Miron Gaj, Jerzy Nowak *

Superachromatic Correction in Compliance with the Chromatic Latteral Aberration

Optical systems with the lateral chromatic aberration corrected within the wavelength range $0.365 \leqslant \lambda \leqslant 1.014\ \mu m$ are usually called superachromats. In the previous papers [1,2] several types of superachromats have been calculated. In the paper [3] the chromatic aberration of magnification for those systems has been analysed. A simple expression for the image magnitude difference for two arbitrary lengthwaves in dependence upon the different image magnitudes difference for two basic colours has been derived. Another solve of a superachromatic system happens to be a three-lens system, in which the first and the last lens are produced of the same sort of glass, while that placed in-between is located as close as possible with respect to the former two. This system arose as a result of cementing together two achromats from the side of the negative elements, the last lens being moved away. The aberrations of the system calculated in this way are presented in Figs 1 and 2; curve a in both the Figs denoting spherochromatic aberrations for 5 chosen wavelengths, while curves b, c and d represent the deviation from the sine condi-

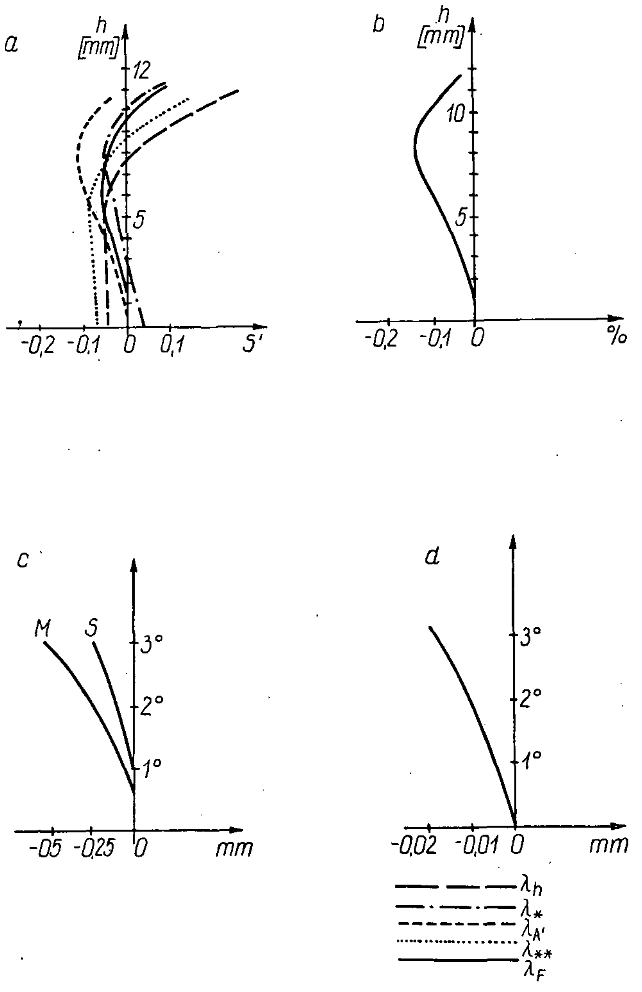

Fig. 1. Aberration of a system without fluorite

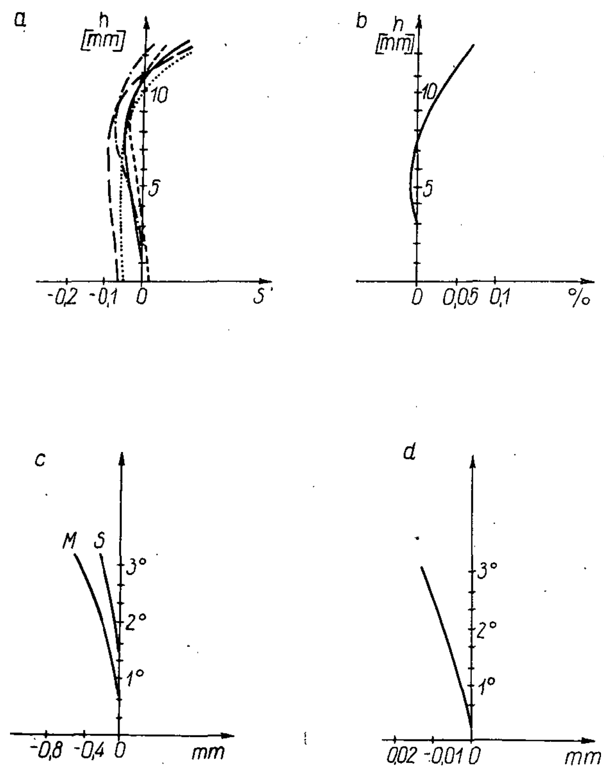

Fig. 2. Aberrations of a system with fluorite

*) Instytut Fizyki Technicznej Politechniki Wrocławskiej, Wrocław, Wybrzeże S. Wyspiańskiego 27, Poland.

tion, field curvature and comatic aberration, respectively. The system the aberrations of which has been presented in Fig. 1 consisted of lenses calculated for glasses FK50 and SK20 (f — number 4, 5, focal length $f = 100$ mm, field angle 3°). The lateral chromatic aberrations do not exist practically in both the systems.

When analysing the superachromatic correction the properties of the photographic material to be used have to be taken into account. According to authors knowledge there exist no photographic materials which would be sufficiently sensitive within the whole wavelength range determined above. If the photographic film is sensitive to the wavelength $\lambda = 0.365$ μm and $\lambda = 1.014$ μm then there exists a wavelength interval most frequently contained between $0.5 \leqslant \lambda \leqslant 0.75$ μm, within which the sensibility is practically equal to zero. In this situation an analysis of the chromatic aberration correction for a slightly diminished wavelength region seems to be worthwhile. It has to be considered if it is possible to find any more glass combinations satisfying the condition of superachromatic correction and if so, what would be the resulting power distribution among the particular lenses. In the case of two-lens systems the reduction of the wavelength interval does not exhibit much interest, because the additional glasses to be applied in this case are technologically complex and their application results in considerable increase of the respective foccusing powers. In spite of this, the number of glass combinations for the three-lens solutions may be enlarged.

The three-glass combinations to be used for superachromatic systems must fulfil the following condition

$$W = \begin{vmatrix} 1 & 1 & 1 \\ P_{*1} & P_{*2} & P_{*3} \\ P_{**1} & P_{**2} & P_{**3} \end{vmatrix} = 0 \qquad (1)$$

where

$$P_{*} = \frac{n_F - n_*}{n_F - n_C},$$

$$P_{**} = \frac{n_F - n_{**}}{n_F - n_C}.$$

To assure a good correction of the chromatic aberration the three glasses should satisfy the following condition within the wavelength interval $0.315 \leqslant \lambda \leqslant 0.75$ μm

No.	Glass	Φ	$S_F - S_\lambda$ [mm]						W	$\overline{W}$
			*	A'	C	g	h	* *		
1	FK 50 KzFS 4 SF 8	2,53 199 —1,92 556 0,39 357	0	—0,03	—0,02	—0,04	—0,1	—0,25	—0,0075	0,0002
2	FK 50 KzFS 4 SF 8	3,12 757 —3,20 123 1,07 336	0,14	—0,02	0,01	0,01	0,02	0,06	—0,0075	0,0002
3	FK 50 KzFS 5 TiF 4	2,14 588 —2,43 359 —1,27 770	0,07	0,02	0	—0,01	0	0,03	0,0040	0

$$\overline{W} = \begin{vmatrix} 1 & 1 & 1 \\ P_{A'1} & P_{A'2} & P_{A'3} \\ P_{**1} & P_{**2} & P_{**3} \end{vmatrix} = 0 \qquad (2)$$

where

$$P_{A'} = \frac{n_F - n_{A'}}{n_F - n_C}.$$

In table the differences of the image distances in the image for the optional wavelengths in a calculated three-lens systems are collected. The glasses used for the first system do not satisty eq. (1) and $|\Delta S_{\max}| = 0.25$ mm. The second system is composed of the same three glasses, provided the system has been corrected within the wavelength range $0.315 \leqslant \lambda \leqslant 0.75$ μm. It is clear that condition (2) is satisfied which results in $|\Delta S_{\max}| = 0.08$ mm. The third system, which is characterized by small focussing powers (lack of fluorite), was corrected for the wavelength interval $0.365 \leqslant \lambda \leqslant 0.75$μm. The system is not expected to be well corrected within the whole interval, because $W = 0.004$. However, when comparing the image distances for the particular waves, it is easy to notice that the system may be considered as being corrected in the whole range of the superachromatic correction because $|\Delta s_{max}| = 0.008$. The general conclusion is that condition (1) is a sufficient and not necessary one. Thus there are some more three-lens combinations applicable to superachromatic correction beside those admissible by Herzberger condition. The problem is being examined in detail and the results will be published in the next paper.

References

[1] GAJ M., NOWAK J., Optik 25, 1967, 203.
[2] GAJ M., NOWAK J., Optica Applicata 1, 1971, 51.
[3] GAJ M., NOWAK J., Optica Applicata (in print).
[4] HERZBERGER M., MC CLURE N. R., Applied Optics 2, 1966, 553.

Maciej Rafałowski *

On an Attempt of Automizing the Lay-out Calculation on Computer

In the paper an attempt has been made to apply a computer to the automation of the lay-out calculation of optical systems.

The lay-out computing for more complex systems and particularly for those of variable magnification are usually tedious and give no guarantee of resulting in an optimal variant. Thus, it may be temptative to try to make the computer to do the job partly. An automation of the analytic evaluation of the optimal system parameters, after having it developed, have to be considered as possible in principle.

Among the discouraging factors appearing by any automation trial the following are to be mentioned in the first line: the great variety of requirements, with may be met in particular systems, the difficulties in determining any reliable criteria for the system quality evaluation at this stage of the design as well as the fact that the decisions taken during the lay-out calculation influence essentially the later correction procedure. For this reason a wide possibility of designer's intervening during the process of computing would be very helpful.

To adjust the calculation to the particular computer the properties of the optical system have been described by a merit function of the form

$$F = \sum \left(\frac{A_{i0} - A_i}{T_i}\right)^2 \tag{1}$$

i.e. by a sum of the squared deviations of the real properties A_i devided by their respective tolerances; the latter playing the role of the importance measure of the particular features (the inessential properties are eliminated by assuming the corresponding $T_i = 0$ in the data deck). The above function has to be minimized.

*) Instytut Konstrukcji Przyrządów Precyzyjnych i Optycznych Politechniki Warszawskiej, Warszawa, ul. Koszykowa 75, Poland.