

# Pointing Correction at the CSO

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## 1. Optical Pointing Correction

The optical pointing model for the CSO telescope has seven conventional parameters for the altazimuthal mount (Meeks et al. 1968) and four additional parameters. The corrections applied to the azimuth angle  $\Delta A_{opt}$  and the zenith angle  $\Delta Z_{opt}$  are modeled as

$$\Delta A_{opt} \sin Z = C_1 + C_2 \sin Z + C_3 \cos Z + (C_4 \sin A + C_5 \cos A) \cos Z + C_8 \sin^2 Z \quad (1)$$

and

$$\Delta Z_{opt} = -C_4 \cos A + C_5 \sin A + C_6 + C_7 \sin Z + C_9 \sin 2Z + C_{10} \cos 2Z + C_{11} A, \quad (2)$$

where  $A$  and  $Z$  are the desired pointing direction in azimuth and zenith distance, respectively, and  $C_1$ – $C_{11}$  are the optical pointing parameters, or the “C-terms.” Their current values (as of March 16, 2003) are tabulated in Table 1.

Equations (1) and (2) can be rewritten using the elevation angle  $E$  instead of the zenith angle  $Z$  as

$$\Delta A_{opt} \cos E = C_1 + C_2 \cos E + C_3 \sin E + (C_4 \sin A + C_5 \cos A) \sin E + C_8 \cos^2 E \quad (3)$$

and

$$\Delta E_{opt} = C_4 \cos A - C_5 \sin A - C_6 - C_7 \cos E - C_9 \sin 2E + C_{10} \cos 2E - C_{11} A, \quad (4)$$

where  $\Delta E_{opt}$  is the correction to the elevation angle and  $\Delta E_{opt} = -\Delta Z_{opt}$ . Note that the gravitational deflection term in the CSO model has the form  $C_7 \cos E$ , while Meeks et al. (1968) chose the form  $constant \times E$  empirically for the Haystack Antenna.

## 2. Radio-optical Axis Collimation

$$\Delta A_{rad} \sin Z = T_{A,A} + T_{A,B} Z + T_{A,C} Z^2 \quad (5)$$

and

$$\Delta Z_{rad} = T_{Z,A} + T_{Z,B} Z + T_{Z,C} Z^2, \quad (6)$$

where  $T_{A,A}$ ,  $T_{A,B}$ , and  $T_{A,C}$  are the “T-terms” for the azimuth and  $T_{Z,A}$ ,  $T_{Z,B}$ , and  $T_{Z,C}$  are the “T-terms” for the zenith distance.

### 3. Alidade Tilt Correction

$$\Delta A_{tilt} \sin Z = LR \cos Z \quad (7)$$

$$\Delta Z_{tilt} = AF \quad (8)$$

## REFERENCES

Meeks, M. L., Ball, J. A., & Hull, A. B. 1968, IEEE Trans. on Antennas and Propagation, AP-16, 746

Table 1. Optical Pointing Parameters of the CSO Telescope

Parameter	Description	Value <sup>a</sup> (") <sup>b</sup>
$C_1$	Collimation error (non-orthogonality of optical axis to elevation axis)	50.35
$C_2$	Azimuth axis encoder offset	586.12
$C_3$	Elevation axis skew (non-orthogonality of elevation axis to azimuth axis)	11.55
$C_4$	Azimuth axis tilt (north–south direction; positive if tilted to the north)	8.02
$C_5$	Azimuth axis tilt (west–east direction; positive if tilted to the west)	-11.52
$C_6$	Elevation axis encoder offset	-985.43
$C_7$	Gravitational deflection error	-49.71
$C_8$	Azimuth axis term proportional to $\cos E$	-23.83
$C_9$	Sinusoidal elevation axis encoder error (proportional to $\sin 2E$ )	-14.68
$C_{10}$	Sinusoidal elevation axis encoder error (proportional to $\cos 2E$ )	-7.79
$C_{11}$	Elevation axis term proportional to $A$	0.05

<sup>a</sup>As of March 16, 2003.

<sup>b</sup>The parameter  $C_{11}$  has a dimension of (" $\text{rad}^{-1}$ ").

Table 2. T-terms for the SHARC II at the N2 focus

Parameter	Value <sup>a</sup>	Unit	UIP		
			Parameter	Value <sup>b</sup>	Unit
$T_{A,A}$	0.00	(")	$TAZOF\_A$	0.00	(rad)
$T_{A,B}$	-12.99	(" $\text{rad}^{-1}$ )	$TAZOF\_B$	$-6.300 \times 10^{-5}$	
$T_{A,C}$	0.62	(" $\text{rad}^{-2}$ )	$TAZOF\_C$	$3.005845 \times 10^{-6}$	( $\text{rad}^{-1}$ )
$T_{Z,A}$	0.00	(")	$TZAOF\_A$	0.00	(rad)
$T_{Z,B}$	-138.03	(" $\text{rad}^{-1}$ )	$TZAOF\_B$	$-6.69182 \times 10^{-4}$	
$T_{Z,C}$	-1.36	(" $\text{rad}^{-2}$ )	$TZAOF\_C$	$-6.593466 \times 10^{-6}$	( $\text{rad}^{-1}$ )

<sup>a,b</sup>As of September 13, 2004.