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DIFFRACTION ANALYSIS OF LAMOST — TWO SEGMENTED MIRRORS INCLUDED

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ABSTRACT

LAMOST is a special reflecting Schmidt telescope. Both the refleting Schmidt plate M_A and the spherical primary mitrror M_B are segmened mirrors. These two cofocus but not co-phase. The diffraction of the optical system is decided by the shape overlapping of M_A and M_B. This paper describes the diffraction caculating results with different declination and different field angle. The diffraction influence to the image quality is acceptable in the error buget of optical system. It also proves that the size seletion of the sub-mirror is reasonable.

I. BASIC PRINCIPLE

The optical system of LAMOST is composed of two segmented mirrors M_A and M_B. Reflecting Schmidt plate M_A consists of 24 hexagonal sub-mirrors. Each segmented is 1.1m long in diagonal.

Because the sub-mirror's distribution of M_A is different from that of M_B, when they overlap more sub-areas will be produced (See Fig. 1). Otherwise, rays of center object of FOV incident M_A with a angle θ, we consider the overlapping shape of M_A and M_B in the perpendicular plane to incident ray (See Fig. 2). Beacause M_A does the tracking and the main optical axis is fixed, obviously, θ vaires with different sky area observed, so the overlapping shape of M_A and M_B is different. When the shape of M_A and M_B overlap with off-axis field there is also a relative movement between their center. So diffraction of the optical system of LAMOST varies with the overlapping of M_A and M_B.

(a) Diffraction of One Sub-Area

If we ignore the aberration of the optical system, the sub-area equal to a diffraction plate which aperture function is $P(x1, y1)$ and the focal length is f. With the parallel rays of unit amplitude incident vertically, the amplitude in the focal plane is given by

$$U_S(x,y) = \frac{1}{\lambda f} \exp\left(jk\frac{x^2+y+2}{2f}\right) \cdot$$
$$\int_{\infty}^{\infty}\int P(x1,y1)\cdot \exp\left[-j2\pi\left(\frac{x}{\lambda f}x1 + \frac{y}{\lambda f}y1\right)\right] dx1\,dy1.$$

The intensity is $I_S(x,y) = U_S(x,y)\cdot U_S^*(x,y)$.

(b) Diffraction of System

Because LAMOST is almost used to get spectral data, each sub-mirror is required only co-focus not co-phase, the diffraction of system is the sum of all intecity contributions $I_S(x,y)$ from each sub-area. We assume the i-th segment of M_A is divided into N sub-area, M_A consists of 24 sub-mirrors, so the result is

$$I(x,y) = \sum_1^{24}\sum_1^{N} I_S(x,y).$$

(c) Encircled Energy

In our occasion, what we concern most is the encircled energy. Discussed in polar coordinate, the total diffration energy is

$$I_A = \int_0^{\infty}\int_0^{2\pi} I(\rho,\theta)\rho\, d\rho\, d\theta.$$

Assuming 80evaluate ρ_0 by

$$\int_0^{\infty}\int_0^{2\pi} I(\rho,\theta)\rho\, d\rho\, d\theta = 80\% \cdot I_A.$$

II. THE RESULTS AND CONCLUSION

The most diffculty is giving out the correct aperture fucntion of all the sub- area. The author does carefully with them and programms strictly according to them. Till now, four kinds of diffraction energy distribution of LAMOST have been calculated when the star is in meridian δ is zenith of the observing sky area. θ is incident angle of center object of FOV.W is the field angle.

(1)$\delta = -10°(\theta = 7.3°)$, $W = 0°$, 80% diffraction energy spreads in 0.49 arcsecond.

(2)$\delta = 30°(\theta = 27.3°)$, $W = 0°$, 80% diffraction energy spreads in 0.53 arcsecond.

(3)$\delta = 90°(\theta = 57.3°)$, $W = 0°$, 80% diffraction energy spreads in 0.51 arcsecond.

(4)$\delta = 90°(\theta = 57.3°)$. Field is in the plane decided by center object and main optical axis (meridional plane), $W_X = 0.75°$. It is estimated to be the worst case. Not only the meridional size of M_A is compressed, but also there are relative movement between the centers of M_A and M_B 80diffraction energy spreads in 0.47 arcsecond.

According to above calculations, we can obtain such a conclusion: even if how M_A and M_B overla, except a few individual cases the diffraction spread is less when each sub-mirror of M_A coincide with sub-mirror of M_B, 80diffraction energy of the optical system of LAMOST spreads in about 0.5 arcsecond. The diffraction influence to the image quality is acceptable in the error buget of optical system.

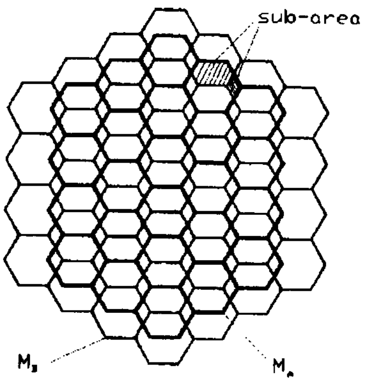

Fig. 1.— The overlapping of the segmented mirrors M_A and M_B ($\delta = -10°$, $W = 0°$)

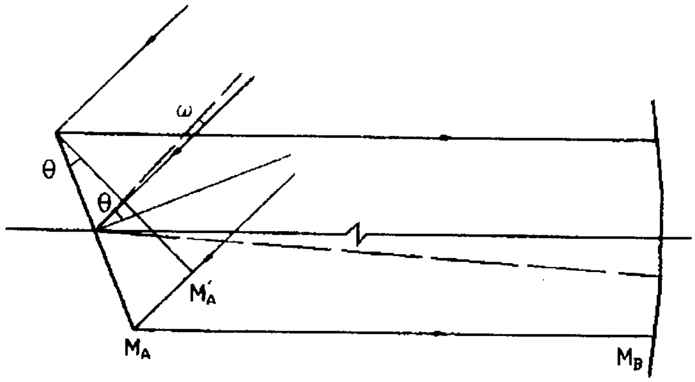

Fig. 2.— The illustration of the overlapping of M_A and M_B

Otherwise, diffraction is calculated when M– and M– are other two segmented shapes.

I. M_A is a segmented mirror with 1.1m hexagonal sub-mirror in diagonal. M_B is a single 6m mirror. Thus the diffraction of optical system is the same as the diffraction of a sub-mirror. $\delta = -10°$, 80

II. Each sub-mirror of M_A and M_B is 1.5m hexagonal in diagonal. 80energy spreads in about 0.42 arcsecond.

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