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ON THE NECESSITY TO STANDARDIZE PHOTOMETRIC PARAMETERS OF THE WET PHOTOMETERS

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Abstract. The temperature dependence of spectral sensitivity of the Hamamatsu photomultipliers R 647P and R 1463P is investigated in the temperature interval –5 (–15)°C to +25°C for the wavelength range between 280 and 820 (850) nm. The influence of the temperature variations on spectral sensitivity of PMTs and transmittance of the *UBV* filters to the accuracy of the WET and classical *UBV* photometry is estimated. It is argued that the temperature effects should be taken into account in WET observations as in the case of precise *UBV* photometry.

Key words: instrumentation: photometers

1. INTRODUCTION

It is well known (Young 1965, 1967, Sperauskas & Kalytis 1978) that photomultipliers (hereafter PMTs) show some variations of spectral sensitivity when the temperature changes. The transmittance of filters is also temperature-dependent (Young 1967, Sperauskas 1974). The task of this investigation was to measure the temperature dependence of spectral sensitivity of small-size Hamamatsu PMTs: R 647P with bialkali (S11) photocathode and R 1463P with multialkali (S20) photocathode. A comparison of spectral sensitivities of both types of PMTs as well as those of separate specimens within the same type of PMTs was also one of our aims. We have made the quantitative evaluation of the temperature influence on the accuracy of photoelectric photometry of the WET program and of the usual *UBV* photometry, when using these types of PMTs. For this purpose, the results of the present investigation were used together with the results of earlier measurements of the temperature dependence on transmittance of the *WBV* filters, done by Sperauskas (1974). Here *W* is the filter proposed by Straižys (1973) to replace the ill-defined Johnson's *U* filter.

2. MEASURING TECHNIQUES

Our investigation of the quantum efficiency of photomultipliers was made using a modernized spectrophotometer SF-46 (made in the LOMO factory in Leningrad) and a modified photoelectric head FEG 310 (Kalytis 1998, these proceedings). In FEG 310, the air ventilated heat absorber was replaced by the running water one, in order to achieve a deeper cooling. The measuring photon counter was realized using the "one cable" system (Kalytis et al. 1997), with the high voltage divider D 304 and pulse amplifier-discriminator F 318 designed especially for this system.

The quantum efficiency of six PMTs R 647P (S11) and seven PMTs R 1463P (S20) was measured in the spectral range from 280 to 820 nm (for R 1463P, up to 840 nm). The dependence of spectral sensitivity of two PMTs R647P was measured at temperatures of –5°C to +30°C and that of three PMTs R 1463P it was measured at temperatures between –15°C and +30°C.

All values of the quantum efficiency of the PMTs under investigation were determined by comparison with the reference PMT Hamamatsu R 1463P (serial No. VC8641) which has the spectral quantum efficiency data measured by the manufacturer in the spectral range from 200 nm to 890 nm.

3. RESULTS

The dependence of the quantum efficiency $q(\lambda)$ on the wavelength for two bialkali PMTs of the R 647P type, which have the maximal and minimal sensitivities of the six PMTs investigated, is presented in Fig. 1. The same for two multialkali PMTs of the type R 1463P with maximal and minimal sensitivities of the seven investigated ones is shown in Fig. 2.

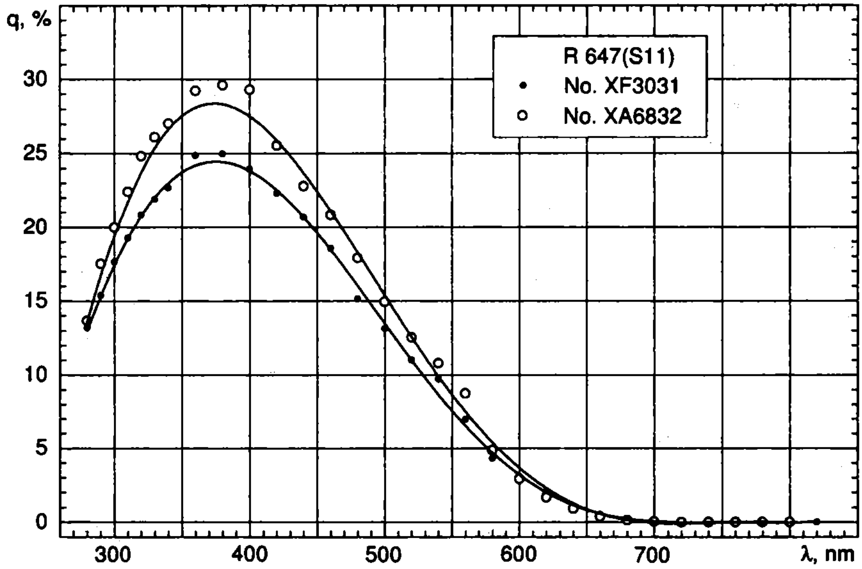

Fig. 1. Spectral response characteristics for the bialkali photomultipliers R647P (Nos. XF 3031 and XA 6832) at the temperature of +25°C.

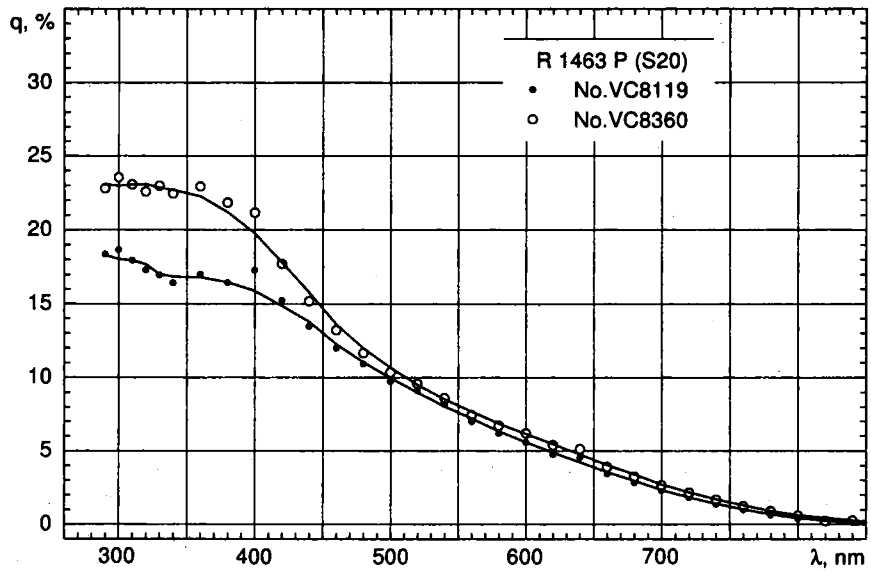

Fig. 2. Spectral response characteristics for the multialkali photomultipliers R1463P (Nos. VC 8119 and VC 8360) at the temperature of +25°C.

Table 1. The mean spectral responses of PMTs R 647P and R 1463P.

λ nm	$q(\lambda)$ in % R647P	$q(\lambda)$ in % R1463P	λ nm	$q(\lambda)$ in % R647P	$q(\lambda)$ in % R1463P
280	13.737	20.143	570	7.235	6.655
290	15.417	20.360	580	6.805	6.273
300	19.342	20.766	590	5.314	5.997
310	20.725	20.135	600	4.210	5.751
320	23.228	19.434	610	3.686	5.381
330	23.539	19.404	620	2.533	4.996
340	24.678	18.860	630	2.431	4.905
350	25.420	19.204	640	1.882	4.862
360	27.801	19.549	650	1.596	4.289
370	27.549	19.176	660	0.267	3.721
380	28.202	18.826	670	0.804	3.420
390	27.667	18.658	680	0.181	3.091
400	27.112	18.567	690	0.373	2.820
410	26.824	17.216	700	0.027	2.521
420	26.516	15.996	710	0.078	2.258
430	25.137	14.947	720	0.007	2.016
440	23.723	13.881	730	0.004	1.768
450	23.039	13.042	740	0.002	1.535
460	21.158	12.158	750	0.001	1.319
470	20.510	11.501	760	4.432E-4	1.113
480	18.750	10.831	770	4.432E-4	0.927
490	17.686	10.227	780	1.343E-4	0.752
500	15.750	9.619	790	1.343E-4	0.591
510	15.000	9.246	800	4.736E-5	0.428
520	13.283	8.889	810	4.736E-5	0.311
530	12.118	8.476	820	7.843E-5	0.177
540	11.422	8.103	830		0.213
550	9.628	7.600	840		0.236
560	8.964	7.049			

Our results show that in some wavelengths sensitivities of individual bialkali PMTs (of the six specimens) can be different up to $\sim$ 20 %, whereas for the multialkali PMTs this difference is near 30 %.

The mean values of the quantum efficiency for both types of PMTs, calculated from the measurements of all PMTs investigated, are presented in Table 1.

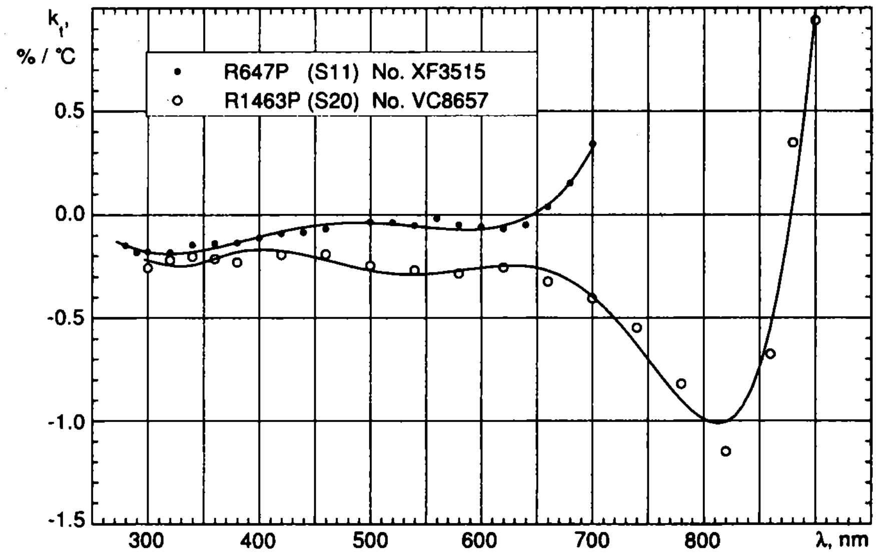

Fig. 3. The dependence of the mean temperature coefficients of sensitivity k_t on the wavelength for the PMTs R 647P and R 1463P.

The dependence of the mean temperature coefficients of sensitivity k_t on wavelength for both types of PMTs is shown in Fig. 3. The boundary temperatures used in the calculations of the mean k_t values were −5°C and +30°C for the bialkali PMTs, and −15°C and +30°C for the multialkali PMTs, since these coefficients practically do not depend on the temperature range (especially in the working range of wavelengths). The temperature coefficients of sensitivity within different PMTs of the same type differ by not more than 30 %. As seen from Figs. 1–3, larger and more varying values of the temperature coefficients are found at the wavelengths where the quantum efficiency is lower than 1 %. It is also found that the temperature coefficients are larger for the PMTs which are more sensitive at the red end of the spectral range.

4. DEPENDENCE OF WBV RESPONSE FUNCTIONS ON TEMPERATURE

The results of investigation of the temperature effects on the transparency of the *WBV* filters made by Sperauskas (1977) are shown in Fig. 4. To characterize the temperature effects we have introduced the following parameters of the photometric passbands: $\Delta\lambda_0$ – the shift of the mean wavelength, $\Delta\tau$ – the change of the area under the filter transmittance curve, $\Delta\phi$ – the change of the area under the response function and Δm – the change of instrumental magnitudes of stars. Table 2 gives these parameters for the *WBV* system passbands when the temperature of the filters and PMTs rises by 10°C. The parameters λ_0, τ and ϕ were calculated by the following equations:

$$\lambda_0 = \frac{\int \tau(\lambda)\lambda d\lambda}{\int \tau(\lambda) d\lambda},$$

$$\tau = \int \tau(\lambda) d\lambda,$$

$$\varphi = \int \tau(\lambda) q(\lambda) d\lambda.$$

The synthetic magnitudes m were calculated by convolution of the spectral flux distribution functions of stars and the response functions of the passbands at different temperatures. We used the mean energy distributions of one F0 V star (Straižys & Sviderskienė 1977) and two white dwarfs of types WDA and WDB, G 738–31 and G 157–34, respectively (Filippenko & Greenstein 1984).

The changes of magnitudes Δm presented in Table 2 are the mean values for all three types of stars, since differences in Δm for individual stars are not larger than 0.002 mag. These differences are slightly larger for hotter stars.

If stellar magnitudes are measured without any filter, the expected temperature changes of magnitudes do not exceed 0.008 and 0.017 mag per 10°C for the bialkali and multialkali PMTs, respectively. Consequently, for the WET-type observations without filters the temperature influence seems to be not so important as in classical photometry.

Although the changes of the main parameters of the *WBV* system with temperature seem to be small, they must be taken into account in the case when the temperature changes considerably. The largest errors in magnitudes (0.01–0.02 mag per 10°C) can appear when one channel is used with a filter and another channel without any filter.

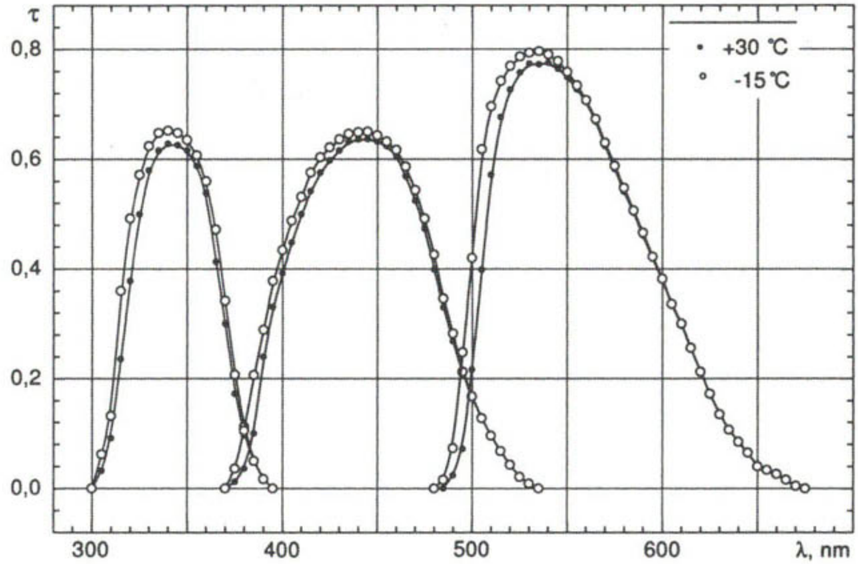

Fig. 4. Temperature effect on the transparency of the *WBV* filters.

Table 2. Temperature effect on the parameters of the *WBV* system.

Parameter		*W*	*B*	*V*
$\Delta\lambda_0$, nm per 10°C		−0.21	−0.37	−0.71
$\Delta\tau$, % per 10°C		−2.30	−1.30	−1.60
$\Delta\varphi$, % per 10°C	for S11	−3.20	−2.00	−2.70
	for S20	−3.90	−2.30	−3.70
Δm, mag per 10°C	for S11	0.034	0.021	0.031
	for S20	0.024	0.024	0.041

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