Tallinna Tehnikaülikooli Füüsikainstituut

TALLINNA TÄHETORN
TALLINN OBSERVATORY

IV

Number 1

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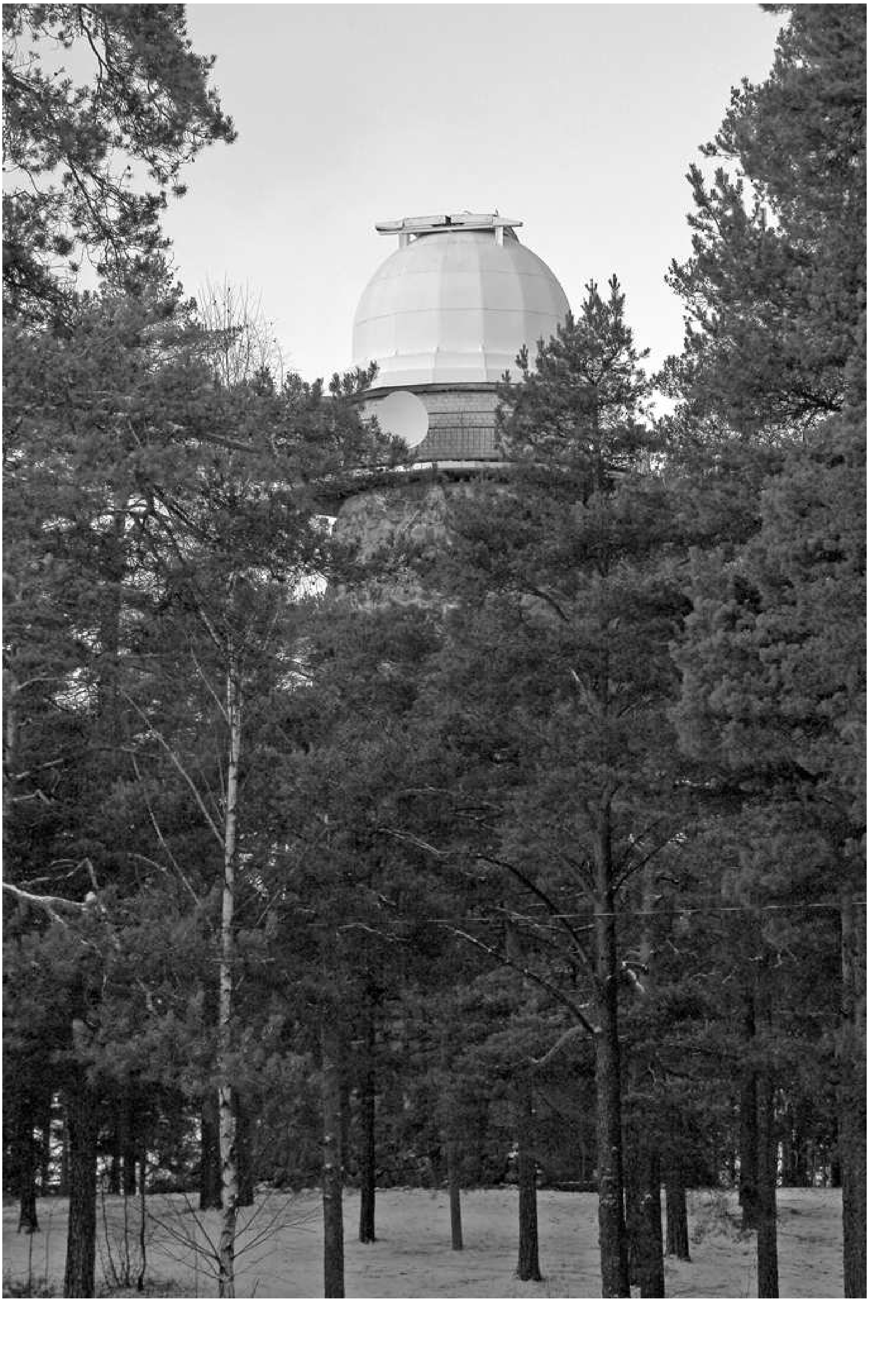

TALLINNA TEHNIKAÜLIKOOL
FÜÜSIKAINSTITUUT
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Photographic Photometry of Variable Stars Based on Tartu Photoplate Collection

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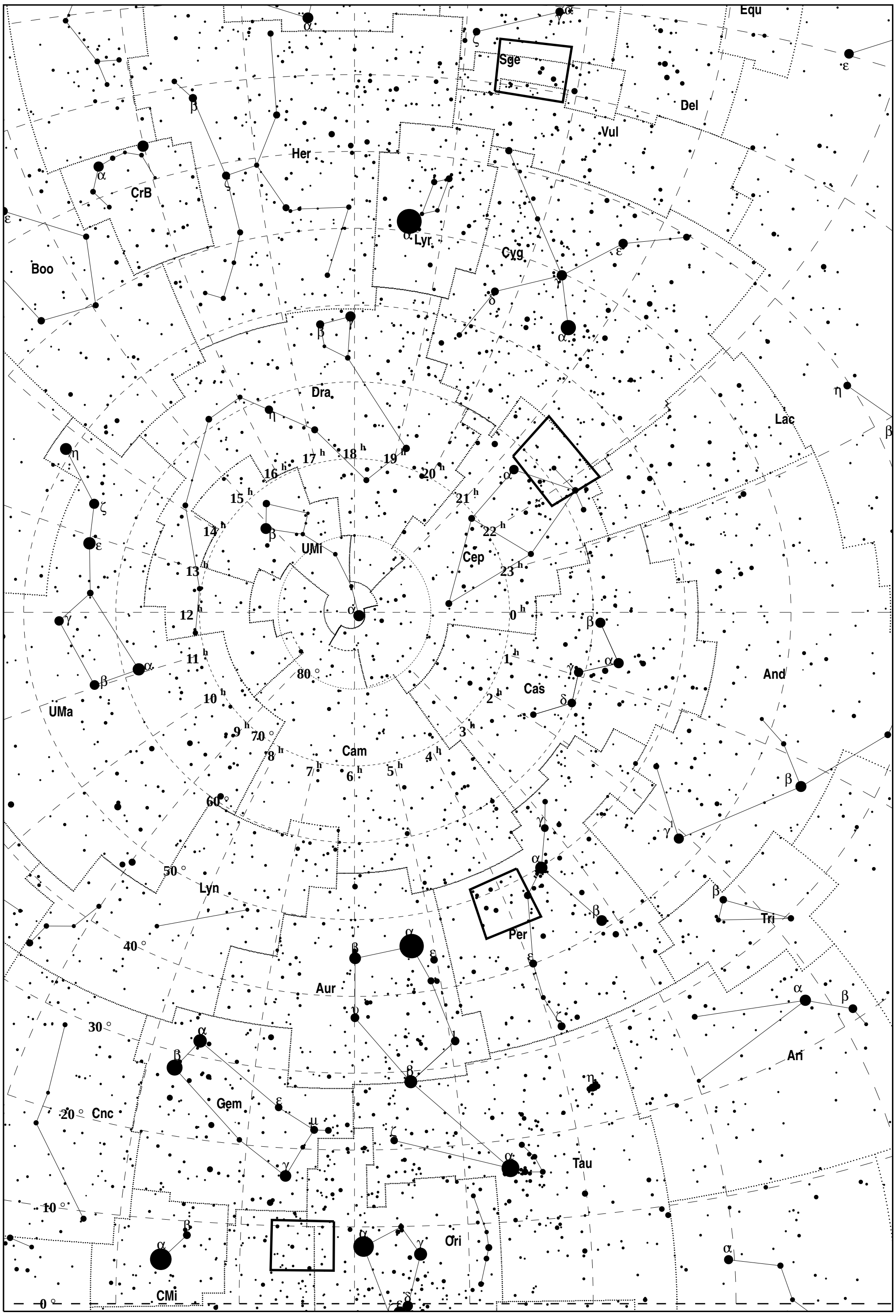
Photometry of variable stars made at the Tallinn observatory is based upon Tartu photoplates. We pursue the goal of using the observational material at our disposal most efficiently from the point of view of studying variable stars: searching for yet undetected variables and investigating photometrically all accessible earlier discovered variable objects. In this paper we describe the observational material, the techniques employed and report the results of investigations of variable stars.

Observational material

Professor Kuzmin has been both an initiator of compiling a collection of photoplates in Tartu (Fig. 1., Table 1.) and principal observer. Among the astronomers who have participated in photographing, the names of H. Albo, H. Eelsalu, J. Einasto, H. Raudsaar, A. Sapar and L. Sorgsepp are to be mentioned. For more data on the collection as a whole see Albo (1964).

The limiting magnitude for a normal exposure time of one hour was $m_{pg} = 15^m - 16^m$. Non–sensibilized NIKFI plates were in use to March 1952 and Agfa Astro thereupon. The colour system of photoplates has been investigated by Albo (1964) who found it for NIKFI plates to be practically coincident with an international m_{pg} colour system, whereas for Agfa Astro relation $m_{pg} = m_{agfa} - 0.3C$ holds with C being the colour index.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23 h
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70 °
60 °
50 °
40 °
30 °
20 °
10 °
0 °

Figure 1:

Table 1: 1950 - 1963

№	Field	Coordinates of Field α, δ (1900)	Interval of Observation	Number of Plates
1	α Sge	$19^h18^m \ldots 19^h54^m$ $+14\overset{\circ}{.}5 \ldots +21\overset{\circ}{.}0$	J.D. 2 433 360 – 2 436 907 (19.03.1950 – 04.12.1959)	233
2	μ Cep	$21^h08^m \ldots 22^h12^m$ $+55\overset{\circ}{.}0 \ldots +61\overset{\circ}{.}5$	2 433 364 – 2 438 111 (23.031950 – 22.03.1963)	267
3	μ Per	$3^h41^m \ldots 4^h34^m$ $+44\overset{\circ}{.}8 \ldots +51\overset{\circ}{.}3$	2 433 336 – 2 438 108 (23.02.1950 – 19.03.1963)	257
4	13 Mon	$6^h11^m \ldots 6^h44^m$ $+4\overset{\circ}{.}3 \ldots +10\overset{\circ}{.}7$	2 435 512 – 2 438 117 (08.02.1956 – 28.03.1963)	134

Investigation techniques

The stellar brightness has been measured with the aid of microphotometers MF–2 and MF–4 suplied with a set of round and oval diaphragms. Precision electron stabilizer manufactured by us has been substituted for the ferroresonance stabilizer from the standard set the photometer. Usually two readings for a star and four for the background were taken but in some cases (the background measurements are influenced by a random condensation of faint stars, or just on the contrary, the background is virtually uniform) botoh variable and comparison stars were measured relative to the mean background of the area in question. The brightness of a variable star has been measured with the aid of characteristic curve drawn for each variable for every plate separately and based upon the measurements of 5 – 6 comparison stars.

To choose the appropriate comparison stars their light and colour indices have been determined by calibrating them with a standard in NGC 6802 (Hoag, Johnson et al., 1961) in the photometric system close to Johnsont́s B and V. We used for this purpose a pair of photoplates taken with a Schmidt camera of Radioastrophysical Observatory in Baldone (Latvian S.S.R.). In those cases when variable was found to lie beyond the limits of a field of the Schmidt plates or the calibration procedure proved to be unreliable (a variable is at the edge of the plate and the stellar image is heavily distorted) the measurements have been made on a relative scale and in the next paragraph we quote the amplitudes Δm_1 and Δm_2 of minima instead of Min I and Min II.

In a search for new variable stars we have used projectional blink microscope in additional colours, designed and manufactured by H. Hoyer. This device has some advantages in comparison with the ocular blink micriscope because it is more convient for an observer to watch for a long time two photoplates as projected upon a screen. Blink microscope has been functioning in three working conditions:

(a) colour contrast has been used with one plate projected through a green and another through a red filter; a black image of a variable object surrounded by a green or a red ring stands out against the grey background;

(b) blinking by the shutter without filters; variable object looks like pulsating one;

(c) hand-blinking using the projecting lamps changing switch. This last mode is advisable for poor stellar images.

Schematic diagram of a blink microscope is shown in Fig. 2.

Its specification data are as follows:

Objective ....Industar 50 (f=5 cm, 1:3.5)
Maximum sizes of photoplates .... 9x12 cm
Projected field .... 1.2x1.2 cm
Maginification .... 20×
Dimensions of a focussing screen .... 24x24 cm
Overall dimensions of a device .... 70x60x55 cm

The device has been constructed in such a way that the projection system moves over the photoplates to be compared, while the desk with the plates moves perpendicularly to it. There is the crude as well as the precisional motion in both directions. To match the images of two channels one plate is shifted by use of micrometer mechanism.

Times of maxima and minima were determined graphically with the aid of a tracing paper. Mean–root–square errors of the normal extreems were computed by formula:

$$\sigma = \sigma_m + \sqrt{\frac{\sum_{i=1}^{n}(\phi_i - \phi m_i)^2}{n(n-1)}} \tag{1}$$

where σ_m is the mean–root–square error of the time of the extreme of an average (standard) curve $f(\phi)$; ϕ_i is the phase angle corresponding to the brightness m_i; ϕm_i – the respective phase of a mean curve $f(\phi m_i) = m_i$; n – the number of points in the normal extreme. As a rule $\sigma_m \ll \sigma$ is neglected. In comparison, for instance, with the error of the time of normal minimum σ_a following Albo (1964), which does not depend on the scattering of observations of a given normal extreme around the mean curve, the error from (1) is always larger or equal:

$$\sigma \geqslant \sigma_a = \sqrt{\frac{\sum_{i=1}^{n}(m_i - m_{m_i})^2}{(n-q)\sum_{i=1}^{n}(\frac{\delta f}{\delta\phi})^2}} \tag{2}$$

where q is the effective number of parameters defining the shape of a mean curve.

The period, if previously unknown, has been determined with the aid of the method of local scanning (Harvig and Kalv, 1975).

The improvement of photometric elements has been made following an ordinary technique of the least squares. An attempt to invsetigate photometrical properties of faint stellar images on the nonsensibilized photographic plates made by Kalv and Harvig (1966).

Muutlike tähtede fotograafilisest fotomeetriast kasutades Tartu astrofototeeki. 'Ajalooline ülevaade'.

Tallinna Tähetornis teostatud muutlike tähtede fotograafilise fotomeetria aluseks oli Tartu astrofototeek. Selle töö eesmärgiks oli avastada uusi muutlikke tähti fotoplaatidelt ning uurida neid ja varem tuntud muutlikke tähti fotomeetriliselt. Antud kirjutise eesmärgiks on kirjeldada kasutatud meetodeid ja esitada kokkvõte saadud tulemustest.

Vaatlused.

Muutlike tähtede fotograafiliste vaatluste algatajaks oli professor G. Kuzmin, kes oli ühtlasi ka üheks vaatlejaks. Vaatlusi on teostanud ka näiteks H. Albo, H. Eelsalu, J. Einasto, H. Raudsaar, A. Sapar ja L. Sorgsepp. Vaatluste kohta detailsemalt võib leida Albo (1964) artiklist.

Piirtähesuuruseks on 15^{m} kuni 16^{m} ekspositsiooniajaga 1 tund. NIKFI astroplaadid olid kasutuses alates märtsist 1952, mis hiljem asendusid AGFA omadega. NIKFI astroplaatide värvussüsteem on praktiliselt sarnane rahvusvahelise värvussüsteemiga (Albo 1964) ja AGFA astroplaatide tundlikkus on leitav valemiga $m_{pg} = m_{agfa} - 0.3C$, kus C on värvusindeks.

Muutlike tähtede fotomeetria.

Tähtede heledused on mõõdetud mikrofotomeetritega MF–2 ja MF–4, mis varustati ümmarguste ja ovaalsete diafragmaga. Standardfotomeetri magnetresonantsstabilisaator asendati täppis elektron–stabilisaatoriga. Tavaliselt on mõõdetud tähele vastavat tumenemise väärtust kahel ja fooni neljal korral, kuid erijuhtudel (siis kui fooni on sattunud nõrgad taustatähed või vastupidiselt, kui foon on eriti ühtlane) on mõlemad (nii uuritav täht kui võrdlustähed) mõõdetud keskmise fooni suhtes. Muutlike tähtede heledus on saadud karakteristliku graafiku pealt, mis on saadud 5 – 6 võrdlustähe mõõtmistest iga astroplaadi jaoks eraldi. Sobivate võrdlustähtede valikuks heleduse ja värvusindeksite järgi on need kalibreeritud standardiga NGC 6802 (Hoag, Johnson et al., 1961) Johnsoni B ja V fotomeetrilises süsteemis. Sellel eesmärgil on paar fotoplaati tehtud Scmidti kaameraga Baldone Raadiofüüsika observatooriumis (Radiophysical Observatory), Lätis. Nendel juhtudel, kui muutlikud tähed on väljaspool välja Schmidti plaatidelt või kui kalibratsiooniprotseduur osutub mitteusaldusväärseks (muutlik täht asub fotoplaadi servaaladel ja tähe kujutis on moonutatud), on mõõtmistel kasutatud suhtelist skaalat. Uute muutlike tähtede otsimiseks kasutati projektsioonkomparaatorit, mis on valmistatud H. Hoyeri poolt. Hoyeri komparaatorit kasutati erinevates reziimides.

Fototeegi skaneerimine.

Fototeegi viimane (13 Mon) Tartu Observatooriumist laenatud ala skaneeriti õppeotstarbelise materjali saamiseks.

Individual stars.

1. WY Aql (Kalv et al. 1984), 120 measurements
   Max Hel = J.D. $2427552.4 + 389\overset{d}{.}37 \times E$

2. LU Aql (Harvig et al. 1981), 224 measurements
   The duration of the light variation cycle is unstable $90 - 100^{d}$

3. OW Aql (Kalv et al. 1984), 103 measurements
   Light elements: Max Hel = J. D. $2425790 + 260\overset{d}{.}96 \times E$

4. OX Aql (Kalv et al. 1984), 34 observations
   Light elements: Max Hel = J.D. $2425790 + 260\overset{d}{.}96 \times E$

5. V340 Aql (Leis et al. 1979), 207 measurements
   Improved light elements: Min Hel = J.D. $2434181.552 + 3\overset{d}{.}749053 \times E$

6. V446 Aql (Harvig et al. 1981), 207 measurements
   Intervals betveen the most deep minima of brihtness are on average 506^{d}

7. V602 Aql (Leis et al. 1979), 187 measurements
   Improved light elements: Min Hel = J.D. $2431330.231 + 3\overset{d}{.}0124428 \times E$

8. V688 Aql (Leis et al. 1979), 215 measurements
   Improved light elements: Min Hel = J.D. $2431326.154 + 3\overset{d}{.}889712 \times E$

9. V830 Aql (Harvig et al. 1981), 217 measurements
   The mean value of the light variation cycle is 62^{d}.

10. V1012 Aql (Harvig et al. 1981), 187 measurements
    The duaration of the cycles of $700 - 1200^{d}$.

11. V1045 Aql (Leis et al. 1979), 139 measurements
    The times of normal minima which well agree with the elements given in GCVS
    Min Hel = 2427713.307 + $2^{d}_{.}193750$×E

12. V1046 Aql (Leis et al. 1979), 141 measurements
    Light elemets determined using only our observations:
    Min Hel = J.D. 2435114.998 + $5^{d}_{.}282908$×E

13. GO Mon (Ostonen 1987), 115 measurements
    Light elements: Min Hel = J.D. 2427100.254 + $12^{d}_{.}46666$×E

14. XZ Per (Harvig, Leis 1981), 232 measurements
    O-C probably varies cyclically

15. AS Per (Maripuu, Kalv 1981), 228 measurements
    Light elements: Max Hel = J. D. 2436816.078 + $4^{d}_{.}972489$×E

16. FM Per (Kalv et al. 1984), 186 measurements
    Light elements: Max Hel = J.D. 2433765.799 + $0^{d}_{.}4892014$×E

17. FO Per (Kalv et al. 1984), 84 measurements
    No regularity.

18. FR Per (Maripuu, Kalv 1981), 110 measurements
    Cycle of slow wariations 5.5 years

19. FV Per (Maripuu, Kalv 1981), 194 measurements
    Cycles 300-350 days, modulated by 1800 wave

20. S8550 Per (Harvig, Leis 1981), 228 measurements
    Possible light elements: Min Hel = J.D. 2434625 + 1496^{d}×E

21. S8552 Per (Harvig, Leis 1981), 237 measurements
    Probable light elements: Min Hel = J.D. 2428327.653 + $2^{d}_{.}446798$×E

22. RW Sge (Kalv et al. 1984), 72 measurements
    Light element: Max Hel = J.D. 2424277 + $432^{d}_{.}5$×E
    or Max Hel = 2424294 + $448^{d}_{.}9$×E

23. TU Sge (Leis et al. 1979), 103 measurements
    Improved light elements: Min Hel = J.D. 2428020.361 + $4^{d}_{.}908918$×E

24. TZ Sge (Kalv et al. 1984), 115 measurements
    Light elements Max Hel = J.D. 2426098 + $270^{d}_{.}30$×E

25. UU Sge (Leis et al. 1979), 167 measurements
    Times of minima are in good agreement with Tsessevich (IBVS No.1320).

26. UV Sge (Kalv et al. 1984), 120 measurements
    Light elements: Max Hel = J.D. 2434075 + $174^{d}_{.}0$×E

27. WX Sge (Kalv et al. 1984), 81 measurements
    light elements: Max Hel = J.D. 2429810 + $394^{d}_{.}2$×E

28. XX Sge (Leis et al. 1979), 147 measurements
    Our light elements: Min Hel = J.D. 2434685.2485 + $3^{d}_{.}5190493$×E

29. ZZ Sge (Kalv 1961), 202 measurements
    New light elements: Min Hel I = 2431019.25 + $5^{d}_{.}6028$×E

30. CU Sge (Leis et al. 1979), 197 measurements
Light elements: Min Hel = J.D. $2428372.229 + 0^{d}.791677 \times E$

31. CV Sge (Harvig et al. 1981), 167 measurements
No regularity.

32. CZ Sge (SVS 1676) (Kalv 1970), 213 measurements
Light elements: Min Hel = $2435838.086 + 9^{d}.85999 \times E$

33. DG Sge (Kalv et al. 1984), 111 measurements
Max Hel = J.D. $2436724.35 + 4^{d}.43724 \times E$

34. DH Sge (Kalv et al. 1984), 156 measurements
Max Hel = J.D. $2427612.5084 + 0^{d}.46958429 \times E$

35. DP Sge (Kalv et al. 1984; Kestlane, Leis 1970), 157 measurements
Light elements: Max Hel = J.D. $2434080.904 + 0^{d}.4883328 \times E$

36. DQ Sge (Leis et al. 1979), 117 measurements
Light element: Min Hel = J.D. $2436126.315 + 2^{d}.87380 \times E$

37. TTV-1=SPZ 1673 (Kestlane, Leis 1970), 156 measurements
Light elements: Max Hel = J.D. $2435337 + 12^{d}.9007 \times E$

38. TTV-2=SPZ 1674 (Kestlane, Leis 1970), 214 measurements
Light elements: Max Hel = J.D. $2433683.8 + 51^{d}.67 \times E$

39. U Vul (Kalv et al. 1984), 108 measurements
Light ekements: Min Hel = J.D. $2420141.645 + 7^{d}.990662 \times E$
(minimum determined better than maximum)

40. RZ Vul (Harvig et al. 1981), 137 measurements
Slow variattions cycle 1410^{d}

41. CS Vul (Leis et al. 1979), 151 measurements
Improved light elements: Min Hel = J.D. $2429162.322 + 4^{d}.37767 \times E$

42. FZ Vul (Leis et al. 1979), 100 measurements
Light element: Min Hel = J.D. $2436763.366 + 2^{d}.4177487 \times E$

43. NO Vul (Leis et al. 1979) [SVS 1988 (Kalv, Leis 1973)], 183 measurements
Light elements: Min Hel = J.D. $2434328.221 + 0^{d}.370768 \times E$

44. NP Vul (Leis et al. 1979) [SVS 1987 (Kalv, Leis 1973)], 74 measurements
Light elements: Min Hel = J.D. $2435051.024 + 1^{d}.905662 \times E$

45. CSV 4733 (Harvig et al. 1981), 156 measurements
No regularity.

46. CSV 4845 (Leis et al. 1979), 140 measurements
No light variations.

47. S8315 (Kalv, Leis 1972a,b), 192 measurements
New light elements: Min Hel I = J.D. $2435401.264 + 4^{d}.92658 \times E$

48. SVS 1303 (Kalv et al. 1984), 40 measurements
Light elements: Max Hel = J.D. $2432799 + 333^{d}.1 \times E$

49. TTV-8 (Leis et al. 1979), 176 measurements
Light elements: Min Hel = J.D. 2434461.529 + $1^{\mathrm{d}}.4147979$×E

50. TTV-9 (Leis et al. 1979), 199 measurements
Light elements Min Hel = 2435428.2445 + $0^{\mathrm{d}}.5157965$×E

51. TTV-10 (Leis et al. 1979), 157 measurements
Probable light elements: Min Hel = $J.D.$2435931.563 + $10^{\mathrm{d}}.5138$×E

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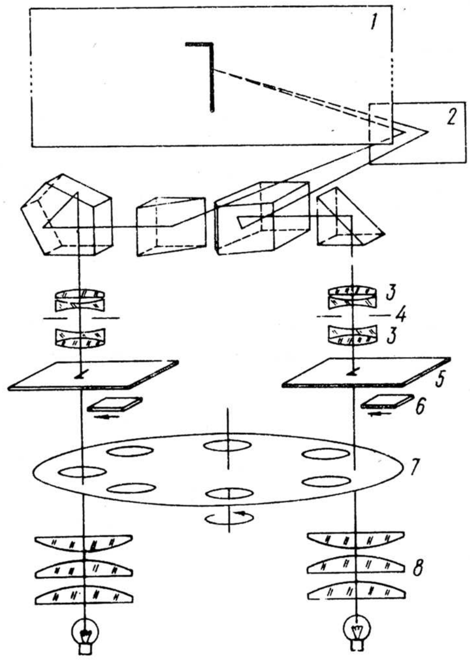

Figure 2:

Figure 3: H. Hoyeri projektsioonkomparaator.

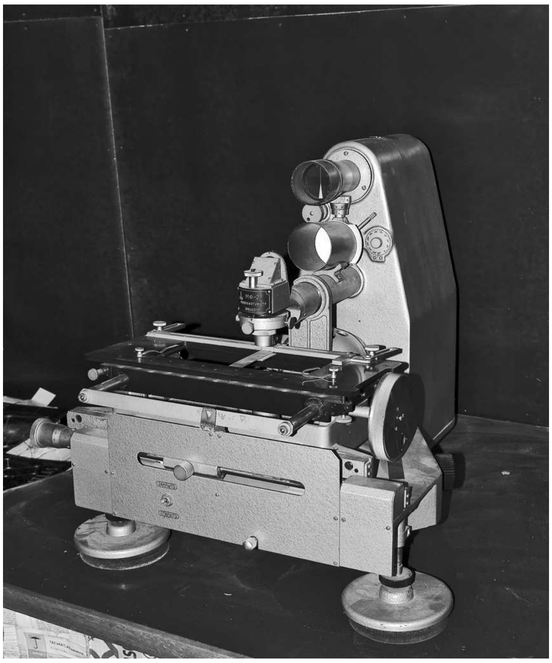

Figure 4: MF – 2

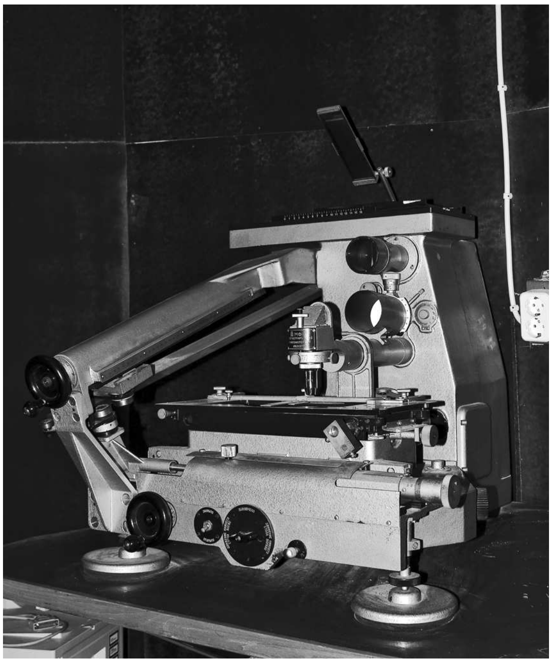

Figure 5: MF – 4

Figure 6: Margit Rästas Tartu astrofototeeki skaneerimas.

Figure 7: Margit Rästas Tartu astrofototeeki skaneerimas.