SIX "LOST" MIRA VARIABLES RECOVERED ON MMO PLATES

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Abstract

Six Mira variables, which were discovered at Harvard Observatory and lacked finding charts, were recovered on Maria Mitchell Observatory plates. We present accurate coordinates and updated light elements for CV Sgr, SW Sct, VV Sct, AO Sct, AV Sct, and BI Sct. AV Sct shows definite period changes during the time interval studied. SW Sct and AO Sct may also have experienced period changes.

1. Introduction

Current large-scale automatic surveys reveal thousands of new variable stars. Accurate coordinates are immediately known for these new discoveries, thus making it easy to identify the objects in the future. New, unprecedentedly deep, and complete surveys (especially the *U. S. Naval Observatory A1.0* and *A2.0 Catalogs)* facilitate determination of coordinates for variables being discovered individually (not in large surveys) by professional as well as by amateur astronomers. However, among variable stars and suspected variable stars discovered prior to the modern period (the *General Catalogue of Variable Stars* (GCVS), the *New Catalogue of Suspected Variable Stars* (NSV), and the recently-published *NSV Supplement* contain about 50,000 galactic variable stars), there still remain several thousand objects with only approximate coordinates and lacking finding charts. Recovering as many such stars as possible would contribute significantly to the quality of variable-star catalogues. For this purpose, existing large collections of sky photographs (plate archives) are very useful. With such archives, a variable star can be discovered anew, provided that its published coordinates are not too seriously in error.

The Maria Mitchell Observatory (MMO) has such a plate collection that is very rich in photographs of the Scutum Cloud and surrounding regions. It provides good prospects for recovering variables in the constellations of Scutum, Aquila, and Sagittarius.

2. Results of our search

In the summer of 1998, we used the plate collection of the MMO to recover and study several "lost" or long-neglected Miras and eclipsing variables. Our results on the eclipsing stars, V936 Aql and VX Sct, have been published elsewhere (Samus and Tam 1998). Here we present our findings concerning six Mira-type variable stars.

Table 1 summarizes our results. Its columns are self-explanatory. We either extracted the coordinates of the variable stars from the *USNO A2.0 Catalog* or derived them ourselves (in the cases of VV Sct and BI Sct) using *USNO A1.0/A2.0* reference stars. Magnitudes were determined using eye estimates of the variable's brightness in relation to neighboring stars of similar magnitude. The B magnitudes of these comparison stars were measured an Moscow University plates using the standard photoelectric sequence in the open cluster M11 (Johnson *et al.* 1956).

Time gaps between observations in the MMO plate collection for this region of the sky range from days to years. These gaps are responsible for most of the significant O-C values listed in Tables 2–7. AV Sct is the only variable that exhibited a definite change in period over the span of observations.

Table 1. Mira variables recovered.

Star	*R.A. 2000.0*	*Dec. 2000.0*	*Epoch of Max JD2400000+*	*Period (days)*	*B range (mag)*
CV Sgr	$19^h06^m37\overset{s}{.}55$	$-12°20'41\overset{''}{.}8$	47740	219.82	14.5–<16.0
SW Sct	18 53 52.69	-12 38 31.6	48454	459.5	12.9–<16.0
VV Sct	18 31 53.55	-14 11 10.8	44785	239.1	12.1–<16.0
AO Sct	18 53 12.04	-12 46 05.5	45525	272.5	14.0–<16.0
AV Sct	18 54 15.90	-12 00 16.9	46321	233.4	13.6–<16.0
BI Sct	18 57 27.95	-07 31 28.8	44140	244.6	12.5–<16.0

3. Remarks on individual stars

CV Sgr = Harvard Variable HV 3126 = HV 9590. Independently discovered by Leavitt (1908) and by Luyten (1937). Harwood (1931) suggested the first light elements, Max = JD 2423343 + 226d x E. Our new light elements connect Harwood's maxima with six brightenings we observed within our 166 data points (Table 2). CV Sgr is very close to our detection limits, so we cannot be sure that the amplitude exceeds 2.5 B magnitudes. Thus, the star could possibly be an SRA variable instead of a Mira.

Table 2. Observed brightenings of CV Sgr.

Julian Date	*O-C*
2440480	-5.9
2442905	1.0
2443336	-7.6
2443783	-0.2
2446653	12.1
2447740	0.0

SW Sct = HV 3109. Discovered by Leavitt (1908). Harwood (1962) gives the light elements: Max = JD 2435275 + 453d x E. In the *IRAS Point Source Catalog* (IRAS PSC; Joint IRAS Science Working Group 1988), the star is associated with the infrared source IRAS 18510-1242 (identical with IRC-10472). This is a correct identification.

The elements in Table 1 represent the five brightenings well observed between JD 2441500 and 2448500 (Table 3) amidst 212 observations of the variable. An attempt to connect them with Harwood's initial epoch would give a period about 457.4 days, but an assumption of a period change seems more probable.

Table 3. Observed brightenings of SW Sct.

Julian Date	*O-C*
2441565	3.5
2442934	-6.0
2445230	-7.5
2446627	11.0
2448450	-4.0

VV Sct = HV 3807. Discovered by Cannon (1924), who indicated that variable was the southern following component of a double star. Only the preceding component is present in the *USNO A1.0/A2.0 Catalogs*. In the IRAS PSC, the star is correctly identified with IRAS 18290-1413. Our 551 observations yielded the brightenings listed in Table 4. The light elements in Table 1 are based only on our observed brightenings; they yield the best light curve for our data as seen in Figure 1.

Table 4. Observed brightenings of VV Sct.

Julian Date	*O-C*	*Julian Date*	*O-C*
2425413	-4.9	2435688	-11.2
2426155	19.8	2439032	-14.6
2426626	12.6	2439730	-33.9
2427312	-18.7	2444785	0.0
2428750	-15.3	2445525	22.7
2434983	1.1	2446972	35.1

AO Sct = HV 3106. Discovered by Leavitt (1908). Harwood (1931) found Mira variations with the elements Max = JD 2423669 + 271.5d x E. We confirm the star's identification with IRAS 18503-1249, suggested in the IRAS PSC. The star was observed on MMO plates 362 times. Like CV Sgr, the star's dimness does not rule out the possibility that it is an SRA variable. The light elements in Table 1 represent six brightenings we found in the interval JD 2432000–2447000 (Table 5), but Harwood's initial maximum deviates considerably (O-C = -56d), suggesting a period change between 1923 and 1947.

Table 5. Observed brightenings of AO Sct.

Julian Date	*O-C*
2432440	-5.0
2432729	11.5
2434624	-1.0
2442271	16.0
2445525	0.0
2446608	-7.0

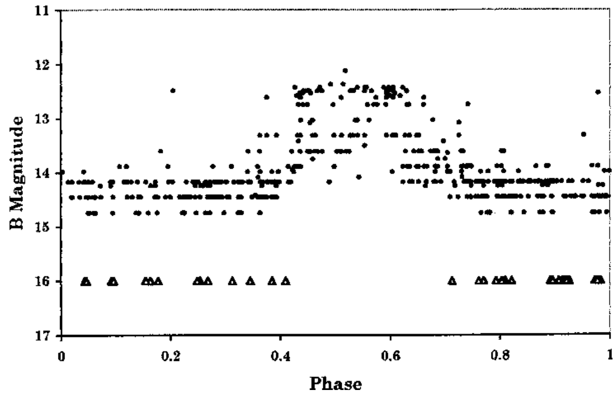

Figure 1. VV Sct Light Curve. This phase diagram of our observations of VV Sct was derived using a period of 239.1 days and epoch of JD 2444785. Triangles represent observations in which the variable was below the detection limit of the MMO plates. Observations below the detection limits were more prevalent for the other Miras studied.

AV Sct = HV 3746. Discovered by Shapley (1924). Harwood (1962) reported Mira variations with the elements Max = JD 2427996 + 242d x E and presented the timings of five brightenings. From the 17 brightenings collected from 185 observations (Table 6), we find that the star showed at least two abrupt period changes. Before JD 2433600, light elements Max = JD 2427996 + 239.74d x E are valid. For JD 2441000– 2444500, we suggest light elements Max = JD 2441955 + 244.9d x E. After JD 2446000, the somewhat uncertain light elements given in Table 1 seem valid.

Table 6. Observed brightenings of AV Sct.

Julian Date		*O-C* *(P = 239.74d)*	*O-C* *(P = 244.9d)*	*O-C* *(P = 233.4d)*
2427996	Harwood 1962	0.0	0.3	113.6
2428470:		-5.5	-15.5	-112.6
2428710		-5.2	-20.4	-106.0
2429190:		-4.7	-30.2	-92.8
2430900:		27.1	-34.5	-16.6
2432080	Present paper	8.4	-79.0	-3.6
2432792		1.2	-101.7	8.2
2433510		7.3	-118.4	26.0
2441220		38.3	-0.3	33.8
2441955		54.1	0.0	68.6
2442685		64.9	-4.7	98.4
2442950		90.1	15.4	-103.4
2443671		91.9	1.7	-82.6
2444404		105.7	0.0	-49.8
2446321		104.8	-42.2	0.0
2447020		84.5	-77.9	-1.2
2448422		48.1	99.6	0.4

BI Sct = HV 3841. Discovered by Cannon (1924). According to Harwood (1962), this is a Mira variable with the light elements Max = JD 2432398 + 244.6d x E. Harwood found that the estimates were complicated by four close companions, at distances

Table 7. Observed brightenings of BI Sct.

Julian Date	*O-C*	*Julian Date*	*O-C*
2433144	11.0	2442685	12.6
2433360	-17.6	2444140	0.0
2433853	-13.8	2444401	16.4
2434603	2.4	2445078	-40.4
2435311	-23.4	2447083	7.8
2440490	19.0	2447803	-6.0
2441220	15.2	2448044	-9.6

from 0.05' to 0.3'. In the Hubble Space Telescope *Guide Star Catalog*, this group of stars corresponds to a "nonstellar" object GSC 5706.00279. The *USNO A1.0 Catalog* contains, at this position, a single object measured only on a blue plate; the star is not in the *USNO A2.0 Catalog*. We measured the position of the correct component on the *Digitized Sky Survey* image. In the IRAS PSC, the variable is correctly associated with IRAS 18547-0735. Our 533 observations confirm the continued validity of Harwood's original period. The light elements in Table 1 well represent our 14 brightenings (Table 7) and Harwood's initial maximum.

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