LOST VARIABLES IN SAGITTARIUS AND CYGNUS RECOVERED ON NANTUCKET PLATES

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Abstract

Mass discoveries of variable stars by modern automatic sky surveys make it very important to determine accurate coordinates for all previously documented variable stars. For many "old" variable stars, no finding charts were ever published, and only rough coordinates were reported. Existing collections of sky photographs, however, make it possible to recover such "lost" variable stars. Here, we present our results on the recovery of nine "lost" variable stars: NY Cyg, QX Cyg, VW Sgr, GW Sgr, GZ Sgr, HK Sgr, HT Sgr, HU Sgr, and HW Sgr, using plates from the Maria Mitchell Observatory collection in Nantucket, Massachusetts. For the stars recovered, we present finder charts, accurate coordinates, improved classification, and light elements. In the case of HW Sgr, there is an indisputably variable star approximately in the published position, but the character of its variability is in complete disagreement with earlier data. Either HW Sgr was misclassified by the discoverer, or the discoverer's position for the star is in error and we have actually discovered a new variable.

1. Introduction

The advent of modern automatic sky surveys has drastically changed the process of finding and cataloging variable stars within the past decade. Previously, researchers had to study stars individually to determine whether they exhibited variability. Automated discovery offers the possibility to study a region of the sky and discover multiple variable stars in that region in a relatively short period of time. Several of such large-scale automated surveys have already proven successful, resulting in the discovery of many thousands of variable stars.

Cataloging the large amount of information generated by these automatic sky surveys is difficult. Low positional accuracy in existing catalogues of "old" variable stars makes automatic identification with "new" variable stars almost impossible. Before the early 20th century, many discoverers used to determine quite accurate coordinates for variable stars. Later, however, discoverers at Harvard and Sonneberg Observatories, the most active places for variable star research, began to present only very rough coordinates. Thus, many "old" variable stars have positions that are incorrect by up to several arcminutes. It is therefore urgent to obtain accurate positions for these "lost" variables.

The process of updating the position of old variables is fairly straightforward when finding charts are available, as is the case for all variables discovered in Sonnenberg. However, there are several thousand Harvard variables that have no finding charts, making their identification more difficult. In order to recover these lost variables, they must first be identified on photographic plates by looking in the general area indicated by the coordinates. They must then be shown to vary, which is done by comparing their relative intensity/brightness to nearby comparison stars over time.

For the reasons discussed by Hazen and Samus (1999), it is important to recover variables lacking finding charts. This problem can be most effectively solved using the Harvard plate collection, especially because many stars for which no finding charts have ever been published were first discovered at Harvard Observatory. However, much can be done using plate collections of other observatories. For several years, we successfully used the plate collection of the Maria Mitchell Observatory (MMO) in Nantucket to recover "lost" variables. The results of 1999 were presented in Samus *et al.* (1999).

This year, we have recovered 9 lost variable stars (7 of them, Harvard variables) in Sagittarius and Cygnus: NY Cyg, QX Cyg, VW Sgr, GW Sgr, GZ Sgr, HK Sgr, HT Sgr, HU Sgr, and HW Sgr, using the photographic plate collection of the MMO, which is especially rich in these constellations. We present here finder charts (approximately 15' x 15'), accurate coordinates, improved classification, and light elements for these stars.

2. Results

Tables 1 and 2 summarize the main results of our research on the 9 "lost" variable stars. Table 1 gives name from the *General Catalogue of Variable Stars* (GCVS)

Table 1. Identifications and coordinates.

Star	HV	GSC	Right Ascension 2000.0	Declination 2000.0	Source
NY Cyg	—	—	19^h 52^m $34\overset{s}{.}61$	+37° 55' 44".1	*A2.0*
QX Cyg	—	3137.02869	19 58 37.79	+38 14 35.0	*GSC*
VW Sgr	1148	6263.0007	18 00 20.44	-21 08 00.8	*GSC*
GW Sgr	4055	6861.01422	18 25 24.53	-25 02 05.9	*GSC*
GZ Sgr	4131	—	18 25 35.91	-23 45 00.7	*A2.0*
HK Sgr	4132	—	18 26 13.84	-24 38 51.6	*A2.0*
HT Sgr	4063	—	18 28 23.20	-25 40 53.9	*A2.0*
HU Sgr	4064	—	18 29 03.16	-25 04 37.9	*DSS*
HW Sgr*	4065	6861.1153	18 29 47.49	-24 50 32.6	*GSC*

**Identification of variable uncertain; see text.*

Table 2. Types and light elements.

Star	Type	Epoch (JD)	Period (days)
NY Cyg	EA	2449274.43	12.05110
QX Cyg	EB	—	—
VW Sgr	EA	2436347.75	8.21304
GW Sgr	RV	2438611.65	—
GZ Sgr	M	2442677	214.56
HK Sgr	M	2448071	300
HT Sgr	M	2447778	228.25
HU Sgr	M	2440088	260
HW Sgr*	LB	—	—

**Identification of variable uncertain; see text.*

(Kholopov *et al.* 1985); Harvard Variable Number; GSC number (if available); the star's right ascension and declination (equinox 2000.0); source of coordinates (A2.0 designates the US Naval Observatory *A2.0 Catalog* (Monet *et al.* 1998); DSS means coordinates measured by us on a *Digitized Sky Survey* (Space Telescope Science Institute 1993–95) image, relative to several reference stars with coordinates from the USNO *A2.0 Catalog*).

Table 2 gives GCVS name; the star type found in our study; light elements (epoch and period) if they could be derived from our data (epochs refer to minimum light for eclipsers and the possible RV Tauri star and to maximum light for Miras). Remarks on the stars follow the Tables.

NY Cyg (Figure 1). The elements in Table 2 are based on 52 minima (JD 2426654–2449274), which reveal a period of 12.05110 days. Our identification of the star as type EA confirms that suggested by Skiff (1997).

QX Cyg (Figures 2 and 3). We confirm the identification suggested by Skiff (1997). We found 43 fadings of the star (JD 2424801–2448481) corresponding to primary minima. They show that the period is monotonously decreasing (see Figure 3). The new light elements are:

$$\begin{array}{l} \mathrm{Min}_{\mathrm{hel}} = 2423352.320 + 0.8996112\ E - 0.156 \times 10^{-8}\ E^2. \\ \qquad\qquad \pm 0.049 \pm 0.0000057 \quad \pm 0.016 \times 10^{-8} \end{array} \qquad (1)$$

VW Sgr (Figure 4). The new elements represent all 27 fadings found by us (JD 2436101–2448067) quite well. They do not agree, however, with the six fadings published by Parenago (1931) and covering JD 2418864–2425778.48. The slight fading of JD 2425777.44 could be a secondary minimum, while Parenago's remaining five minima may indicate a shorter period than 8.2101 days. The variable period is therefore left in question.

GW Sgr (Figure 5). The type (RV) and period (119 days) from Hoffleit (1959) still need confirmation.

GZ Sgr (Figure 6). This Mira variable has a period of 214.56 days. The new elements are based on the epoch (JD 2426590) from Hoffleit (1960) and on 8 reliable maxima (JD 2437115–2443760) derived from our estimates.

HK Sgr (Figure 7). This Mira's period varies. The elements in Table 2 are valid after JD 2446000 (from 5 maxima). Before JD 2446000,

$$\text{Max} = 2432380 + 289.46\ \text{E} \tag{2}$$

(from 20 new maxima after JD 2436132 and one maximum, JD 2432380, from Hoffleit 1960).

HT Sgr (Figure 8). The new elements are based on the epoch (JD 2426100) from Hoffleit (1961) and 13 new maxima (JD 2436132–2448043). The GCVS classification is based upon Hoffleit's magnitude in minimum light (15.0 photographic) leading to an amplitude insufficient for a Mira. However, the star is definitely very faint at minimum, and the published magnitude refers to a close component, as was correctly suspected by Hoffleit.

HU Sgr (Figure 9). The elements in Table 2 combine our epoch of maximum with the period from Hoffleit (1960).

HW Sgr (Figure 10). We have found a definitely varying star in a position very close to that published by the discoverer (Luyten 1927); the GSC number, coordinates, and type in the Tables correspond to this object. The star is red in the USNO *A2.0 Catalog* (B-R = 3.8); it shows slow, apparently irregular brightness variations. Luyten (1927), however, attributed the star discovered by him to intermediate-period eclipsing variables, a classification excluded by our data. Dr. M. L. Hazen could not find any of Luyten's marks—which might help to resolve our problem concerning the position of HW Sgr—in the Harvard plate archive. Either he misclassified the star or the object found by us is a new variable, having nothing to do with Luyten's HV 4065, and the coordinates published by Luyten are in error. In either case, HW Sgr should be carefully examined on all available plates in order to clarify the type of variation and period.

3. Acknowledgements

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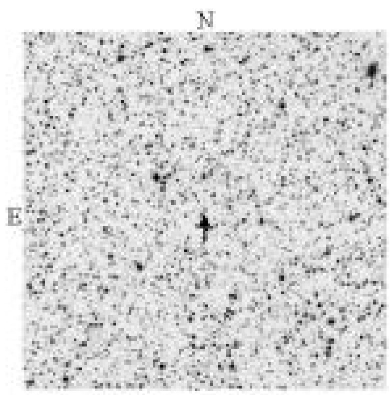

Figure 1. NY Cyg.

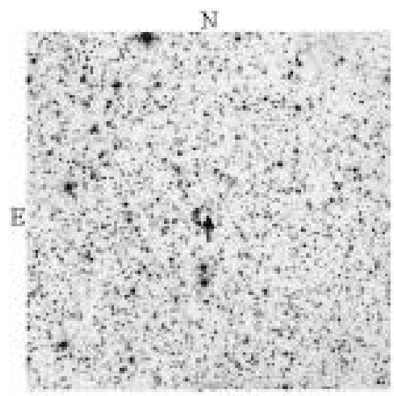

Figure 2. QX Cyg.

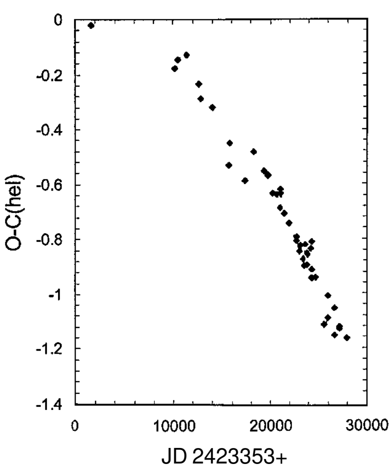

Figure 3. QX Cyg: O-C Graph.

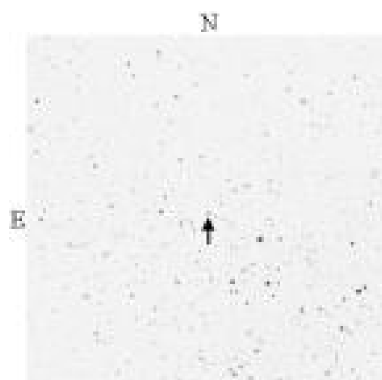

Figure 4. VW Sgr.

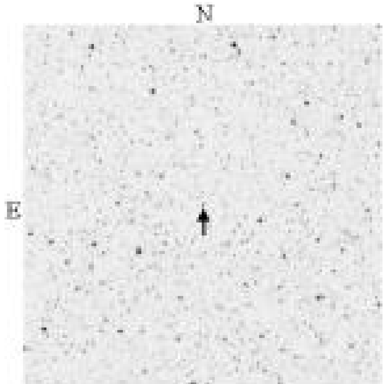

Figure 5. GW Sgr.

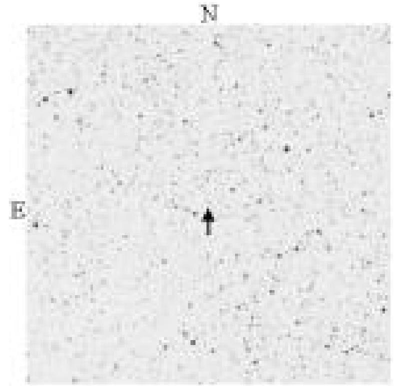

Figure 6. GZ Sgr.

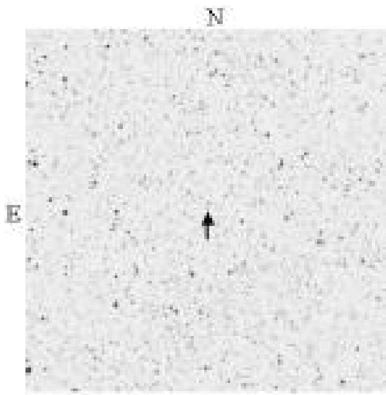

Figure 7. HK Sgr.

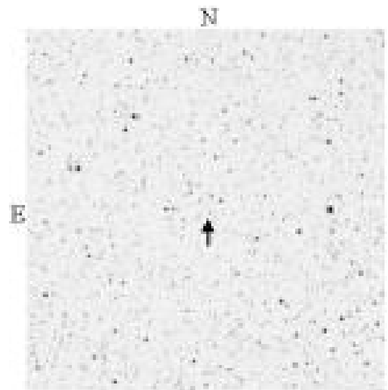

Figure 8. HT Sgr.

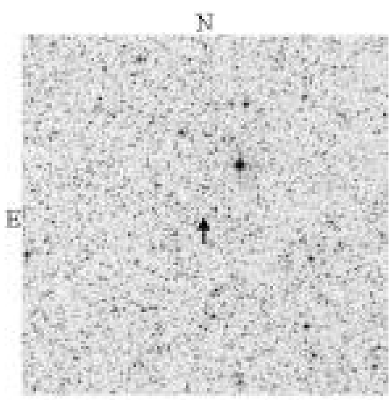

Figure 9. HU Sgr.

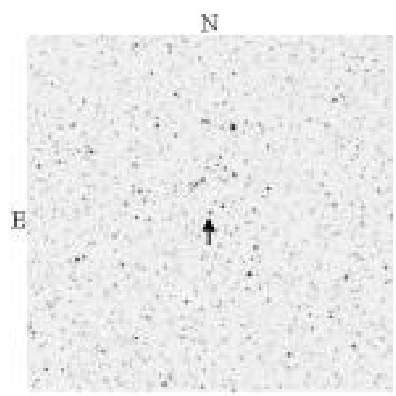

Figure 10. HW Sgr (see text for discussion on identification of the variable).