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Relation between the peak wavelength of moderately monochromatic light and the interfringe spacing in interference pattern

I. Double refracting interference system

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The commercial interference microscopes are usually equipped with the white light source, from which the monochromatic light is filtered out by using interference filters. The filters are usually typical filters of spectral half-band-width not less than 10 nm. It has been stated that such filters may introduce some errors to the optical path difference due to their insufficient monochromacy. These errors occur mainly in the short-wavelength (violet to blue) and long-wavelength (red) parts of the visual spectrum. They follow mainly from the fact that in insufficiently or moderately monochromatic violet-blue and/or red light the observed interference fringe frequency is slightly different from that occurring in the highly monochromatic light of the same peak wavelength.

1. Introduction

The quantity being measured directly with the help of interferometers is the optical path difference (or its gradient) from which different derivative physical magnitudes, like refractive index, birefringence, thickness of microobjects, depth of the surface microroughness, and the like are next determined. In general, the optical path difference δ may be expressed by the formula

$$\delta = c\frac{\lambda}{b} \tag{1}$$

where b — interfringe spacing, c — interference fringe displacement caused by the examined object, λ — light wavelength. Obviously, the displacement c must be measured between the fringes displaced and undisplaced belonging to the same interference order. There is no trouble with the identification of the latter only when the displaced fringes are joined in an easily observable way or when it is known a priori that this displacement should not be greater than the interfringe spacing. In the opposite case identification of the interference order may be difficult (if possible at all). In many situations the doubts may be removed by using the white light in the preliminary observation and selecting the fringe of zero interference order as a measurement fringe. This fringe is easily recognizable in the white light as it is achromatic in contrast to all the others. Depending on the interference system used it may be either black or bright. The black one is usually more advantageous. However, very often in white light the interference fringe of zero interference order displaced by the object under test is no more achromatic but coloured and then there occur some identification problems [1]. They follow, above all, from the index and birefringence dispersion in: the object under examination, the object surrounding medium, and the material of which the optical system of microinterferometer is made.

It is not only the correct identification of interference order and the accurate determination of the displacement c but also the knowledge of the correct value of the λ/b ratio that influence the accuracy of the optical path difference measurement. For a given interference system and a given geometry of this system the λ/b ratio is the value determined once for ever, being only controlled from time to time. If a highly monochromatic light is used, the λ/b ratio is one of the most accurately determined parameters in interferometry. If, however, the light is moderately monochromatic, for instance, it is separated from the white light with the help of the interference filters, there are some problems with the accurate determination of the λ/b ratio. The present work is devoted to these problems. It deals with a double refracting microinterferometric system with lateral wavefront shear. The "classical" interferometric system without birefringent and polarizing elements will be discussed in a separate paper. The difference between these two systems consists first of all in the fact that in the first case some spectral dispersion includes both the refractive index and birefringence, while in the second one we have to do with dispersion of the refractive index only. (Here, we mean the instrumental dispersion not that connected with the examined object and the surrounding immersion medium).

2. Optical system of the considered microinterferometer

This is the well known system, since its different variants have been described earlier [2–5]. In this work, its simplest version [2] is taken into account which constitutes the basis of the Biolar PI interference microscope (earlier mark MPI-5) produced by Polish Optical Works in Warsaw. This microscope has been used in the experimental part of the present work. It is characteristic that this microscope contains a system of two simultaneously operating birefringent prisms in the image space of the objective: objective prism W_0 and tube prisms W_1, W_2, W_3 (Fig. 1). The prism W_0 may rotate around the optical axis of the objective and, cooperating with one of the tube prisms, it enables to change the direction and amount of the interference image splitting (duplication) of the examined object 0. Four basic orientations of the prism W_0 with respect to the prisms W_1 – W_3 are possible: i) additive (like in the Fig. 2), ii) subtractive (prism W_0 rotated with respect to the additive orientation by the angle $\gamma = 180°$, iii) crossed left-handed ($\gamma = +90°$) and right-handed ($\gamma = -90°$), iv) neutral ($\gamma = \pm 45°$ and $\pm 135°$). The exchangeable prisms W_1, W_2 and W_3 are installed in the head (tube) of the microscope and are shifted perpendicularly (p), and parallelly (axially) (a) to the objective axis. The prisms W_1, and W_3 produce a uniform interference field in the image plane π' (i.e. that with infinitely broad fringes), while the prism W_2 gives in this plane a fringe interference field. The axial shift is an adjusting movement and is important only for the prisms W_1 and W_3 since it serves to optimization of the interference field uniformity in the image plane (π') of the microscope when the objective Ob (together with the prism W_0 or without it) is

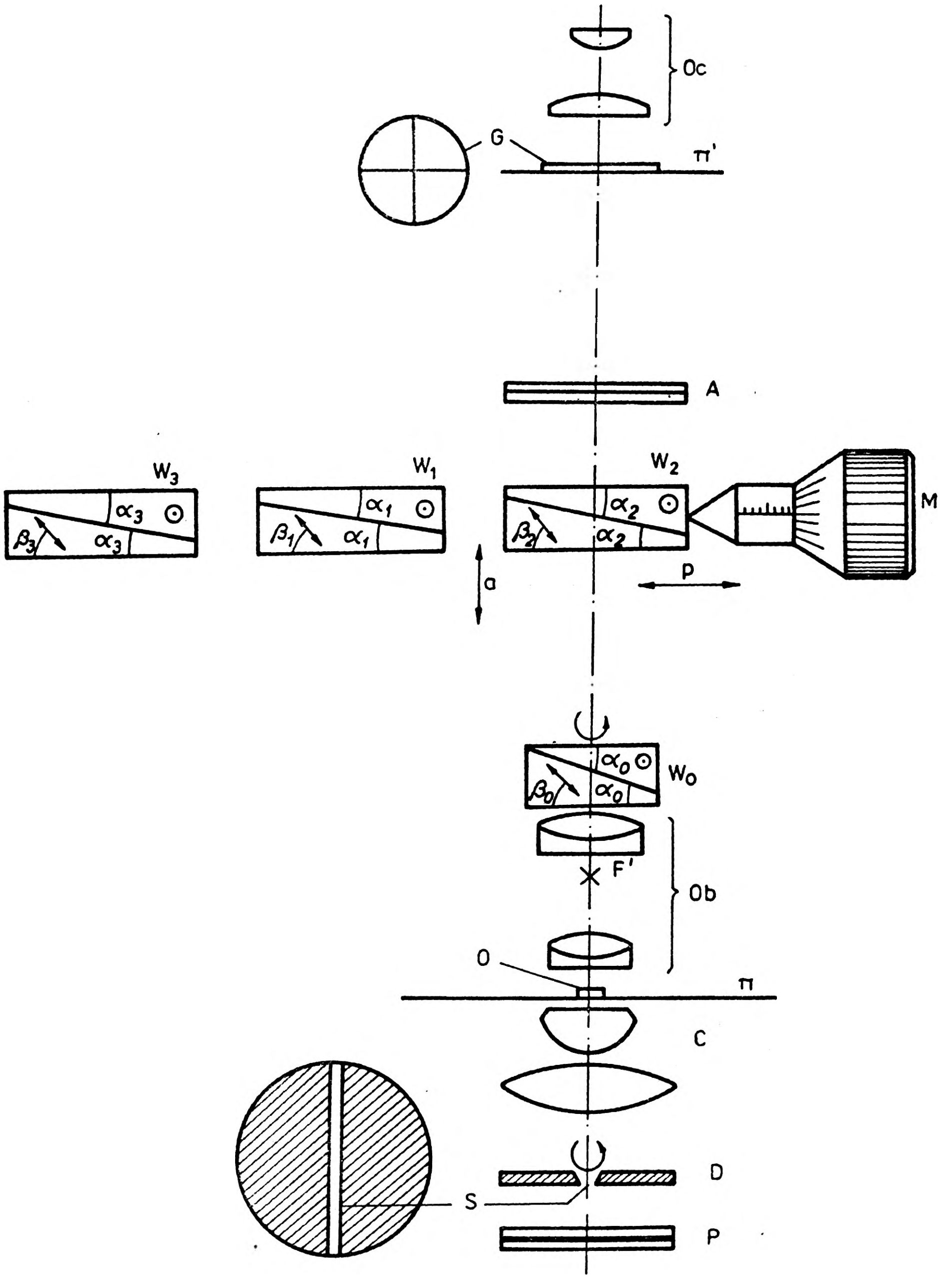

Fig. 1. The scheme of the optical system of the interferometer used in experiments. *P* — polarizer, *D* — slit diaphragm positioned at the front focus of condenser, *S* — slit of adjustable width, *Ob* — objective, π and π' — object and image planes of the objective, W_0 — objective birefringent prism, W_1, W_3 — tube birefringent prisms, *M* — micrometer screw for transversal displacement of the W_1 — W_3 birefringent prisms and by the same means for the measurement of the interfringe distance (*b*) and the displecement (*c*) of the interference fringes generated by the examined object *O*, *Oc* — ocular, *G* — ocular focus plate with the hair-cross

replaced by another one (i.e. of other magnification). On the other hand, the transversal (p) shift of the prism $W_1 - W_3$ is the measurement movement. It is realized with the help of the micrometer screw M, called phase screw, and connected with the slidable revolving disc in which the $W_1 - W_3$ are distributed. This shift enables to change the phase between the interfering light waves, to measure the interfringe distance (b) and the fringe displacement (c) caused by the object under examination. Usually, the analyser A is crossed with polarizer P, while their polarization planes create an angle 45° with the principal sections of the prisms $W_1 - W_3$ (shown in the figure). The slit S of the condenser diaphragm D is so positioned that it creates an angle 90° with the resultant splitting direction in the image of the examined object. It should be noticed that this microscope is equipped with four objectives of magnification 10, 20, 40, and 100 ×. In each of them a rotating birefringent prism W_0 of the wedge angle α_0 equal to about 10° is mounted. These objectives are marked with the trade mark PI. The prism W_0 is positioned so that, when used alone, i.e., without birefringent tube prisms, it gives a uniform interference field in the image plane (π') of the microscope. Further, though less essential, detailes concerning this interference system may be found in the papers cited earlier [2, 3].

3. Relation between b and λ; fringe interference in the image plane of the microinterferometer

In this case the birefringent tubes prism W_2 is active. It produces straight line interference fringes in the microscope image plane π' (Fig. 1) oriented parallelly to the edge of wedge angle in the prism W_2. Density of these fringes and their direction are independent of the objective birefringent prism W_0 since, as it is well known, its position with respect to the back focus F' of the objective is such that it gives a uniform interference field in the plane π' when used alone.

3.1. Theoretical relation

The relation between the interfringe distance b and the light wavelength λ is described by the following formula [6]:

$$b = \frac{\lambda}{[(n_e - n_0) + (n_2 - n_0)]\tan\alpha_2}. \tag{2}$$

Here α_2 — wedge angle of the birefringent prism W_2, n_0 and n_e — principal refractive indices (i.e., ordinary and extraordinary ones) of the quartz crystal of which the prism is made, while

$$n_2 = \frac{n_0 n_e}{\sqrt{n_0^2\cos^2\beta_2 + n_e^2\sin\beta_2}}, \tag{3}$$

where β_2 is the angle made by the external surface of the lower wedge of the prism W_2 with the optical axis of the quartz crystal.

From the formula (2) it may be seen that the dependence of b upon λ would be linear if the expression $(n_e-n_0)+(n_2-n_0)$ were independent of the light wavelength λ, i.e., if the quartz crystal were free of birefringence dispersion. Although this dispersion is insignificant (Table 1) it nevertheless becomes essential in the situation considered. By substituting to the formula (2) the values from the Table 1, $a = 12°$ (the birefringent prism W_2 has such a wedge angle) and n_2 calculated from the formula (3) we obtain the values of b for the successive light wavelengths λ. These are listed in Table 2 in which the values of the ratio λ/b (necessary to calculate the optical path difference δ from the formula (1)) are also given.

Table 1. Birefringence dispersion in crystal quartz ([9])

λ [nm]	n_e-n_0
400	0.00957
450	0.00940
500	0.00927
550	0.00917
600	0.00910
650	0.00904
700	0.00899
750	0.00895

Table 2. Theoretical values of the interfringe distance (b) on the ratio λ/b for the birefringent prism W_2 ($a'_2 = 12°$, $\beta_2 = 45°$)

λ [μm]	b [μm]	$(\lambda/b)\cdot 10^{-5}$
0.40	131.09	305
0.45	150.15	300
0.50	169.17	296
0.55	188.11	292
0.60	206.80	290
0.65	225.51	288
0.70	244.21	287
0.75	262.83	285

The dependence $b(\lambda)$ is plotted in Fig. 2. As it may be seen the deviation from the straight line is so small that it is unobservable. It amounts to $\pm 3\%$ within the spectral range 400–750 nm and only to $\pm 2\%$ within the spectral range 450–650 nm.

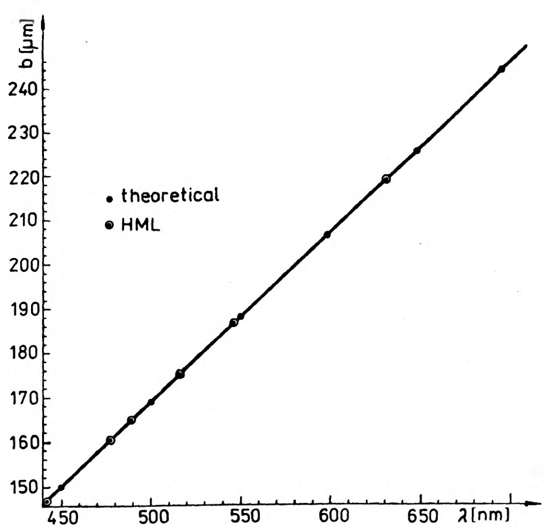

Fig. 2. Theoretical plot of the dependence of the interfringe spacing b for birefringent prism W_2 upon the light wavelength λ. The measured values of b measured in the highly monochromatic light (HML) are marked by circles

3.2. Measurement of the interfringe distance b in the highly monochromatic light

By using highly monochromatic light sources distance b between the interference fringes produced by the birefringent prism W_2 in the microscope image plane π' has been measured (Fig. 1). The following sources were used: helium-cadmium laser ($\lambda = 441.6$ nm), argon laser ($\lambda = 476.5$, 488.0, 514.5 nm), HBO mercury lamp with narrow passband interference filter ($\lambda = 548.5$ nm), and helium-neon laser ($\lambda = 632.8$ nm). The spacing between the fringes of plus and minus fiftieth interference order have been measured by using the transversal shift of the prism W_2 to realize the successive coincidence of the midpoints of these interference fringes with the vertical line of the micrometer plate hair-cross in the ocular Oc (fig. 1). The difference in the read-out positions of the micrometer screw M was next divided by 100. The measurement accuracy for the parameters b achieved in this way was being practically 100 times better than it could be obtained by measuring the single interfringe spacing, i.e., the spacing b between two neighbouring dark (or bright) fringes. The results of measurement are given in Tab. 3 and Fig. 2. The measurement points, marked by circles in this figure, are very close to the theoretical graph.

Table 3. Interfringe distance b of the birefringent prism W_2 measured visually in the highly monochromatic light. For comparison in the last column the values b read out from the theoretical plot are given

Light source	Light wavelength λ [nm]	b [μm]	
		Measured values	Theoretical values
He-Cd laser	441.6	147.02	147.0
Ar laser	476.5	160.62	160.1
Ar laser	488,0	164.82	164.4
Ar laser	514,5	174.98	174.5
HBO lamp with filter	548.5	187.16	186.4
He-Ne laser	632.8	218.97	219.0

3.3. Measurement of the interfringe spacing b in the moderately monochromatic light

The halogen 12 V/100 W lamp used for measurements was equipped with metallic interference filters of common (IF), special (SIF) and multidielectric (DIF) types. Their basic spectral parameters are listed in Table 4. The SIF filters differ from those of IF type by slightly narrower passbands (Figs. 3 and 4), while the multidielectric filters (Fig. 5) are characterized by much (about two times) higher peak transmittance as well as by incomparably higher slope of the spectral characteristics (than those of both the IF and SIF filters). The basic experiments were carried out by applying the IF filters, since they are the most common in practice and commercially available.

If the light is suitably monochromatic, then, in the whole field of view in the microscope well contrasty interference fringes are observed in the image plane π' (Fig. 1). Neither the IF filters nor the SIF filters give such an interference field and, their behaviour is, morover, different if the interferometer is equipped with the white light source, for instance, with the halogen lamp. In general, not more than nine suitably black interference fringes may be obtained; the others being gray and of contrast decreasing with increase of interference order (Fig. 6a). Frequently, there appear only five black fringes

Table 4. Spectral parameters of the used interference filters: peak wavelength λ, peak transmittance τ, level half-width $\Delta\lambda_{(0.5\tau)}$, and the width at the transmittance level 0.1 τ, 0.05 τ and 0.01 τ

Filter mark	λ [nm]	τ [%]	$\Delta\lambda_{(0.5\tau)}$ [nm]	$\Delta\lambda_{(0.1\tau)}$ [nm]	$\Delta\lambda_{(0.05\tau)}$ [nm]	$\Delta\lambda_{(0.01\tau)}$ [nm]
IF 450	456.0	34	15.0	40.0	—	—
IF 466	477.0	28	16.0	48.0	61	110
IF 475	483.3	45	11.0	29.1	—	—
IF 491	498.5	38	12.0	31.0	—	—
IF 500	504.5	31	11.0	28.5	—	—
IF 525	525.0	44	11.0	29.0	—	—
IF 546	546.7	35	11.7	29.0	—	—
IF 550	555.0	42	12.0	33.0	44	93
IF 575	586.7	47	10.6	29.4	—	—
IF 578	592,0	38	11.0	33.0	—	—
IF 589	592,6	48	12.0	36.0	40	110
IF 600	602.2	43	10.0	27.0	—	—
IF 616	623.0	36	10.0	26.1	—	—
IF 625	638.0	30	11.0	30.0	—	—
IF 650	658.7	38	14.0	38.0	52	106
IF 675	679.2	41	13.1	35.7	—	—
SIF 486	489.0	24	8	19	27	68
SIF 551	550.3	25	8	19	28	55
SIF 589	595.0	28	11	28	38	72
SIF 656	656.0	25	12	30	38	71
DIF 487	492.5	80	10	18	21	30
DIF 546	549.0	78	8	16	19	26
DIF 632	637.5	56	12	21	24	31
DIF 657	658.5	50	8	17	20	30
DIF 695	697.0	65	14	26	32	49

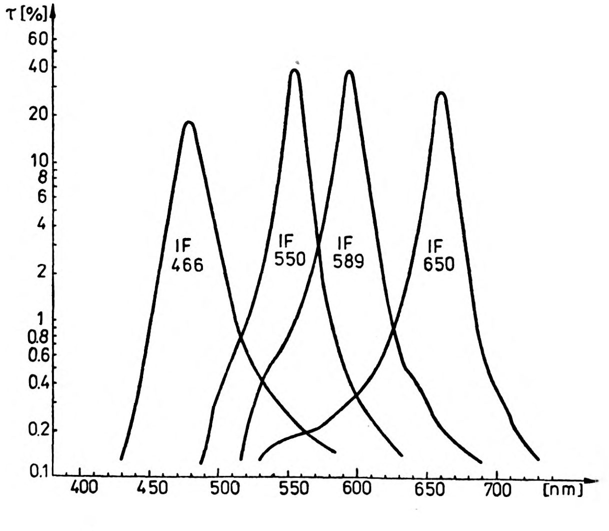

Fig. 3. Spectral characteristics (transmittance τ as a function of the wavelength λ) of four IF interference filters chosen as examples, i.e. blue, green, yellow and red ones

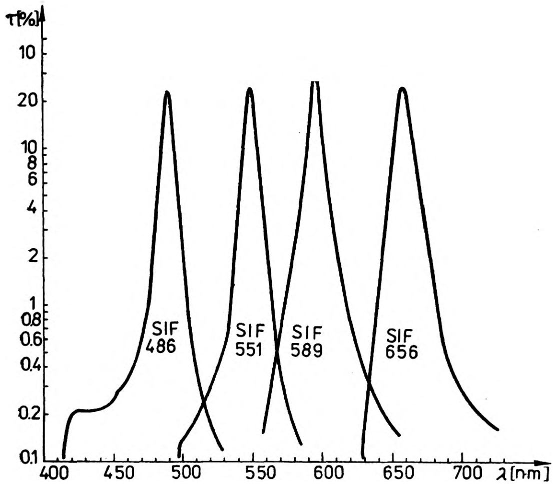

Fig. 4. Spectral characteristics of the SIF interference filters

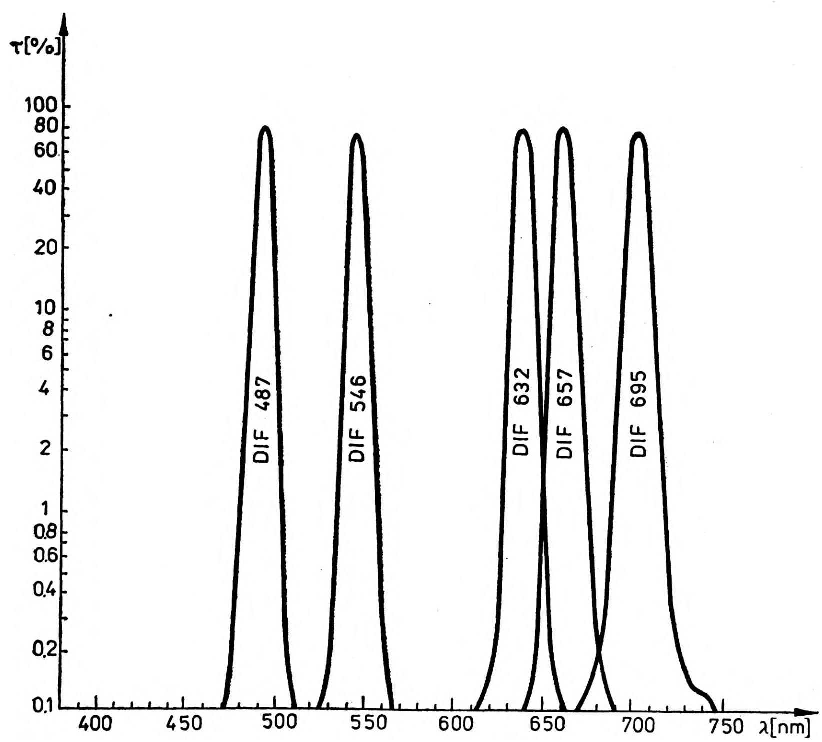

Fig. 5. Spectral characteristics of the DIF interference filters

(Fig. 6b) or sometimes even one such fringe (i.e. the fringe of zero order), while the others are gray or slightly coloured. Consequently, neither the interfringe spacing nor, the deviation *c* of the zero order interference fringe may be exactly determined during the measurement of the optical path difference, when the image of the examined object is disturbed

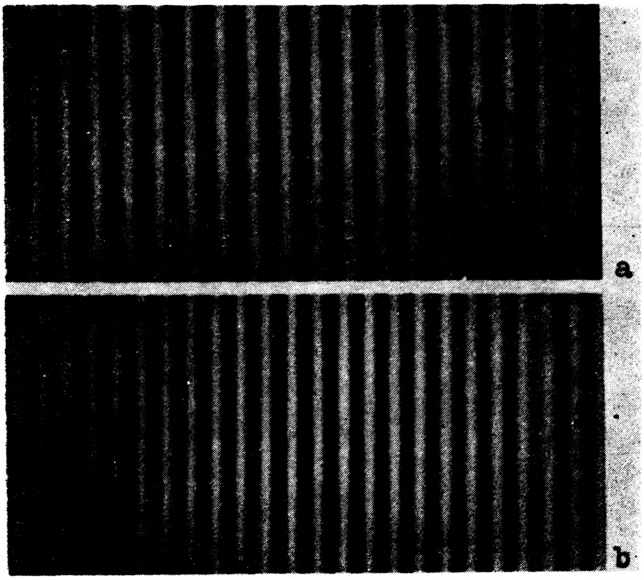

Fig. 6. Examplified images of the interference fringes observed in the image plane π' (Fig. 1) in the halogen lamp filtered out with the help of the IF589 (a) and IF466 (b) interference filters, respectively

by the refractive index dispersion. Morover, the measured interfringe spacing *b* may diffe- considerably from that one, which should really correspond to the wavelength λ transmitted maximally by the filter. This fact may be illustrated by the results of the measurement of *b* listed in Table 5 and plotted in Fig. 7. In the Table 5 also the theoretical values read out from the graph in Fig. 2 are given for comparison. The experimental values are the averaged ones obtained by measuring the respective distances 2*b*, 4*b*, 6*b* and 10*b* between the fringes of plus and minus first, second, third and fifth interference orders.

As it may be seen from Table 5 and Fig. 7 not all the experimental results coincide with the theoretical data. Good agreement exists only in the middle part of the visual spectrum, while in the shortwave part $b_{\text{vis}} > b_{\text{theor}}$ and in the longwave part $b_{\text{vis}} < b_{\text{theor}}$. This discrepancy is without doubt a result of insufficient monochromacy of the IF and SIF filters, since the results of analogical measurements made at the presence of well monochromatic DIF filters are pretty well consistent with the theoretical data. A question arises why the said discrepancy is not observed in the middle part of the visual spectrum, in spite of the fact that the spectral characteristics of the yellow and green filters—as it may be seen from Table 4 and Fig. 5—are almost the same as the spectral characteristics of the blue and red filters. The considerations on this topic will constitute the subject of a separate paper. Here, it may be only mentioned that the nonuniform spectral sensitivity of the eye which – as it is well known – diminishes quickly with the distance in both directions from visual spectrum centre, is responsible to a great degree for this situation. In simplified version the problem may be understood so that the eye sees not the light wavelength, which is maximally transmitted by the wide-passband red filter but a slightly

Table 5. Interfringe spacing b due to the birefringent prism W_2 measured visually in the halogen lamp light filtered with the help of metallic (IF and SIF) and multidielectric (DIF) interference filtres. For comparison in the last column the values of b read out from the theoretical plot (Fig. 2) are given

Filter mark	λ [nm]	b [μm] Experimental values	Theoretical values
IF 450	456.0	155.1	152.4
IF 466	477.0	163.0	160.3
IF 475	483.3	164.9	162.6
IF 491	498.5	171.6	168.9
IF 500	504.5	173.4	170.6
IF 525	525.0	180.6	178.5
IF 546	546.7	188.1	186.8
IF 550	555.0	190.0	189.9
IF 575	586.7	202.0	201.7
IF 578	592.0	203.8	203.7
IF 589	592.6	204.0	203.9
IF 600	602.2	207.7	207.4
IF 616	623.0	214.6	215.4
IF 625	638.0	220.9	221.0
IF 650	658.7	226.3	228.7
IF 675	679.2	230.7	236.3
SIF 486	489.0	166.8	164.9
SIF 551	550.4	188.0	187.5
SIF 589	595.0	204.9	204.9
SIF 656	656.0	226.7	227.7
DIF 487	492.5	168.0	166.2
DIF 546	549.0	187.2	187.4
DIF 632	637.5	221.3	220.8
DIF 657	658.5	228.4	228.6
DIF 695	697.0	242.4	243.0

shorter one or vice versa a slightly longer one than that transmitted by the blue filter. It should be added that during visual observation the spectral sensitivity of the eye plays the same role as the spectral sensitivity of the photographic emulsion used to photograph the interference fringes. For instance, in Table 6 the interfringe spacings b are given which have been determined from the interferograms recorded on the TRI-X Pan Kodak film by using the light generated by the halogen lamp but transmitted by some IF filters. Two of these interferograms are shown in Fig. 6. The distance between the fringes of plus and minus fifth order has been measured to be next divided by 10. Thereupon, the result of measurement has been calculated so that the values b be expressed in the same way as the theoretical ones and these measured visually with the help of the micrometer screw M (Fig. 1) coupled with the transversal displacement of the birefringent prism W_2. In the said calculation it has been assumed that during photographic determination of the interfringe distance b the values consistent with theory are obtained in the middle part of

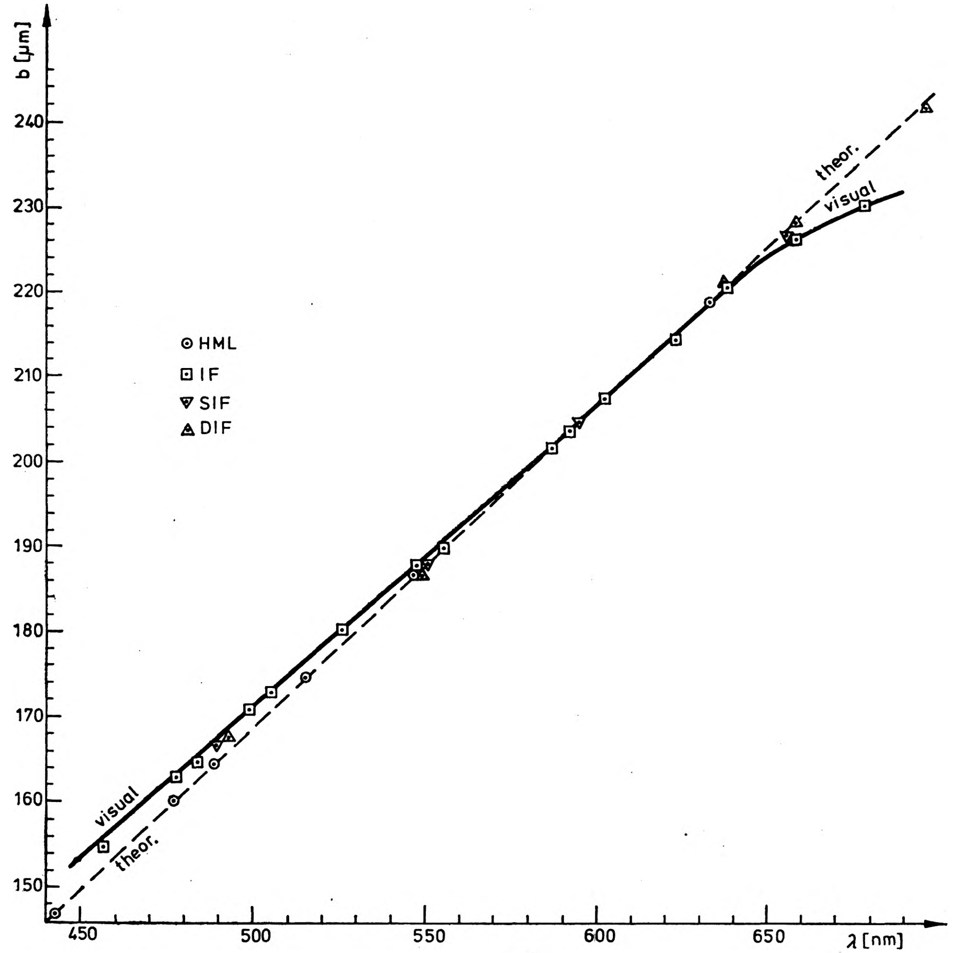

Fig. 7. The dependence of the interfringe spacing (b) for the birefringent prism W_2 upon the peak light wavelength (λ) of the interference filters. The broken line was used to plot the theoretical graph (transferred from Fig. 2)

Table 6. Interfringe spacing b in the moderately monochromatic light due to the birefringent prism W_2 determined photographically. For comparison the values b read out from the theoretical plot (Fig. 2) are given in the last column

Filter mark	λ [nm]	b [μm] Photographical	Theoretical
IF 466	477.0	162.7	160.3
IF 475	483.3	163.3	162.6
IF 500	504.5	171.6	170.6
IF 546	546.7	187.8	186.8
IF 589	592.6	203.2	203.9
IF 616	623.0	215.0	215.4
IF 650	658.7	217.6	228.7
IF 675	679.2	215.0	236.3

the visual spectrum (i.e., in the light transmitted by the IF550 and IF589 filters) similarly as it is the case for visual measurement of this distance (Table 5 and Fig. 7). From Table 6 and Fig. 8 it may be seen that when compared to the discrepancy between b_{vis} and b_{theor}, given in Fig. 7, the discrepancy between b_{phot} and b_{theor} is less in the shortwave part

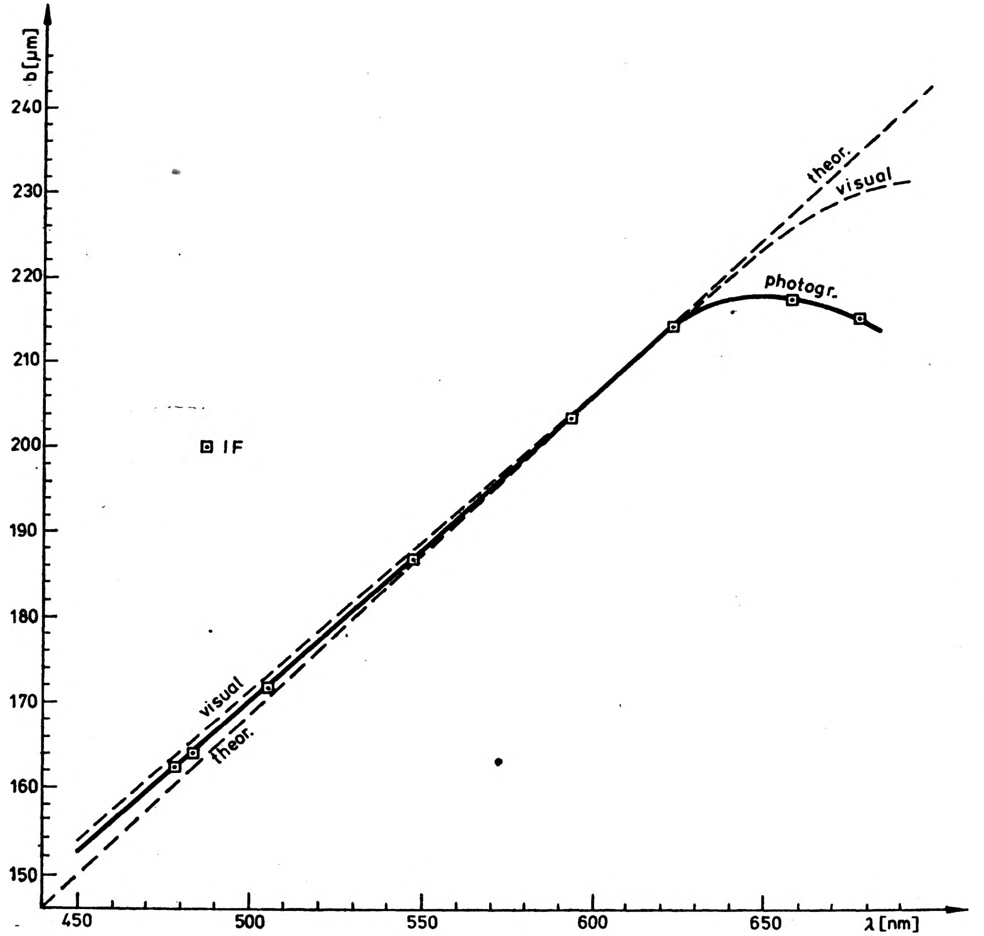

Fig. 8. The graph similar to that in Fig. 7 but here the interfringe spacing (b) is determined from the interferograms recorded on a TRI-X Pan film exposed under the same conditions, under which the visual measurements of the interfringe spacing were made (the graphs transferred from the Fig. 7 are marked with broken lines)

of the spectrum, while it is many times greater in the long-wave part of the spectrum. This may be explained by the fact that the TRI-X Pan film is characterized by a great drop of sensitivity in the red part of spectrum starting from $\lambda \approx 600$ nm, while in the blue part of the spectrum such sensitivity drop is not observed; except for slight minimum of sensitivity which occurs in the vicinity of $\lambda \approx 490$ nm only [7].

4. Relation between b and λ; uniform field interference in the image plane

In this case the birefringent tube prism (W_1 or W_3) is acting (Fig. 1). These two prisms differ from each other only by the wedge angle α_1 and α_3 ($\alpha_1 = 47'$, and $\alpha_3 = 3°$). In the interference field produced by these prisms in the image plane π' no fringes appear, but instead the light intensity distribution is uniform, which together with the transversal shift in the p direction reaches the minimal and maximal values in the properly monochromatic light, while in the white light there appear the sequences of colours associated with the successive interference orders. This time the interference fringes in the π' plane are apparently infinitely spread and the measure of their mutual distance b is the shift of the prism W_1 (or W_3) in the transversal direction p during which the microscope field

Table 7. Interfringe spacing b due to the birefringent prism W_1 ($\alpha_1 = 47'$, $\beta_1 = 35°$): calculated from the formula (2) measured visually by the half-shadow method [2] and read out from the plot 2 in Fig. 9 at the points corresponding to the peak wavelengths λ of the interference filters

Light source	Filter mark	λ [nm]	Interfringe spacing b [μm] Theoretical	Measured	Read out from the plot 2 in Fig. 9
—	—	400	1834.86	—	—
—	—	500	2364.36	—	—
—	—	589.3	2835.56	—	—
—	—	600	2889.52	—	—
—	—	700	3411.54	—	—
Ar laser	—	476.5	—	2225.0	—
Ar laser	—	488.0	—	2281.4	—
Ar laser	—	514.5	—	2423.7	—
He-Ne laser	—	632.8	—	3027.7	—
Halogen lamp	IF 450	456.0	—	2210	2120
	IF 466	477.0	—	2330	2225
	IF 475	483.3	—	2328	2255
	IF 500	504.5	—	2412	2365
	IF 546	546.7	—	2606	2585
	IF 575	586.7	—	2800	2790
	IF 589	592.6	—	2830	2820
	IF 616	623.0	—	2970	2975
	IF 625	638.0	—	3040	3055
	IF 650	658.7	—	3097	3160
	IF 675	679.2	—	3143	3265
	SIF 486	489.0	—	2321	2285
	SIF 551	550.4	—	2614	2600
	SIF 589	595.0	—	2836	2830
	SIF 656	656.0	—	3151	3145
	DIF 487	492.5	—	2319	2305
	DIF 546	549.0	—	2604	2595
	DIF 632	637.5	—	3069	3050
	DIF 657	658.5	—	3156	3155
	DIF 695	697.0	—	3334	3355

of view takes consecutively the same intensity in the monochromatic light, for instance, the maximal darkness or maximal brightness, whereas, the deviation c of the zero order interference fringe corresponds to such a prism shift, for which the background of the microscope field of view and the image of the examined object (or the chosen fragment of this image) take successively the same intensity.

The results of the interfringe spacing measurements in the case when the birefringent prisms W_1 and W_3 are used, are listed in Tables 7 and 8, and illustrated graphically in Figs. 9 and 10. As may be seen the discrepancies between b_{vis} and b_{theor} are the same as previously (Fig. 7), when the monochromatic light is separated from the white light

Table 8. Interfringe spacing b due to the birefringent prism W_3 ($\alpha_3 = 3°$, $\beta_3 = 45°$): calculated from the formula (2), measured visually by the half-shadow method [2] and read out from the plots 1–2 in Fig. 10 at the points corresponding to peak wavelengths λ of the interference filters

Light source	Filter mark	λ [nm]	Interfringe spacings b [µm] Theoretical	Measured	Read our from the plot in Fig. 10
—	—	400	531.67	—	—
—	—	450	608.95	—	—
—	—	500	686.10	—	—
—	—	550	762.94	—	—
—	—	600	838.69	—	—
—	—	650	914.62	—	—
—	—	700	990.45	—	—
—	—	750	1065.95	—	—
Ar laser	—	476.5	—	649.27	649.3
Ar laser	—	488.0	—	666.68	666.7
Ar laser	—	514.5	—	708.93	708.0
He-Ne laser	—	632.8	—	889.44	889.2
Halogen lamp	IF 450	456.0	—	661	618
	IF 466	477.0	—	680	650
	IF 475	483.3	—	677	659
	IF 500	504.5	—	706	692
	IF 525	525.0	—	732	724
	IF 546	546.7	—	763	757
	IF 575	586.7	—	817	818
	IF 600	602.2	—	835	842
	IF 625	638.0	—	877	896
	IF 650	658.7	—	863	928
	IF 675	679.2	—	926	960
	SIF 486	489.0	—	677	669
	SIF 551	550.4	—	762	763
	SIF 589	595.0	—	831	831
	SIF 656	656.0	—	920	924
	DIF 487	492.5	—	677	674
	DIF 546	549.0	—	760	760
	DIF 632	637.5	—	895	896
	DIF 657	658.5	—	924	928
	DIF 695	697.0	—	975	988

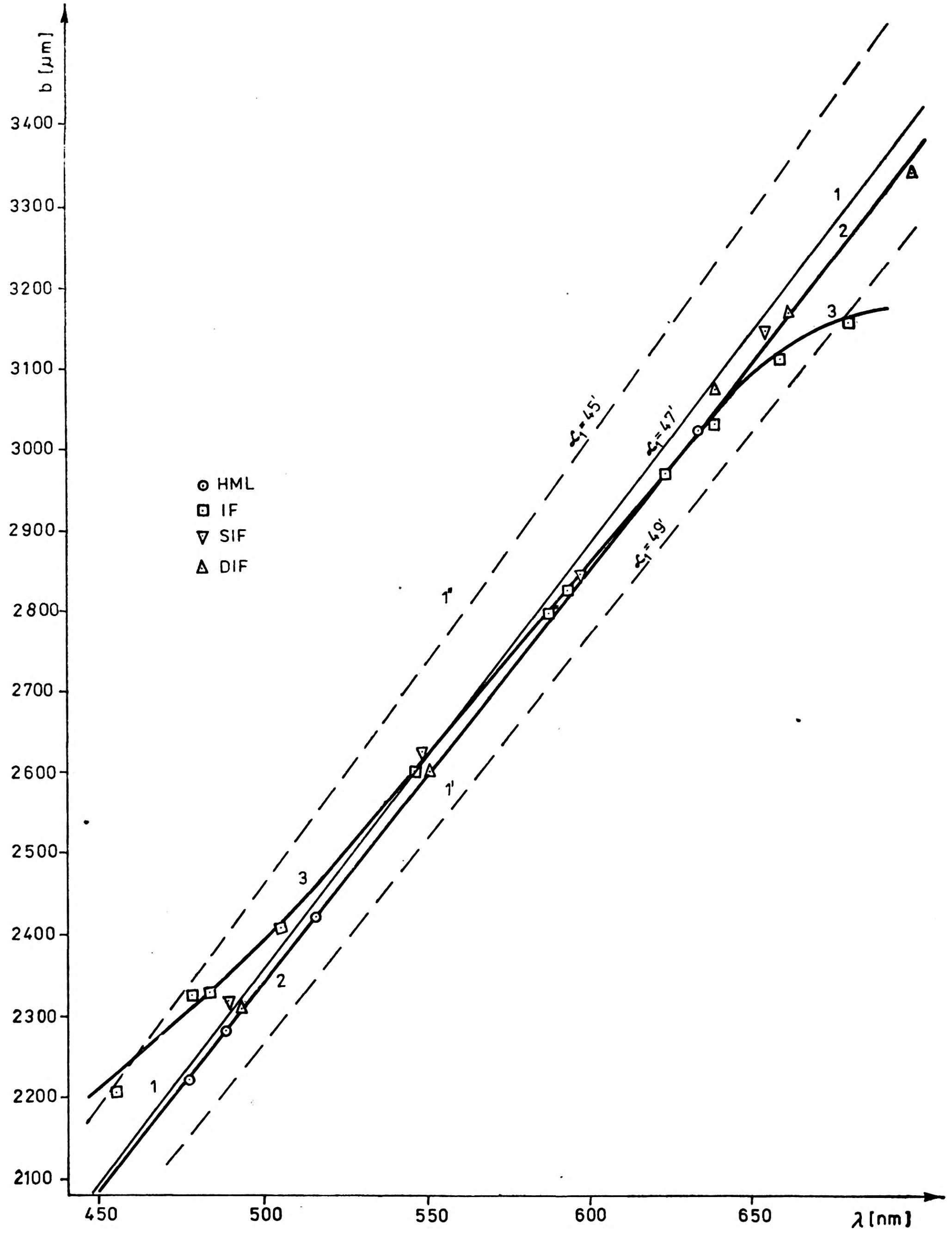

Fig. 9. Dependence of interfringe spacing (b) for the birefringent prism W_1 upon the light wavelength (λ): 1 — theoretical graph for nominal wedge angle $\alpha_1 = 47',1'$ and 1″ — graphs for the angles $\alpha_1 = 49'$ and $\alpha_1 = 45'$, which comprised the given manufacturing tolerances of the prism W_1; 2 — experimental graph following from the measurements of b in the highly monochromatic light (laser — HML); 3 — experimental graph following from the measurements of b in the moderately monochromatic light (halogen lamp and IF filters)

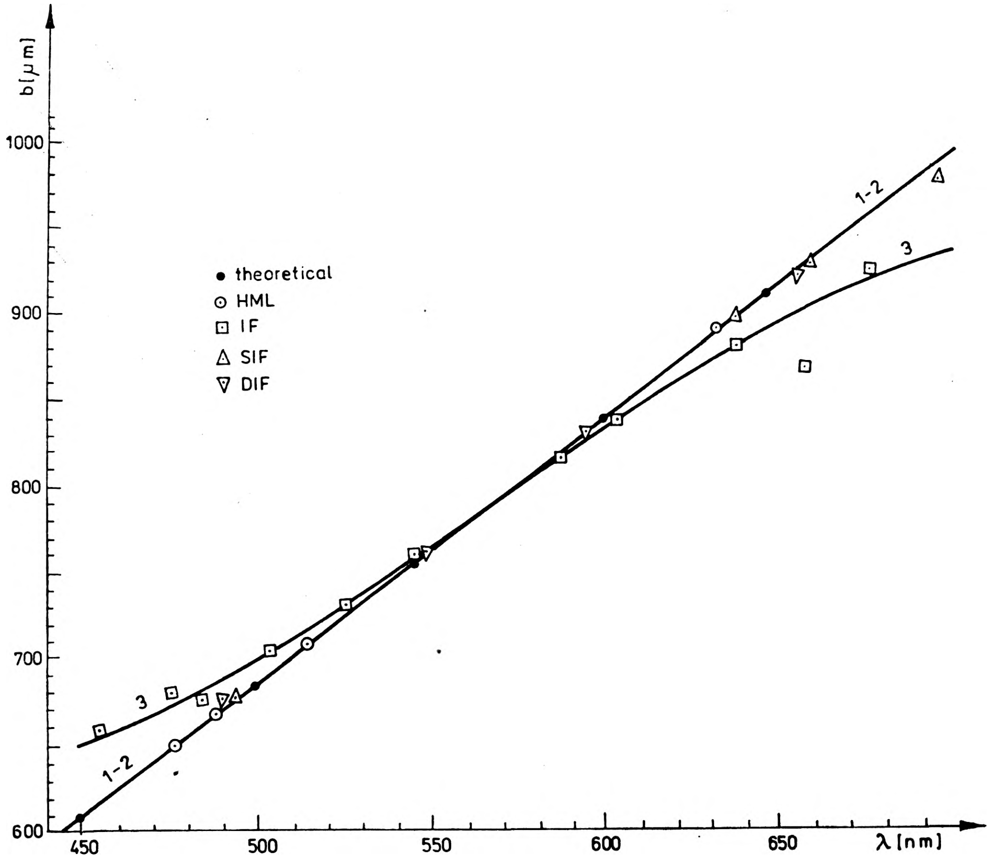

Fig. 10. The dependence of the interfringe spacing (b) for the birefringent prism W_3 upon the light wavelength (λ): 1 — 2 two graphs – theoretical one and that following from the measurement b in the highly monochromatic light (laser HML): 3 — experimental graph following from the measurement of b in the moderately monochromatic light (halogen lamp and IF filters)

source by using the interference filters IF. The measurement results and the theoretical values are, however, in a good agreement whenever highly monochromatic laser light or the white light, but filtered out with the help of narrow-passband multidielectric interference filters, is used. The shift of the theoretical graph ($\alpha_1 = 47'$) with respect to the experimental one (2) appearing in Fig. 9 is kept within the manufacturing tolerance limits for birefringent prisms, which for the wedge angles α_1, α_2 and α_3 amounting to $\pm 2'$, $\pm 5'$, and $\pm 2'$, respectively, cause the deviations of b from the nominal values calculated for $\alpha_1 = 47'$, $\alpha_2 = 12°$ and $\alpha_3 = 3°$ by $\pm 4\%$, $\pm 0.7\%$ and $\pm 1\%$, respectively.

5. Conclusions

Although the presented experimental results concern a concrete type of interferometers their real importance is much more general in the fields of microinterferometry and interferometry. Metallic interference filters (IF and SIF) are commonly used to separate the moderately monochromatic light from the white light source. However, this procedure is not generally correct. The green and yellow filters act in moderately correct way, while the blue and red filters introduce some errors to the interfringe distance measurement and by the same means to the measurement of optical path difference and the related quantities [8]. The application of multidielectric interference filters, characterized by much narrower and steeper spectral passband than that of the metallic interference filters, is the only highly recommendable procedure. However, the multidielectric filters are very expensive and the price of a possibly complete set of those filters may exceed the value of high class interferometers. For this reason, multidielectric filters working in the central part of the visual spectrum may be sometimes replaced by much less expensive metallic interference filters.

From the measurements performed as well as from the extraordinary good agreement of the formula (2) with the experiment, an additional very important practical conclusion may be drawn. Namely, that there exists a possibility of accurate determination of the peak wavelength of the suitably monochromatic light by using very simple interference system (Fig. 1). By measuring the interfringe spacing b in the described way the accuracy below 1 nm in the peak light wavelength determination may be achieved. Such an accuracy would be difficult to achieve with the help of typical spectrophotometers most widely used in practice. While analysing the drop of contrast on the interference fringes with the increase of interference order it is also possible to determine the degree of monochromacy of interference filters as well as monochromacy of the light sources. When doing so it is advantageous to place the birefringent objective prism W_0 (Fig. 1) in the subtractive position with respect to birefringent tube prism W_2. Then the slit of the condensor diaphragm is relatively broad and a contrasty and bright image of interference fringes is obtained. The "spectrophotometric" and other measuring possibilities of the microinterferometric system considered in this work will be discussed in more detail in a separate paper.

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Соотношение между пиковой длиной волны умеренно монохроматического света и расстоянием между линиями интерференционного поля

I. Интерференционная двупреломляющая система

Доступны в продаже интерференционные микроскопы, в общем снабжены источником белого света, из которого выделяется монохроматический свет с помощью интерференционных фильтров. Эти фильтры бывают часто типичными, с половинчатой спектральной шириной, не меньшей 10 нм. Получено, что такие фильтры могут вводить – из-за их недостаточной монохроматичности – некоторые ошибки при измерении разности оптической длины пути. Они появляются, прежде всего, в коротковолновой (фиолетово-синей) и длинноволновой (красной) части видимого света. Эти ошибки вытекают, главным образом, из того, что в недостаточно или умеренно монохроматическом фиолетово-синем и красном свете наблюдается несколько иная плотность интерференционных линий, чем в высокомонохроматическом свете с той же пиковой длиной волны.