained by the MDM 2.4-m telescope on Kitt Peak.

Koff and Krajci, and an increasing number of other observers continued to monitor the star. But as it turned out, the initial night's observations proved critical to the solution of this enigmatic event.

3. The Explanation

The solution began to take shape. Koff and Krajci received a request from a professional astronomer in England for their data. At this point, we had several nights of observations. Figure 4. After examining the observations, he voiced the possibility that it might be a microlensing event. Soon after, Maciej Mikolajewski (Nicolaus Copernicus University) was the first to publish this proposal (Mikolajewski 2007).

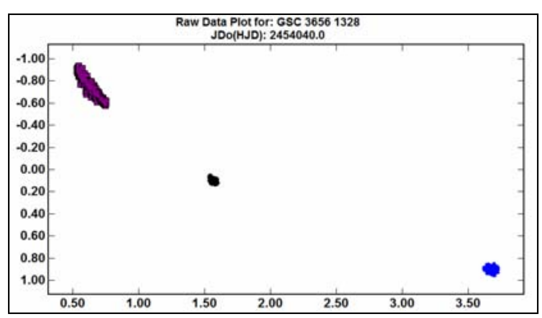

Figure 4: GSC 3656-1328, First Three Nights

A microlensing event takes place when a massive object passes between the observer and a background star. The foreground object bends space-time in such a way as to behave as a lens, focusing the light of the background object. This geometric condition allows us to study objects that would otherwise be difficult or impossible to detect. It has been used successfully in the search for extrasolar planets. These searches hunt for microlensing events and the study their lightcurves for anomalies that would indicate planets. Figure 5.

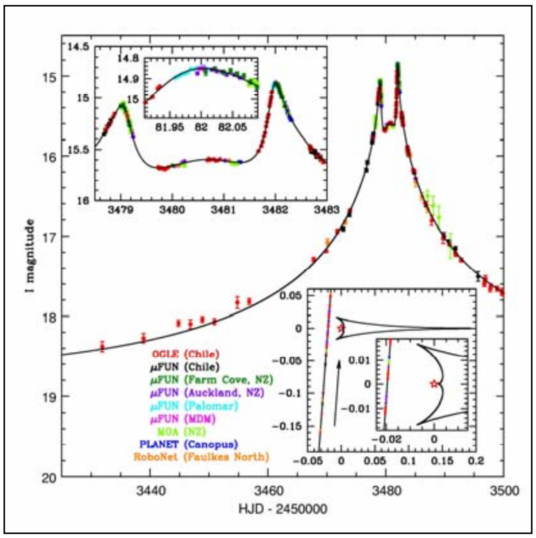

Figure 5: A Microlensing Event, from OGLE and MicroFUN

However, these searches are carried out on distant and crowded fields, such as the galactic plane or the Large Magellenic Cloud. This is because the more stars in the field of view, the better the chance of seeing a microlensing event. In addition, the probability of a microlens occurring on a given star increases with the square of the distance, so searches have concentrated on distant, and thus dim, stars.

To better analyze whether or not this was a microlens, it would be necessary to get data on the portion of the lightcurve at the beginning to the event, and at the maximum. A true microlens should show a symmetrical, achromatic curve that follows a specific mathematical shape.

A call went out for pre-Halloween images of this star. Digital camera images were received from two British amateurs, and were analyzed by Michael Richmond (Rochester Institute of Technology). Richmond was able to take these unfiltered images from short-focus cameras and extract calibrated magnitudes.

But most importantly, it turns out that the field had been imaged during test runs of the northern site of ASAS, the All-Sky Automated Survey at Haleakala, Hawaii. ASAS uses telephoto lenses to survey the entire sky every night in V and I filters. ASAS supplied a number of images of the microlens event, including five during the previously unseen rise and maximum. These observations were critical, as they filled in the missing curve with calibrated magnitudes through standard filters (Gaudi, 2007). Figure 6.

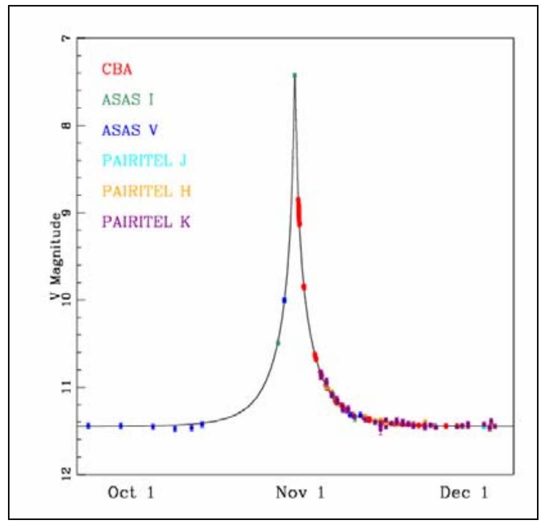

Figure 6: Lightcurve of GSC 3656-1328

4. Conclusions

All of the observations were now consistent with a microlens, and for the nearest and highest magnification event ever recorded.

An analysis of the data (Gaudi, 2007) yielded estimates of the nature of the lens object. It appears to be relatively low mass, about one/sixth that of the Sun. It is probably located about 130 pc from us, whereas GSC 3656-1328 is located at about 1 kpc distance. The lens, which may be a brown dwarf or a main sequence star, has an approximate magnitude of about 20 V. It is probably moving at a rate of about 150 mas/yr. At this rate, it may become detectable as a separate object in a few years.

By one estimate, an event involving a star this bright might occur in our sky once every 12 years. If we have to wait 12 years for the next one, and then be fortunate enough to catch it, this might not be a promising field of research. But if we can use the existing and upcoming surveys, we can increase the odds considerably by the fact that we will be examining more stars at higher magnitudes. It would seem that ASAS, Pan-Starrs, and LSST could be programmed to watch for these events in their normal processing pipeline. It is also practical to initiate a new survey, using wide-angle cameras with CCD detectors, to monitor for microlenses and other transient events (Gaudi, 2007).

If we can detect such events, how will we follow up on them? In all likelihood, this will fall to the amateur astronomers. Only we are spread out all over the world, and only we have the telescope time and target discretion to jump on a new discovery and image it at high time resolution for days on end if necessary. In this case, by the end of 2006 Koff and Krajci had made 8000 observations, and 43 other observers including 16 other CCD observers had contributed another 11,000 observations to the AAVSO. Figure 7.

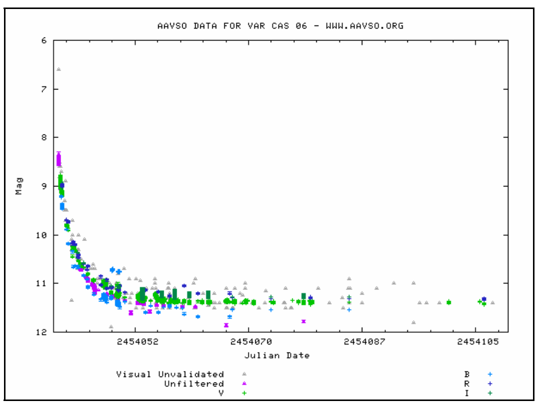

Figure 7: GSC 3656-1328, AAVSO Data www.aavso.org

It is this ability that makes us a valuable partner to the professional community. We can target any transient celestial event, be it a microlens, a variable star or an asteroid that needs intense observation. That is why we would like to encourage amateurs to learn lightcurve photometry. There are numerous projects available to you, from targets of opportunity like GSC 3656-1328 to all manner of variable stars to asteroids. It's not difficult, and seeing and publishing a lightcurve of your own observations is very satisfying.

5. Conclusions

GSC 3656-1328, the sudden brightening of an ordinary 11th magnitude star, was almost certainly a microlensing event, and the closest and brightest such event ever observed. The participation of amateur observers in the discovery and follow-up of this occurrence was key to understanding the nature of the phenomenon.

6. Acknowledgements

The authors thank the AAVSO for collecting and disseminating the thousands of observations involved in this project.

We also wish to acknowledge the many amateur and professional observers that contributed to the analysis of this unusual event.

7. References:

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