PHOTOMETRIC FACILITIES OF THE AIST SPACE PROJECT

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Abstract. The arguments are given of the choice for the Vilnius seven color medium band photometric system as the most effective one for the *AIST* space project. A prediction is made of the limiting stellar magnitudes V for every Vilnius passband and the integral band T at $\sigma_{\Sigma} \leq 30mmag$ from a 3 year *AIST* mission.

1. Introduction

The main aim of the scientific program of the *AIST* project is to create a fundamental catalogue of positions, proper motions and parallaxes for faint stars at the epoch of mission with milliarcsecond precision, to carry out their high precision multicolor photometry and direct optical measurements A the precise quasar coordinates to fit a fundamental system. The last was the main reason for a choice of the limiting magnitudes to be of the order of $V_{lim} = 18mag$.

2. Instrumentation

We estimate for a two Schmidt telescopes instrument. The version is: one of two telescopes has a beam combiner, another one, with full pupil, has no beam combiner. As the standard detector units we use (Fig.1) a square CCD chips with 256 x 256 pixels ($4.1 \times 4.1mm$), the pixels being 16 $\mu m = 1.32''$ squares. The central diffraction spot for the full telescope pupil is $d_0 = 0.75''$. The adopted spectral sensitivity $QE(\lambda)$ of CCD has values 56,76,77 and 42% for the wavelength 300, 500, 700 and 900 nm respectively. At the angular velocity of $150''/s$ the star crosses the field of view within 34^s and the single CCD chip within 2.25^s. The main axis of rotation has a scan step $20'$ and small drift during one rotational period.

E. Høg and P. K. Seidelmann (eds.),
Astronomical and Astrophysical Objectives of Sub-Milliarcsecond Optical Astrometry, 327–330.

3. The Choice of the Photometric System

We have compared the parameters and qualities of several modern most usable multicolor photometric systems. The criteria have been used: (a) the of the selected passbands and their positions, fixing spectral type and luminosity, and domains of application of the system; (b) the bandwidths and their comparative abilities in achieving the necessary limiting magnitude of the whole system; (c) the system purity parameters (Jaschek and Frankel, 1986), i.e. the quality and ability of the photometric system to classify stars with different characteristics in the optimal way and to reveal and classify the various types of peculiar stars, for example, Ap, Am, carbon and metal-poor stars, subdwarfs, white dwarfs, some types of binaries etc.; (d) the availability of a sufficient number of standards, including both ordinary and peculiar stars observed in a given photometric system; (e) the possibility of transformation of the photometric data collected in the chosen system to other systems with a minimum loss of precision. These criteria were applied for the comparison of the $UBVRI, uvby + \beta_n + \beta_w$, Vilnius and Geneva photometric systems. The firm conclusion has been reached that the most effective one is the medium-band seven-color Vilnius system $WPXYZVS$ (Straižys 1977 and 1992).

After that, we compared main merits and problems of the basic versions of this system: Standard, VilGen, Interferometric and CCD-adapted (Straižys 1977; Straižys et al. 1992). As a final result, we have used the Interferometric version (Int) whose parameters are listed in Table 1. The contents of columns 1 - 4 are understandable. The 5th column contains the integrated filter transparency (the equivalent width W_λ).

4. Calculation Scheme

For the calculation of the expected limiting magnitudes V_{lim}, the magnitude error in 1^s exposure σ_1 and the error in the whole flight time σ_Σ we use the standard formula

$$\sigma = \frac{\sqrt{N_* + N_n + N_{CCD}}}{N_* \sqrt{t}}. \tag{1}$$

Energy distribution $E(\lambda_i)$ in the spectrum of the faint stars, of the faint stars background (SL) and of Zodiacal light (ZL) is similar to that of a star of spectral type G. With the adopted aperture, optics transparency $p(\lambda_i), W(\lambda_i)$ and $QE(\lambda_i)$ we find for every band the value N_* in units $[e^-/s]$. For the calculation of N_n in formula (1) we have used the mean integrated sky brightness $\overline{m_i}(ZL + SL)$ per pixel given in column 8 of Table 1.

All the calculation for the band T (the last row of Table 1) was made taking into account only the losses of light in optics and the $QE(\lambda)$ of the

TABLE 1. The adopted version of the Vilnius system.

Band	λ_0 nm	$\Delta\lambda$ nm	τ_{max} %	W_λ nm	$\frac{W_\lambda(Int)}{W_\lambda(Std)}$	QE %	$\overline{\frac{m_i}{pix}}$ mag	t_{total} s
1	2	3	4	5	6	7	8	9
W	350	52	65	35.5	2.10	62	21.7	670
P	375	20	58	12.2	1.11	65	21.7	1080
X	406	17	60	10.7	1.57	68	21.6	1005
Y	468	23	82	19.8	2.61	74	21.4	310
Z	518	18	74	14.0	1.47	77	21.1	380
V	547	26	85	23.2	3.14	79	20.9	285
S	656	32	85	28.6	7.94	80	20.5	205
T	625	587	100	548	–	80	20.2	105

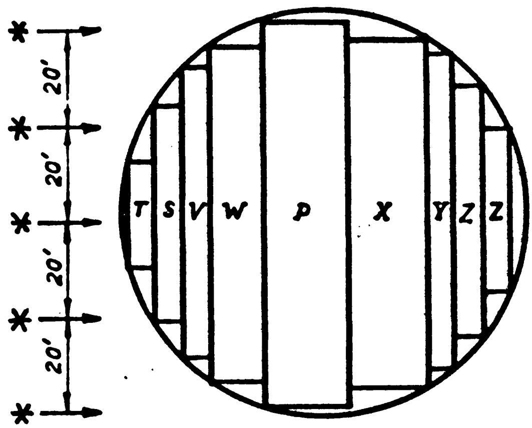

Figure 1. Relative areas in the field of view covered by 7 Vilnius filters (and by T-band), to reach the same V_{lim} magnitude of a G2 IV-type star.

CCD. The total noise N_{CCD} in the formula (1) was assumed to be $5e^- \; s^{-1}$. A "drift-scan" principle was used throughout calculations.

5. Analysis of the Results

Extensive tables were prepared, containing the relations between V and σ_1 for the bands of the Vilnius system and for the T-band. These tables demonstrate that because of the rather small W_λ values for the P and X bands and relatively low $E(\lambda_i)$ for the W band, the magnitudes V (or V_{lim}) at some adopted σ (or σ_{lim}) for these bands are smaller than $\overline{V}$ (or $\overline{V}_{lim}$) of the remaining four Vilnius bands by 1.6, 1.3 and $0.8mag$ respectively. The best possibility for an approximate equalizing of V_{lim} for different bands is

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to enlarge the relative widths and lengths of the chips within the field of view covered by the "poor" filters P, X and W.

The result of one such numerical equalization of V_{lim} (the number and size of CCD chips covered by the Vilnius filters) is presented in Fig. 1.

We have estimated also the approximate scanning times (column 9 of Table 1) for the Vilnius bands during the time of the *AIST* mission (3 years) which would be necessary in order to reach nearly the same V_i.

In Table 2 we represent the dependences of the final errors for all the Vilnius and T bands. The upper row of asterisks marks $\sigma_\Sigma \leq 1mmag$, at $V \approx 11mag$, the lower one shows us the V_{lim} at $\sigma_\Sigma \leq 30mmag$.

TABLE 2. The final errors σ_Σ of the predicted stellar magnitudes V_i of G2IV-star. Total flight time is 3 years. Errors are given in *mmag*.

V	σ_W	σ_P	σ_X	σ_Y	σ_Z	σ_V	σ_S	σ_T
11	*0.92*	*1.07*	*0.94*	*0.92*	*1.00*	*0.98*	*0.92*	0.32
12	1.42	1.71	1.51	1.60	1.56	1.40	1.46	0.51
13	2.3	2.8	2.4	2.4	2.4	2.2	2.3	*0.80*
14	3.7	4.5	3.8	4.0	4.0	3.5	3.7	1.28
15	6.1	7.5	6.4	6.4	6.4	5.7	5.9	2.0
16	10.4	13.3	10.8	10.5	10.6	9.2	9.6	3.2
17	18	* 26 *	21	18	18	15.5	16	5.2
18	* 37 *	55	* 42 *	* 32 *	* 35 *	* 28 *	* 29 *	8.6
19	77	125	99	70	72	58	56	15
20	178		230	147	107	119	118	* 28 *

6. Conclusion

The calculation shows that the *AIST* project would obtain medium band multicolor photometry of faint stars down to $18.0mag$ with a final error $\sigma_\Sigma \leq 30mmag$, photometry of bright stars down to $\approx 11mag$ with $\sigma_\Sigma \leq 1mmag$ and surface photometry of extended objects down to $\approx 18mag$ per pixel with $\sigma_\Sigma \leq 30mmag$. In addition, the T band allows to measure stars with the same precision but $2.0 - 2.5mag$ fainter.

References

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