AST/RO Pointing Model and Software Description

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In this memo, we describe the star pointing model for the AST/RO telescope, as well as the procedure for running the pointing data reduction software.

The Star Pointing Model

The derivation of the common terms of pointing errors due to an imperfect Az-El telescope mount can be found in the GBT technical memo by Condon. For the AST/RO telescope, the horizontal pointing error $\Delta Azcos(El)$ has the following experssion:

$$\begin{aligned}
\Delta Azcos(El) = C_1 + C_2 * \cos(El) + C_3 * \sin(El) \\
+C_4 * \cos(Az) * \sin(El) + C_5 * \sin(Az) * \sin(El) \\
+C_6 * \cos(2Az) * \cos(El) + C_7 * \sin(2Az) * \cos(El) \\
C_8 * \cos(3Az) * \cos(El) + C_9 * \sin(3Az) * \cos(El), \qquad (1)
\end{aligned}$$

where C_1 term is the optical telescope horizontal collimation error, C_2 term is the constant azimuth (encoder) offset, C_3 term is the elevation axis horizontal offset, C_4 and C_5 terms are due to the constant tilt of the telescope azimuth track, and C_6 to C_9 terms account for the higher order errors due to the azimuth track unevenness.

The vertical pointing error ΔEl has the expression

$$\begin{aligned}
\Delta El = D_1 + D_2 * \cos(El) + D_3 * \sin(El) \\
+D_4 * \cos(Az) + D_5 * \sin(Az) \\
+D_6 * \cos(2Az) + D_7 * \sin(2Az) \\
+D_8 * \cos(3Az) + D_9 * \sin(3Az) \qquad (2)
\end{aligned}$$

where D_1 term accounts for the optical telescope vertical collimation error, as well as elevation encoder offset, D_2 and D_3 terms are mainly due to the elevation encoder decentering on the AST/RO telescope, D_2 term also includes the gravitational bending effect, D_4 and D_5 terms are due to the constant tilt of the telescope azimuth track, and D_6 to D_9 terms account for the higher order errors caused by the azimuth track unevenness.

The star-pointing data must first be corrected for atmosphere refraction of the amount,

$$\Delta El(\text{refraction}) = \frac{-51.84"}{\tan(El)} \tag{3}$$

before doing the pointing fitting.

Oftentimes, we also correct for time-dependent tilt of the telescope, as measured by a pair x, y tiltmeters, before doing pointing fitting. The horizontal pointing error due to the tiltmeter ΔT_h is given by

$$\begin{aligned}\Delta T_h &= -\Delta y(\sin Az \sin El \cos\theta + \cos Az \sin El \sin\theta) \\ &\quad +\Delta x(\cos Az \sin El \cos\theta - \sin Az \sin El \sin\theta),\end{aligned} \tag{4}$$

where θ is the tiltmeter orientation as defined in Zhang (1996), and the vertical pointing error ΔT_v is given by

$$\begin{aligned}\Delta T_v &= -\Delta y(\cos Az \cos\theta - \sin Az \sin\theta) \\ &\quad +\Delta x(-\cos Az \sin\theta - \sin Az \cos\theta).\end{aligned} \tag{5}$$

The Pointing Data Reduction Software

The data obtained through the CCD program is stored as /data/pnt/date.pnt on ROYAL. If you want to reduce the data on ROYAL (without a graphical display), copy the data to "/usr1/obs/lib/POINTING" directory and run the program "point" there.

If you need the graphical display of the pointing data, copy the data onto gentoo, and a version of the reduction program can be found in "/home/xzhang/pointing" directory, and it is also called "point".

One of the outputs of the “point” program is the “point.corr” file, which can be used as the replacement pointing model.

To use the new pointing model, rename “point.corr” as “/usr/obs/lib/POINT/point.corr.date” on ROYAL. Then make the symbolic link, “ln -s /usr1/obs/lib/POINT/point.corr.date point.corr”, this overwrites the old point.corr file.

Reference

Condon, J. J. “GBT Pointing Equations,” GBT technical memo, No. 75

Zhang, 1996, “Pointing Errors due to the Effect of Telescope Tilt as Measured by a Pair of Arbitrarily Oriented Tiltmeters”.