UNFINISHED BUSINESS: LUYTEN'S HARVARD VARIABLES—I

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Abstract

W. J. Luyten discovered 1,764 variable stars during the Bruce Proper Motion Survey of the southern sky on Harvard plates during the 1930s. Most have remained unstudied to the present day because the variables are generally fainter than 12th magnitude and Luyten did not publish identification charts. This paper begins an investigation of Luyten's variables on Harvard patrol plates and reports types, periods, magnitude ranges, improved positions, and finding charts for UV Pyx, HS Vel, NSV 4234, and NSV 4286.

1. Introduction

During the 1930s, W. J. Luyten conducted a monumental survey of the southern sky for stars with large proper motion. Pairs of photographic plates taken 30 years apart were compared with a blink microscope, and as a by-product of this search, many new variable stars were noted. The plate comparison work was carried out at the Astronomy Department of the University of Minnesota, but the plates were taken with the 60-cm f/5.6 Bruce astrograph of Harvard College Observatory's Boyden Station in Peru (first-epoch plates) and South Africa (second-epoch plates).

The Bruce telescope (Jones and Boyd 1971) was the largest wide-field photographic refractor ever placed in service. Plates taken with this telescope were used by Henrietta Leavitt to discover the period-luminosity relationship for Cepheids in the Magellanic Clouds and by William Pickering to discover the ninth moon of Saturn. The objective was optimized for work in the blue photographic passband, and the 14x17-inch (35 x 42.5-cm) plates recorded a sky area of 5.9 x 7.1 degrees. The plate scale was 60 arcsec/mm.

The Bruce telescope was used to systematically photograph the southern celestial hemisphere in the interval 1898–1904. At that time, one-hour exposures reached 14th magnitude and exposures up to six hours long reached 18th magnitude. It required 1,008 plate centers to cover the entire celestial hemisphere, and 950 of these Bruce Regions were successfully photographed (58 regions were missed due to weather or other circumstances). This provided a treasure trove of suitable first-epoch plates so that, 30 years later, Luyten could undertake a search for proper motion stars most expeditiously by obtaining second-epoch plates with the same instrument.

The new plates were taken in 1928–1936. Luyten took 300 of the plates himself and devoted 4,000 hours to blinking the 950 plate pairs. He found 75,000 stars with noticeable proper motion and also detected 2,680 variables. Of this latter total, 480 were known variables with official designations, 106 others had already received Harvard Variable (HV) numbers, and 330 were duplicates found on more than one plate pair. To acknowledge the central role of Harvard College Observatory in the Bruce Proper Motion Survey, Luyten assigned an HV number to each of the remaining 1,764 variable stars, beginning with HV 8001 and ending with HV 9764.

A few of these variables at lower southern declinations had already been reported by Ross, Hoffmeister, and others but had not yet received official designations.

These were included in Luyten's HV list because their independent detection confirmed the previously-reported variability. Luyten noted that some of his discoveries seen on only one plate might be asteroids. However, this seemed unlikely because the Bruce refractor's focal length and the extended exposure times made it almost certain that an asteroid, even near its stationary point, would produce a visibly-trailed image. Nonetheless, the asteroid Pallas was caught at its stationary point and managed to enter the list as a possible 8th magnitude nova (Luyten 1986). (This exception does not invalidate the premise, however, because an 8th magnitude image would be grossly overexposed on the Bruce plates and would appear circular even when trailed.)

Most of Luyten's Harvard Variables showed substantial changes in brightness, one magnitude and often more. But with only two plates available (or at most four, when a variable appeared in the overlap area between two plate centers), the types and periods of the new variables could not be determined. Also, Luyten conducted his survey on long-exposure plates taken with a large aperture, so his variable star discoveries were relatively faint. Most of Luyten's HV stars have maxima of 12th to 16th magnitude in the blue photographic passband.

Luyten published his variable star discoveries as lists in 13 numbers of the *Astronomische Nachrichten* and a final collective tabulation (Luyten 1938). These lists include approximate celestial coordinates and the roughly estimated magnitude of each variable on the two plates. This means that Luyten's published magnitudes for each variable do not represent the full range of variation but only a lower limit.

Unfortunately, Luyten did not have the time or resources to publish finder charts, and most of his discoveries remain unstudied to the present day. A few have received official GCVS designations, thanks to additional observations obtained during southern variable star surveys at Sonneberg and Bamberg. But without known types, periods, or finding charts, most of Luyten's HV stars languish in the *New Catalogue of Suspected Variable Stars* (NSV) (Kholopov *et al.* 1982). Indeed, it is very difficult to find a page in the NSV catalogue that does not include the telltale reference "380003."

During my extensive work with the Harvard patrol plates, I have made a habit of looking for neglected variables in the fields of the variables I plan to investigate. Recently, while observing southern eclipsing binaries with unknown periods, I noticed that several of Luyten's discoveries could be observed on the same plates. Without finding charts, I could only identify these stars by their light variations. I therefore examined the published positions of these variables on several dozen plates and was eventually rewarded by finding a star that brightened above the plate limit very close to each position.

This initial success stimulated my interest in the Luyten variables, and on my next visit to Harvard I investigated the subject more thoroughly. I found that all of Luyten's discovery plates are still available in the plate archives. The second-epoch plates are marked by a rubber-stamped form on the paper jacket, indicating the Bruce Region number, the plate number of the first-epoch plate, and the total number of proper motion stars and variables that were found on that pair. In most cases, Luyten's discovery marks are still present on the backs of the plates, the proper motion stars labeled with numbers and variables labeled with letters (A, B, etc.). This makes the recovery of Luyten's HV stars a relatively straightforward task.

In some cases, the backs of the plates have been cleaned so that the plates could be used for other projects, such as galaxy counts. But because Luyten's variables show substantial magnitude differences on the two plates, I found that it was easy to rediscover them by examining the stars near the published position on each plate. It only took a few minutes to find each variable. Charts prepared with the Guide CD-ROM program, showing the positions of Luyten's variables from the NSV catalogue, make the process even easier.

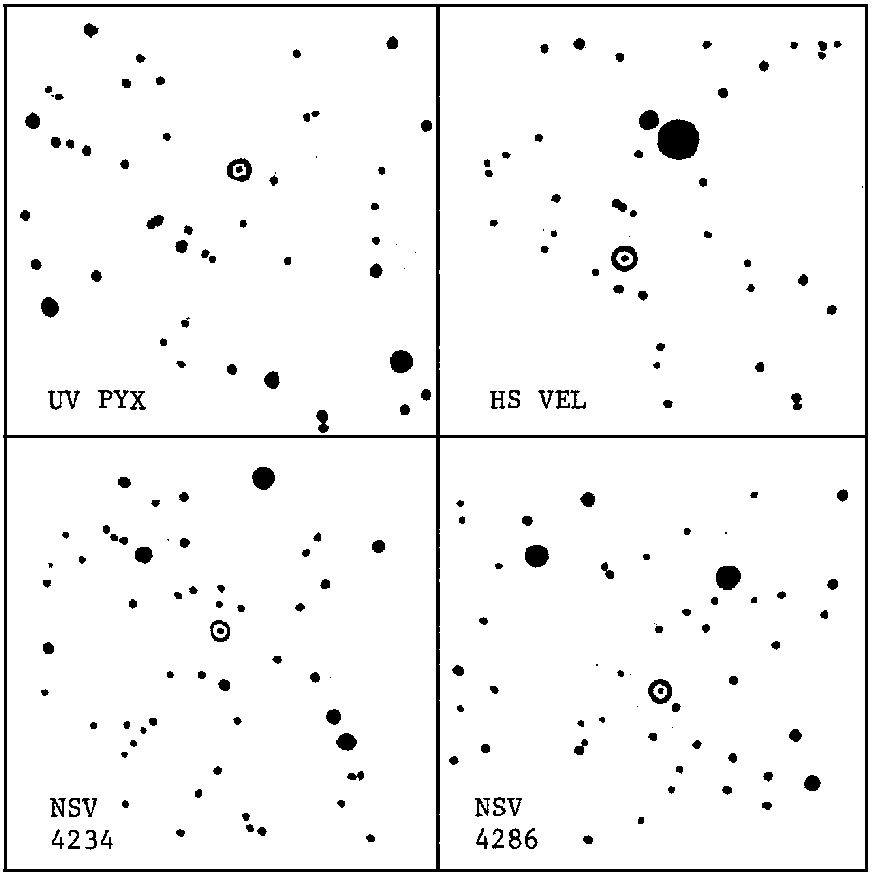

Figure 1. Finding charts for UV Pyx, HS Vel, NSV 4234, and NSV 4286. Each chart is 5 arcmin square. North is up, east left. Based on Digital Sky Survey, STScI.

Each of the following stars was observed on blue-sensitive plates taken with the RB and Damon patrol cameras. In addition, some of the stars could be checked on plates taken with much larger apertures. The RB patrol plates (1930–1952) usually reach 14th magnitude and the best reach 15th. The Damon patrol plates (1980–1988) have a faint limit of 13.5–14.5 magnitude. The MF (25-cm aperture) and B (20-cm) series plates reach to 16.5 ptg. Comparison star magnitudes were estimated by direct comparison with photoelectric B sequences in nearby fields of the *Guide Star Photometric Catalogue* (Lasker *et al.* 1988). Finding charts are presented in Figure 1.

2. UV Pyxidis = HV 8157

UV Pyx is a Luyten HV star that has received an official designation, though its period is unknown and no finding chart has been published. Luyten reported a range of 12.0–<15.0 ptg. I observed UV Pyx on 328 Harvard patrol plates and 12 deep MF and B plates. These observations indicate that UV Pyx is a Mira variable with an extreme magnitude range of 11.5–<16.0 ptg. Julian Dates of plate maxima, 12.5 ptg or brighter, are listed in Table 1. A least-squares solution of the times of maxima resulted in the following light elements:

$$JD_{max} = \underset{\pm 5}{2444040} + \underset{\pm 0.2}{353\overset{d}{.}5}\ E \tag{1}$$

UV Pyx is not recorded in the Guide Star Catalogue, but an improved position, estimated relative to nearby GSC stars, is RA = $08^h 45^m 34^s$, Dec. = -25° 06' 21" (2000).

3. HS Velorum = HV 8316

The *General Catalogue of Variable Stars* (GCVS) (Kholopov *et al.*1987) lists HS Vel as a Mira variable with a range of 11.3–16.0 ptg and unknown period. I observed HS Vel on 197 Harvard patrol plates. The brightest maximum found was 10.8 ptg. No deep MF or B plates were examined, so the minima were not observed. JDs of plate maxima, 11.8 ptg or brighter, are listed in Table 2. Preliminary analysis indicated that a significant period change occurred during the observational gap between the first 10 maxima and the last two. A least-squares solution of the first 10 maxima yields the following light elements:

$$JD_{max} = \underset{\pm 4}{2429727} + \underset{\pm 0.5}{324\overset{d}{.}8}\ E \tag{2}$$

The O-C values in Table 2 are derived from these light elements. Assuming that the period change occurred abruptly after the 10th maximum, then the current period is at least 331 days. To predict maxima in the near future, this period can be combined with the most recent time of maximum:

$$JD_{max} = 2447565 + 331^d\ E \tag{3}$$

Times of maxima during the observational gap in the Harvard plates and new observations are needed to define the true period behavior of this star. HS Vel was recorded near maximum on the GSC source plates and is identical to GSC 8207-1303, RA = $10^h 54^m 03^s$, Dec = -49° 21' 12" (2000).

4. NSV 4234 = HV 8155

Luyten reported a range of 12.0–<15 ptg. I observed NSV 4234 on 264 Harvard patrol plates and 12 deep MF and B plates and found that it is also a Mira variable with an extreme range of 12.5–<16.0 ptg. The JDs of plate maxima, 13.5 ptg or brighter, are listed in Table 3. The maxima between JD 2427000 and 2435000 agree well with a constant period, and the following light elements were determined by a least-squares analysis:

$$JD_{max} = \underset{\pm 11}{2434063} + \underset{\pm 0.6}{330\overset{d}{.}9}\ E \tag{4}$$

The O-C residuals in Table 3 are derived from these light elements. Observations of NSV 4234 on the more recent Damon patrol plates, JD 2442000 to 2448000, are difficult to interpret. Only 18 positive observations were obtained, and 8 of those are uncertain due to faintness. Only three estimates as bright as 13.5 were made, and if these observations are considered to be maxima, they do not fit the period in Equation 4. NSV 4234 may have changed its period, range of variation, or both. However, it may well be that none of these few observations represents a true maximum (all but three of the maxima in Table 3 are brighter than 13.5). New observations of this variable are needed to define its current behavior.

NSV 4234 is identical to the star GSC 6575-2880, RA = $08^h 45^m 09^s$, Dec. = -25° 59' 08" (2000).

5. NSV 4286 = HV 8163

Luyten reported a range of 12.0-15.0 ptg. I observed NSV 4286 on 140 Harvard patrol plates and 12 deep MF and B plates. I found that NSV 4286 is also a Mira variable with an extreme range of 13.2–<16.0 ptg. JDs of plate maxima, 13.7 ptg and brighter, are listed in Table 4. Light elements determined by a least-squares analysis of the times of maxima are:

$$JD_{max} = \underset{\pm 12}{2444745} + \underset{\pm 0.3}{299\overset{d}{.}4}\,E \tag{5}$$

The position of NSV 4286 is identical to the star GSC 6576-1333, RA = $08^h 52^m 43^s$, Dec. = -25° 14' 44" (2000).

6. Conclusions

W. J. Luyten was a distinguished astronomer (Upgren 1995; Hoffleit 1996). He was also a charter member of the AAVSO and was still a member when he served as the banquet speaker at the 75th anniversary meeting (Luyten 1986). Although his primary work continued in the field of proper motions, his variable star observations included discovery of the first nova in the Large Magellanic Cloud and the first conclusive observation of a flare star (UV Cet). His 1,764 variable star discoveries during the Bruce Proper Motion Survey may place him second only to Hoffmeister among individual discoverers of variable stars in the galactic field. (Leavitt found a few more variables—1,777—in the Magellanic Clouds, also on plates taken with the Bruce telescope.)

I have counted 171 of Luyten's HV stars in the NSV catalogue with maxima of 13.0 ptg or brighter, which are therefore observable on the Harvard patrol plates. As I complete other observing projects, I intend to make a special effort to investigate more of Luyten's discoveries, which represent some unfinished business in the Harvard plate archives.

References

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Table 1. Plate maxima of UV Pyx.

JD 2400000+	*mag(ptg)*	*E*	*O-C(d)*	*JD 2400000+*	*mag(ptg)*	*E*	*O-C(d)*
26712	11.8	-49	-7	45798*	12.4	5	-10
27065	12.4	-48	-7	46536	12.4	7	+22
30627	12.2	-38	+20	46860	12.0	8	-8
44022	12.4	0	-18	47236	12.2	9	+15
44751	11.5	2	+4	47565	11.7	10	-10

**Mean JD of two plates exposed on 45783 and 45812, on each of which UV Pyx was estimated at 12.4 ptg.*

Table 2. Plate maxima of HS Vel.

JD 2400000+	*mag(ptg)*	*E*	*O-C(d)*	*JD 2400000+*	*mag(ptg)*	*E*	*O-C(d)*
26145	11.4	-11	-9	30044	11.1	1	-8
26802	11.8	-9	-2	32002	11.8	7	+1
27156	11.4	-8	+27	32324	11.1	8	-1
29072	11.0	-2	-5	32983	11.0	10	+8
29394	10.8	-1	-8	46563	11.5	52	-54
29721*	11.3	0	-6	47565	11.0	55	-26

**Mean JD of two plates exposed on JD 29718 and 29724, on each of which HS Vel was estimated at 11.3 ptg.*

Table 3. Plate maxima of NSV 4234.

JD 2400000+	*mag(ptg)*	*E*	*O-C(d)*	*JD 2400000+*	*mag(ptg)*	*E*	*O-C(d)*
27097	13.5	-21	-17	31080	13.2	-9	-5
27456	13.2	-20	+11	31409	12.5	-8	-7
27784	13.2	-19	+8	31746	13.3	-7	-1
28465	13.5	-17	+27	33055	12.8	-3	-15
29777	13.2	-13	+16	33381	13.5	-2	-20
30444	13.0	-11	+21	33735	12.8	-1	+3
30761	12.6	-10	+7	34035	12.8	0	-28

Table 4. Plate maxima of NSV 4286.

JD 2400000+	*mag(ptg)*	*E*	*O-C(d)*	*JD 2400000+*	*mag(ptg)*	*E*	*O-C(d)*
27097	13.7	-59	+17	44751	13.6	0	+6
28315	13.7	-55	+37	45348	13.2	2	+4
29777	13.4	-50	+2	45647	13.2	3	+4
30375	13.7	-48	+1	46536	13.3	6	-5
32998	13.6	-39	-70	46851	13.2	7	+10