DRAFT II

December 19, 1991

In order to meet the WIYN project timeline, it will be necessary to polish the primary and secondary mirrors at separate facilities. This memo is intended to establish tolerances on the basic optical parameters for the primary and secondary so that the assembled optics will meet WIYN's performance criteria.

The basic performance goal can be stated as two stipulations:

1). The optics must produce excellent images, and;
2). The images must form inside a particular volume in space.

Both of these criteria are effected by the basic optical parameters, that is, the vertex radii of curvature, R1 and R2, and by the aspheric shape, here described by the conic sections K1 and K2.

We propose the following tolerances:

Primary Mirror

R1 = -12250 mm +/- 25mm
K1 = -1.070833 +/- 0.00167

and K1 and R1 shall be constrained so that:

$| 0.3878\ \Delta R1 - 18600\text{mm}\ \Delta K1 | < 6\text{mm}$

Secondary Mirror

R2 = +5332.25 mm +/- 17mm
K2 = -3.721667 +/- 0.014

and K2 and R2 shall be constrained such that

$| 1.41\ \Delta R2 + 2200\text{mm}\ \Delta K2 | < 7\text{mm}$

Discussion

Image error allowance for the WIYN telescope

WIYN is intended to provide three configurations; a narrow field of 15 arcminutes diameter as a bare RC system (that is, with no refractive corrector optics); a 30 arcminute diameter field with correction and atmospheric dispersion compensation (ADC) over a bandpass from 3500 Å to 1.1 μm; and a sixty arcminute field with correction but no ADC and a bandpass of 3300 Å to 1.5 μm. All foci are designed to be confocal. Removing field corrector optics also causes zero focal shift.

The image error allowance over the sixty arcminute diameter field allocates 0.20 arcseconds fwhm for optical design. Assuming a point spread function with a Gaussian profile, a 0.20 fwhm image has an RMS diameter of 0.24 arcseconds, or 0.0253 mm RMS diameter at the WIYN plate scale.

The image error allowance over the thirty arcminute diameter field allocates 0.17 arcseconds fwhm for optical design, equivalent to an RMS diameter of 0.20 arcseconds (0.0214 mm RMS diameter).

The image error allowance over the narrow 15 arcminute diameter field is not explicitly defined, but we can assume it is the same as the thirty arcminute field diameter.

These allowances apply at zenith pointing, hence we can neglect the effects of atmospheric dispersion and ADC.

The tolerances we are considering (the radius of curvature and conic constants of the primary and secondary) can be regarded as tolerances on the optical design, so these are the pertinent limits to the degraded images.

In practice the primary and secondary parameters could vary over a very broad range and still produce a combination capable of producing at least excellent on-axis image. However, both the primary mirror to secondary mirror spacing and the location of this optimum focal surface has to vary. For WIYN we limit the variation of the focal surface to no more than +/- 25 mm, and the primary to secondary spacing to no more than +/- 20 mm. This limits the allowable variation in the primary and secondary radii and conic sections.

Deviations in either the primary or secondary parameters effect the position of the optimal focal position. For small deviations (on the order of +/- 25 mm) the relation is very nearly linear. By raytracing we find the following:

$$\frac{\partial B}{\partial K_1} = 18600\ mm$$

$$\frac{\partial B}{\partial R_1} = 0.3878$$

$$\frac{\partial B}{\partial K_2} = 2200\ mm$$

$$\frac{\partial B}{\partial R_2} = 1.41$$

The effects of parameter changes can offset one another, hence they can be linked into expressions for the focal surface displacement due to the primary and secondary parameters:

$$[0.3878\Delta R_1 + 18600mm\ \Delta K_1] = \Delta B \qquad \textit{primary contribution}$$

$$[1.41\Delta R_2 + 2200mm\ \Delta K_2] = \Delta B \qquad \textit{secondary contribution}$$

It is clear that a coupled change in parameters can result in a zero net focal shift. The result of doing so is a telescope which maintains the focal position, but departs from the zero coma or Ritchey-Chretien condition. There is also some change in the curvature of the best image surface.

In principle the field correctors could be designed to correct for coma as well as astigmatism. However, it is preferable to choose tolerances which will realize excellent images with a wide-field corrector fabricated according to the nominal design so that fabrication may proceed on the corrector concurrent with the fabrication of the primary and secondary mirrors.