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PLATEHOLDER–MIRROR ALIGNMENT OF SCHMIDT TELESCOPE

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ABSTRACT

In the plateholder mirror alignment, we produce an auxiliary point source which falls at the correcting lens. If the adjustment is correct, then the image of once reflection, I_1, will coincide with the image of three reflections I_3, as proposed by Dewhirst and Yates. However our results indicate that, due to off-axis position of the source, there exists aberrations at I_1 and I_3.

SARI

Sebuah sumber-cahaya-titik buatan telah dibentuk pada lensa-koreksi guna tes pelempangan kaset pelat potret Schmidt, di Observatorium Bosscha. Cara Dewhirst dan Yates diadaptasikan untuk keperluan tes. Dalam tes ini, diselidiki jalan berkas cahaya yang terpantul sekali (I_1) dan 3 kali (I_3) oleh cermin utama. Kalau kedudukan kaset pelat baik, maka I_1 akan berimpit dengan I_3.
Tetapi hasil tes kita memperlihatkan bahwa, akibat kedudukan sumber cahaya di luar sumbu, terjadi aberasi pada I_1 dan I_3.

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To detect tilt of plateholder in a Schmidt telescope, Dewhirst and Yates (1954) proposed to use a point source on the correcting lens. An auxiliary mirror replaces the photographic plate in the plateholder. to participate in the forming of image I_3. This point is the image formed by three reflections, due to the concave primary mirror, convex mirror in the plateholder and again due to the concave mirror. I_1 is the image formed by only one reflection in the concave mirror. Fig. 1 shows the light path producing I_1 and I_3. According to Dewhirst and Yates, the mirror plateholder adjusment is correct when I_1 coincides with I_3.

Haffner (1954) shows that I_1 is astigmatic, and I_3 is free of aberration. Furthermore, Andersen and Clausen (1974) showed that I_3 occured as two lines, because of the astigmatism and vignetting, while I_1 is still a point and free of aberration. So, according to them, the adjusment is correct when I_3 is in the centre of I_1.

The aberration function, originally known as the Seidel aberration, can be expressed as follows.

$$W(Q') = -\frac{1}{4} C \left(\frac{D_{12}}{L}\right)^4 \left\{ r'^4 + 4bhr'^3 \cos\phi + 4b^3h^3 r' \cos\phi + 2b^2h^2r'^2 \left(2\cos^2\phi + 1\right)\right\} \qquad (1)$$

where

$$C = \frac{1}{2} \left\{ \left(\frac{1}{D_{01}} - \frac{1}{R}\right)^2 \frac{1}{D_{01}} + \left(\frac{1}{D_{12}} - \frac{1}{R}\right)^2 \frac{1}{D_{12}} \right\} \qquad (2)$$

$$b = \frac{(R + L' - D_{12})}{(D_{12} - R)} \qquad (3)$$

Q' is the position at exit pupil
D_{01} is the distance of object to mirror
D_{12} is the distance of image to mirror
R is the radius of curvature of the mirror
L' is the distance of exit pupil to image
r' and ϕ are polar coordinates of point Q' at the exit pupil
h is the distance object to the axis of system

For the object on the correcting lens, it can be shown that

$$R - D_{01} = - \lim_{d \to 0} d \tag{4a}$$

$$R - D_{12} = \lim_{d \to 0} d \tag{4b}$$

$$L' \approx R \tag{4c}$$

Thus we will obtain

$$W(Q') = -\frac{1}{4} \lim_{d \to 0} \left(\frac{d^2}{R^5}\right) \left(\frac{D_{12}}{R}\right)^4 \left\{ r'^4 - 4\left(\frac{R}{d}\right) h r'^3 \cos\phi + 4\left(\frac{R}{d}\right)^3 H^3 r' \cos\phi + 2\left(\frac{R}{d}\right)^2 h^2 r'^2 (2\cos^2\phi + 1) \right\} \tag{5}$$

Furthermore, the first and the second term become zero, while the third becomes infinitely large, which does not have physical meaning. Therefore, the aberrations formed are astigmatism and field curvature, explained by

$$W(Q') = -\frac{1}{2} \frac{h^2}{R^3} r^{-2} (2 \cos^2\phi + 1) \tag{6a}$$

In the Cartesian coordinate, it becomes

$$W(Q') \equiv (x' . y') = -\frac{1}{2} \frac{h^2}{R^3} (3x'^2 + y'^2) \tag{6b}$$

The deviations in the x and y directions are

$$\Delta (x) = -\frac{D_{12}}{\cos\alpha} \left(\frac{\partial W(x', y')}{\partial x'}\right) \tag{7a}$$

$$\Delta (y) = -\frac{D_{12}}{\cos\alpha} \left(\frac{\partial W(x', y')}{\partial y'}\right) \tag{7b}$$

where

$$\mathrm{Sin}\ \alpha = \frac{h}{R} \tag{8}$$

The Bosscha Schmidt Telescope used for this experiment has been described by The (1961). The technical data of this instrument are as follows: diameter of the mirror 71.12 cm, radius of curvature 253.33 cm and h is 17.40 cm. Inserting these values into aquations (6) and (7), we obtain I_1 as an ellipse with dimension of the axes: $\Delta x_{max} \approx 0.504$ cm, and $\Delta y_{max} \approx 0.168$ cm as pointed out by Andersen and Clausen (1974) the image I_1 would become a ellipse which is cut in its centre, and resemble a capital letter M, due to astig... and vignetting.

According to the additive theorem (Klein, 1970), the image formed by three reflections is simply the total aberration function and is the sum of the respective aberration function caused by each reflection.

From Fig. 2, we get

$$W_1(x', y') = W^{(1)}(x' + 2h, y') + W^{(2)}(x', y') + W^{(3)}(x', y') \tag{9}$$

where

$$W^{(1)}(x', y') \cong W^{(3)}(x', y') = \frac{1}{2}\frac{h^2}{R^3}\; r^2\,(3x'^2 + y'^2) \tag{10}$$

Similarly $W^{(2)}(x', y')$ can be obtained here $R^{(2)} = -R/2$.

$D_{12}^{(2)} \approx D_{12/2}'$ $D_{01}^{(2)} \approx D_{01/2}'$ and $h^{(2)} = h$ 30 that

$$W^{(12)}(Q') = \frac{h^2}{R^3}\, r'^2\,(3x'^2 + y'^2) \tag{11}$$

Therefore

$$W_1(x', y') = \frac{1}{2}\frac{h^2}{R^3}\left\{3(x' + 2h)^2\right\} + \frac{h^2}{R^3}\,(3x'^2 + y'^2)$$

$$\cdot\ \frac{1}{2}\frac{h_2}{R^3}\,(3x'^2 + y'^2) \tag{12a}$$

$$W_t(x', y') = \frac{6h^3}{R^3}\,(x' + h) \tag{12b}$$

The aberration that occurs in the image formed by three reflections is a distortion. A deviation appears with the presence of aberration function, in accordance with (7). Therefore

$\Delta x \approx 0.494$ cm

$\Delta y = 0$

From the above derivation, we know that the image formed by three reflections has no astigmatism and field curvature. This image still retains the form of a point, but it moves radially at distance $\dfrac{6\,h^3}{\cos\alpha \, . \, R^2}$ away from the image of the centre of the correcting lens.

In our experiment we found the image I_1 looks like "H", while I_3 is distorted. The distortion will displace I_3 a certain distance away. The present result supports the finding by Andersen and Clausen (1974) in which they asserted that the method is sensitive for tangential shifts. Here we found again that the adjustment is correct, due to the off-axis position of the source, if I_3 is not in the centre of I_1.

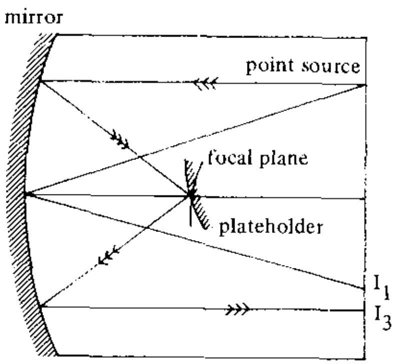

Figure 1

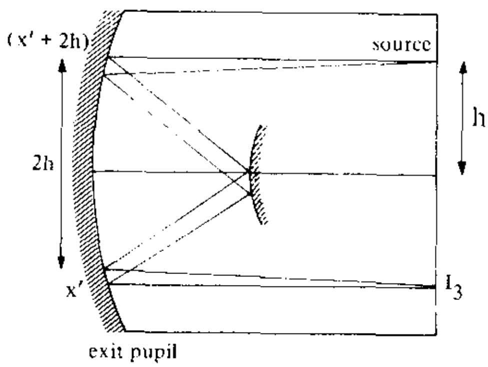

Figure 2

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REFERENCES

Andersen, J. and Clausen, J.V., 1974, Astron. & Astrophys. *34*, 423.

Dewhirst, D.W. and Yates, G.G., 1954, Observatory *74*, 71.

Haffner, H., 1954, Observatory *74*, 210.

Klein, N.V., 1970, Optics, John Wiley & Sons, New York.

The, Pik - Sin, 1961, Contrib. Bosscha Observatory, no. 9.