HIPPARCOS Relay Optics and IFOV Depointing Simulations

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Using the methods and software described in the note, "Distortion of the Detector Signal Caused by IFOV Edges and Piloting Errors" (1980 Sept 1), the effects of certain relay optics aberrations have been computed for a modified instrument with semi-circular entrance pupil.

The common parameters for the simulation runs are as follows (for notations, see the abovementioned note):

Effective Wavelength : 550 nm (monochromatic)

Entrance Pupil : semi-circular $\phi$ 0.29 m, central obstruction $\phi$ 0.128 m ($z > 0$) \& ($0.064^2 < y^2 + z^2 < 0.145^2$)

Grid : period $s = 1.2$ arcsec, (slit width)/(period) $\delta = 0.38$

Relay Optics Pupil : semi-circular $\phi$ 0.29 m ($\beta = 1.0$), no obscuration ($z^2 > 0$) \& ($y^4 + z^4 < 0.145^2$)

IFOV : circular, radius 15 arcsec, lorentzian PSF ($\mu = 1''$); see Fig. 3b in the note from 1980. Scale 3 \(\mu\)m/arcsec

Telescope Aberrations : none, $W(y, z) = 0$

Five runs were made, with the following relay optics aberrations:

Run # 1 : no aberrations $W = 0$

Run # 2 : defocus 0.1 mm at pk $W = 1.3058E-4(y^4 + z^4)$

Run # 3 : coma, max WFE = 0.5\(\lambda\) $W = 9.021E-5(y^4 + z^4)y^4$

Run # 4 : coma, max WFE = 2\(\lambda\) $W = 3.608E-4(y^4 + z^4)y^4$

Run # 5 : defocus 0.05 mm at pk, plus coma with max WFE = \(\lambda\) $W = 6.529E-5(y^4 + z^4) + 1.804E-7(y^4 + z^4)y^4$

Results are given in the five plots, each showing the signal parameters distortions as functions of the IFOV depointing in arcsec.

Remark: The discretization of the semi-circular pupil by means of a rectangular mesh is not so accurate as for the rectangular pupil. Discretization errors on the level $\sim 1%$ produce "scattered light" on the level of \(10^{-4}\), which is probably the reason why the $B_0(\beta')$ plots are not as clean as in the note of 1980.
Explanation to the Figures

For each run, six contour plots are given, each covering an area of 49.3 x 49.3 arcsec$^2$ (= aliasing period) and centered on the principal ray. The disposition is as follows:

$E_0(\hat{\rho}'_W)$, normalized

Average count rate as function of IFOV offset $\rho'_W$, normalized to 100% at maximum.

Contour levels:

100 99.5 99 98 95 90 80 50 10 %

$B_0(\hat{\rho}'_W)$, normalized

Average intensity in the detector plane, normalized to unity at maximum intensity.

Contour levels: $-10 \log(I/I_{\text{max}}) = 0 \ 0.5 \ 1 \ 2 \ 3 \ 4 \ 5$

$M_1(\hat{\rho}'_W)$

Percent modulation of the first harmonic of the detector signal.

Contour levels:
multiples of 2%

$\Delta_1(\hat{\rho}'_W)$

Displacement of the first harmonic, in mas.

Contour levels:
multiples of 1 mas

$M_2(\hat{\rho}'_W)$

Percent modulation of the second harmonic of the detector signal.

Contour levels:
multiples of 1%

$\Delta_2(\hat{\rho}'_W)$

Displacement of the second harmonic, in mas.

Contour levels:
multiples of 1 mas
Run #5: defocus 0.05 mm + coma, max WFE = λ