Some Personal Thoughts on TV Corvi

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Abstract As part of the AAVSO's role in celebrating the United Nations' International Year of Light, I have been asked to prepare a brief retrospective on my interest in Clyde Tombaugh's star, TV Corvi. Because of the clever light pollution ordinances that have governed the night sky surrounding the area around Tucson, Arizona, and the International Dark Sky Association, our Jarnac Observatory has been blessed with a dark night sky that often permits observations down to 19th magnitude, the star's suspected minimum magnitude. Preparing this article has also helped me to understand that variable star observing is not just science; it is community. My own understanding of the behavior of Tombaugh's Star is gathered from my long friendship with Clyde Tombaugh, discoverer of Pluto and the scientist who opened the door to the Kuiper Belt to other AAVSO observers over many years, Steve Howell, from the Planetary Science Institute, who alerted me to the possibility that one component of TV Crv is a brown dwarf, and the pure joy of being able to observe this faint variable star under a dark sky.

1. Introduction

Recently Dr. Stella Kafka, newly appointed Director of the AAVSO, asked me to write an article for *JAAVSO* about TV Corvi, my favorite variable star. One thing I learned long ago is that when a Director, particularly of the AAVSO, asks me to write something, the best thing to do is to drop whatever it is that I am doing and fulfill her request. My own concern for this particular star dates back almost thirty years to February 9, 1986, the perihelion date of Halley's comet. Sitting in the basement of Lowell Observatory, I was studying the original photographic logs of Clyde Tombaugh in preparation for a biography I was writing about him. On the plate exposed 10 January 1931 was circled the trailed image of a comet. I spent years trying to substantiate Clyde's images, but found nothing. Even though Clyde's telescopes recorded several images of this object, the International Astronomical Union's Central Bureau for Astronomical Telegrams would not announce it unless images from other observers could be found. The comet was rediscovered in 2012 on images taken by the Tenagra Observatories, and is now known as Comet 274P/Tombaugh-Tenagra.

The search for comets did not end there, however. During the summer of 1987 I retuned to Lowell and checked every one of Clyde's planet search plates. (Although the search for trans-Neptunian planets was what the search began as, after Pluto was discovered the search was expounded to a "trans-Saturnian planet" program, and this is how Clyde always referred to it.) This time I uncovered evidence of Clyde's discovery of a single star annotated:

> Nova. 1 nova suspect "T 12" near southwest corner of plate, magnitude about 12, confirmed well on Cogshall [telescope] plates of MARCH 22. No trace of object on 13-inch plates of March 20 and 17, 1931. The image is exactly deformed, like the other star images in the neighborhood. Evidently a very remarkable star to rise from 17 or fainter to 12 in 2 days time.... This object was discovered on May 25, 1932, at 11:00 AM. (Tombaugh 1931; Levy 1991)

Sixty years after the fact, Clyde was still alive and remembered well the moment of discovery. "It was a definitely a real star," the discoverer of Pluto told me over the phone, adding that its image was slightly deformed just like the surrounding stars near the edge of the plate he had taken. He knew it was a "temporary star" as he called it, because it did not appear on either of the other plates he had exposed of the same region. Brian Skiff, a staff astronomer there, suggested that I search some plate archives for other images of this star that could confirm its existence.

2. Confirming Tombaugh's star

On September 11, 1989, therefore, I visited the famous plate stacks at Harvard College Observatory, just a long block down the road from the AAVSO's old headquarters on Concord Avenue. Over three days, I searched through 260 patrol plates, probably the entire collection that HCO had containing the position of the star Clyde had discovered 58 years earlier. The search period spanned a long period of time, from 1930 to 1988. The search yielded nine additional outbursts of what I concluded had to be an SS Cygni-type dwarf nova.

Armed with this evidence, I walked across the lawn to Brian Marsden's office in an adjoining building. He looked at the list of outbursts I presented to him, then back at me. "I agree this is interesting," he said, "but I am not going to announce it yet."

"Why not?" I asked.

"Because," Brian answered sagely but with a grin and a wink, "you are an amateur astronomer." I took a couple of deep breaths, then prepared to say something less than friendly. Brian then added, "If you were a professional astronomer, you'd have to apply for telescope time, and probably you wouldn't bother with it. But as an amateur with a beautiful 40-centimeter reflector capable of discovering comet after comet, you can keep a visual watch on the star's position every night. When you next see the star in outburst, which I don't doubt would someday occur, then I will announce it as a current item."

Thus, in November 1989 when Corvus began to make its appearance in the predawn sky after solar conjunction, I began daily observations of the field.

On March 22, 1990, after giving a lecture in Florida, I checked the region using one of Don Parker's telescopes. The following night, back home, I used my own 40-cm reflector and saw a new star of magnitude 13.6 where nothing had been before!

Since that memorable night I have seen several further outbursts of this star, which Steve Howell of the Planetary Science Institute determined to be not only a high galactic latitude cataclysmic variable star (most such stars lie near the galactic plane), but also that it consists of a white dwarf and a brown dwarf that orbit each other in an area smaller than the Sun in a period under two hours (Planetary Science Institute 2005; Wood *et al.* 2011). One outburst in 2005 deserves particular note. The star was apparently just beginning its rise to maximum when I recorded it. I decided to take repeat exposures every thirty minutes for the rest of the night. My sequence recorded a series of images showing this beautiful star on its way to maximum, and at the AAVSO spring meeting a few months later I played the animation, actually "TV Corvi: The motion picture," during the paper session. After a few showings I went to shut it off, but the audience refused to allow this. Thus I had to continue the animation for the remainder of my paper. Incidentally, this episode is one of the reasons I love going to AAVSO meetings. (Another episode, that had nothing to do with TV Crv, took place during an evening observing session during a spring meeting at our Jarnac Observatory. I casually asked if anyone would be interested in seeing my small collection of old blueprint charts; within a minute the whole crowd was gathered round, admiring the way we used to do variable stars.)

3. Tombaugh's star and the community of variable star observers

Of all the outbursts I have seen since 1990, four have occurred near the date of my first one, March 23, which was coincidentally the date of Clyde's first detection back in 1931. The one on March 23, 2000, was so special to me that I informed then-director Janet Mattei about it by telephone. It meant so much to her that I called because it brought to the forefront her wish to see the human side of variable stars. And on that particular evening, she did. I have presented a paper and co-written other short pieces about this atar, and have discussed it on countless occasions with many astronomers both amateur and professional (Levy *et al.* 1990; Levy 2000).

More important, Tombaugh's star has a unique role to play in the history of the AAVSO and in its many decades of outreach. It is important because it reminds us of one of the most important astronomical observers in the twentieth century. It is important because it suggests the existence of a stellar type that is very, very small; much smaller than our Sun and whose components might be not much larger than Jupiter. And for me, it reminds me of some interesting times that have happened in my life.

4. Superoutbursts for a super star

We now understand that TV Crv is an SU-Ursae Majoris variable: a cataclysmic variable whose outbursts come in two varieties, normal outbursts and superoutbursts, and that exhibits superhumps (small periodic variations related to the length of the orbital period) during superoutbursts. Outbursts occur when gas that is gathering in the accretion disk reaches a certain temperature, the viscosity in the disk changes, and the gas collapses onto the brown dwarf. As gravitational potential energy is released, the system brightens exponentially. This particular star's outbursts apparently result when the accretion disk surrounding the smaller star becomes unstable.

TV Crv (Figure 1) is a special type of SU UMa variable in that its superoutbursts come in two varieties—one with an uninterrupted rise to maximum, and one with a partial rise, slight decline, then full rise to maximum. This latter type is the result of a precursor normal outburst which happens to affect the disk in a way that triggers the superoutburst (Uemura *et al.* 2005).

For examples, we can revisit the superoutburst of 2001 18 February, during which the first recorded visual magnitude observation was 12.9 (Figure 2). In this event, TV Crv went into its superoutburst phase without warning; the preceding night the star was typically fainter than magnitude 14.6—there was no precursor in this superouburst.

The 2004 June 4 superoutburst was associated with a precursor. It appeared to begin as a normal outburst. TV Crv brightened from its quiescent state to about magnitude 13.7

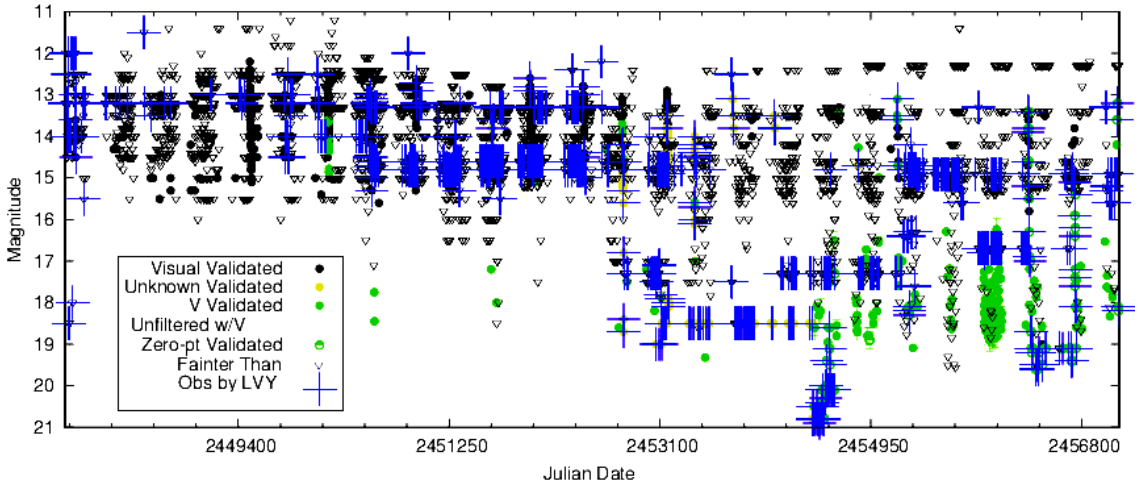

Figure 1. TV Crv, 17 November 1989–4 June 2015 (JD 2447848–2457178). Data from AAVSO International Database (AID). Earliest, historical data in AID (February 1930–April 1981, not shown) were digitized by D. Levy from the Harvard College Observatory plate collection and the Palomar Observatory Sky Survey.

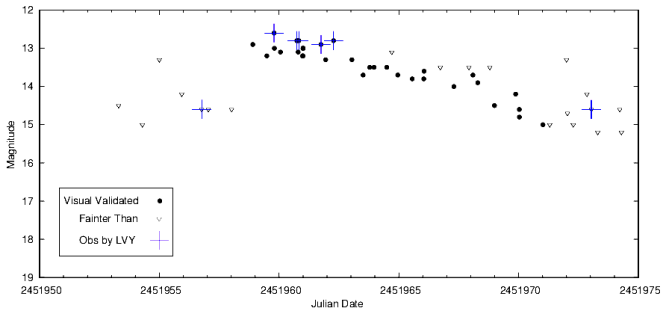

Figure 2. TV Crv, 9 February–6 March 2001 (JD 2451950–2451975). Data from AAVSO International Database.

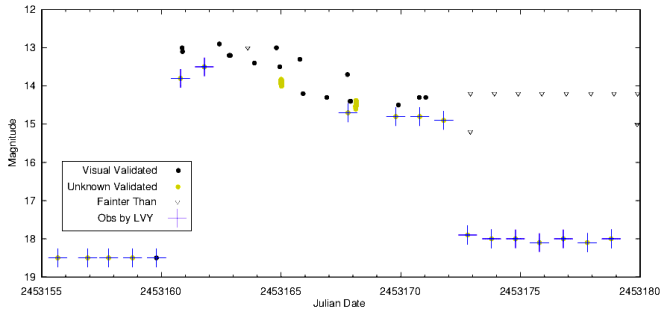

Figure 3 TV Crv, 29 May–23 June 2004 (JD 2453155–2453180). Data from AAVSO International Database.

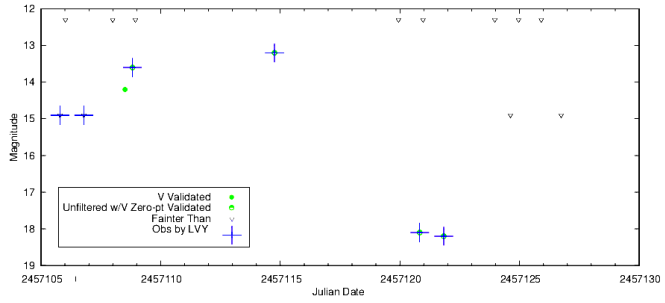

Figure 4. TV Crv, 23 March–17 April 2015 (JD 2457105–2457130). Data from AAVSO International Database.

over a few hours, and then, after a slight fading, continued brightening in a superoutburst, reaching maximum 1.7 days later (Uemura *et al.* 2005) (Figure 3).

In the superoutburst of 27 March 2015 (Figure 4), which took place as I was writing this paper, TV Crv was still at maximum when I observed it again on 2 April. It subsequently returned to minimum by May 17.

5. TV Crv: its astronomical and personal significance

Why exactly is TV Corvi, or Tombaugh's star, my favorite variable? This is not a hard question to answer. Every time I observe either the star itself or its field, I am reminded of my close friendship with Clyde Tombaugh. Most people know Clyde only for his discovery of Pluto, connected today with the continuing arguments over its status. Years ago Steve Howell told me that he considered TV Corvi to be Tombaugh's most significant discovery, far more so than his primary discoveries of the Kuiper Belt. As I was now devoting most of my observing hours to comets, it seemed appropriate to observe its field every night during its season to determine its outburst frequency. Although, as a cataclysmic variable, its outbursts cannot be predicted, the outbursts have the unlikely habit of occurring roughly once each year. March appears to be the favored month, and on four occasions the outbursts have taken place either on March 23, or have been in progress on that date or slightly after. Besides being the date on which more than two outbursts have been detected, March 23 is also the date marking the discovery of my most important comet, Shoemaker-Levy 9 in 1993, and it is the day I married Wendee in 1997. More recently, one of the telescopes I use for my nightly comet search is named "Clyde" not for his discoveries, but for the personality of the man: his love of science, his sense of humor, and his ubiquitous and unforgettable puns. All these things are rooted in this unusual cataclysmic variable, TV Crv. This wonderful pairing of two tiny stars has made a personal and continuing involvement in my life that I will not soon forget.

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