GBT MEMO 139

Low Tracking Rates in Azimuth

M. M. McKinnon

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In GBT memoranda 129 and 134, Gawronski and Parvin identify a minimum tracking rate in azimuth ($R_A \simeq 0.5$ mdeg/sec) for the GBT. At rates below the minimum, static friction on the azimuth drive wheels can cause "a significant loss of pointing accuracy". The purpose of this memorandum is to illustrate when the minimum tracking rate occurs.

The equation for the time rate of change of azimuth is derived in Smart (1977, Textbook on Spherical Astronomy, Cambridge Univ. Press). This tracking rate, in units of degrees per second, is

$$R_A = \frac{dA}{dH} = \frac{1}{240}[\cot(z) * \cos(A) * \cos(\phi) - \sin(\phi)] \qquad (1)$$

where A is azimuth, H is hour angle, ϕ is latitude, and z is zenith distance. In Smart's derivation, the azimuth increases from zero to 360 degrees from north through west (see Fig. 25 on pg 49).

Figures 1, 2, and 3 show the azimuth tracking rates calculated from equation 1 for sources with low ($\delta < 0$), intermediate ($\delta \sim \phi$), and high declinations ($\delta > \phi$), respectively. The latitude of the GBT, $\phi = 38°25'58.8"$, was used in the calculation. The range of hour angles shown in the figures is restricted by an assumed limit on telescope elevation of eight degrees. The dashed horizontal lines in each figure define the region where the magnitude of R_A is less than the minimum. Figures 1 and 2 indicate that all sources with $\delta < \phi$ will have negative tracking rates for the times they can be observed. With the exception of $\delta \sim \phi$, the magnitude of this rate is greater than the minimum rate. The tracking rate approaches $-\sin(\phi)/240 = -2.6$ mdeg/sec at large hour angles. As can be seen in Figures 2 and 3, all sources with $\delta \geq \phi$ will have $R_A = 0$ at some point. This condition will occur when the hour angle, in units of radians, is

$$H = \arccos[\tan(\phi)/\tan(\delta)] \qquad (2)$$

High declination sources, particularly circumpolar sources, will have tracking rates less than the minimum rate for long periods of time (many hours). Static friction will adversely affect tracking and pointing for these sources because the low tracking rate must be sustained for long periods of time.

The maximum tracking rate occurs at source transit. Given the maximum slew rate of a telescope, one can calculate the range of zenith distance, the so-called zone of avoidance, over which some sources (i.e. those with $\delta \sim \phi$) cannot be observed. For the GBT, the maximum slew rate is 40 degrees per minute, and the zone of avoidance is $|z| < 17$ arcminutes (Ghigo, GBT Memo 52).

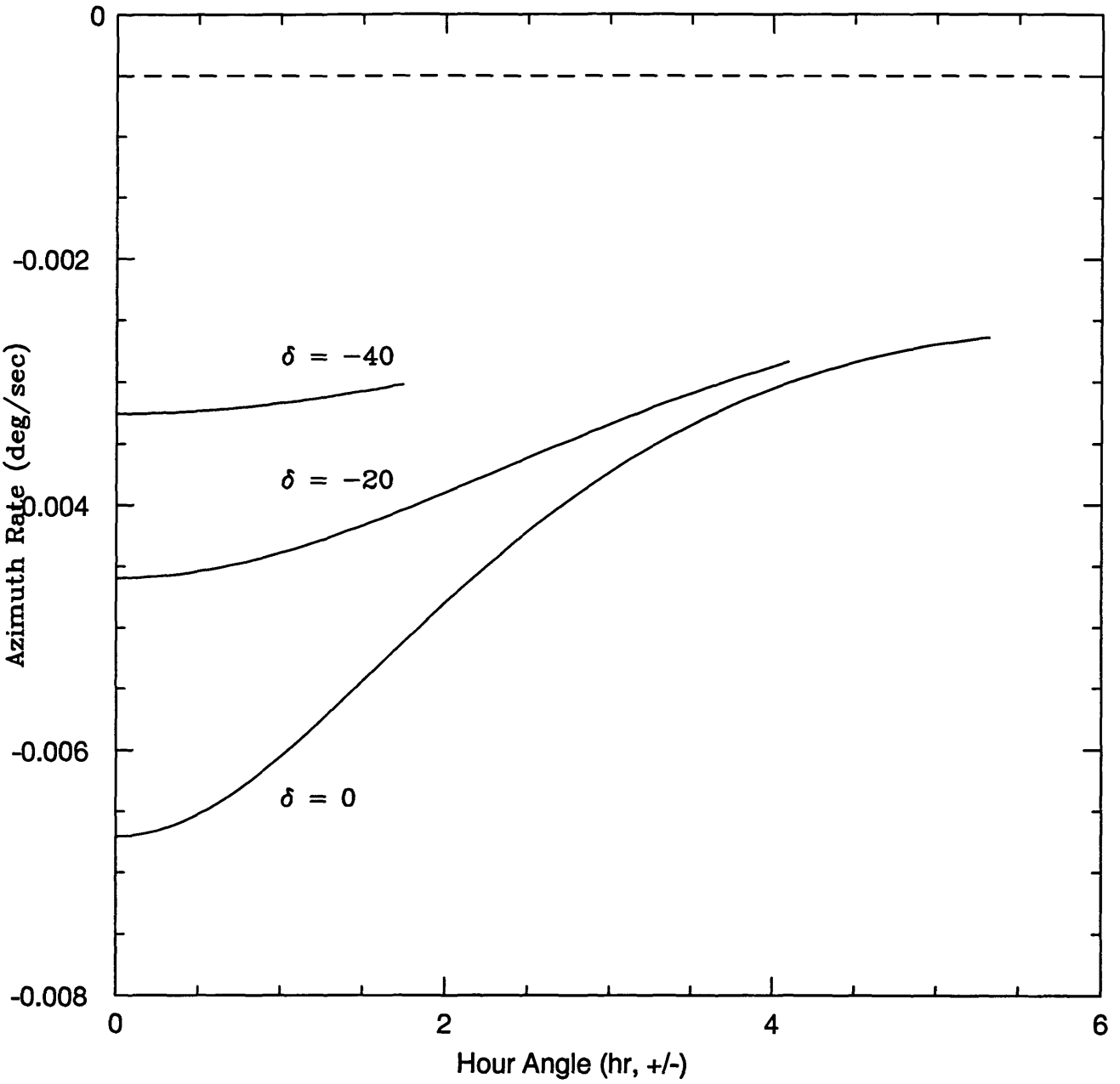

Figure 1: Azimuth tracking rates for sources with low declinations

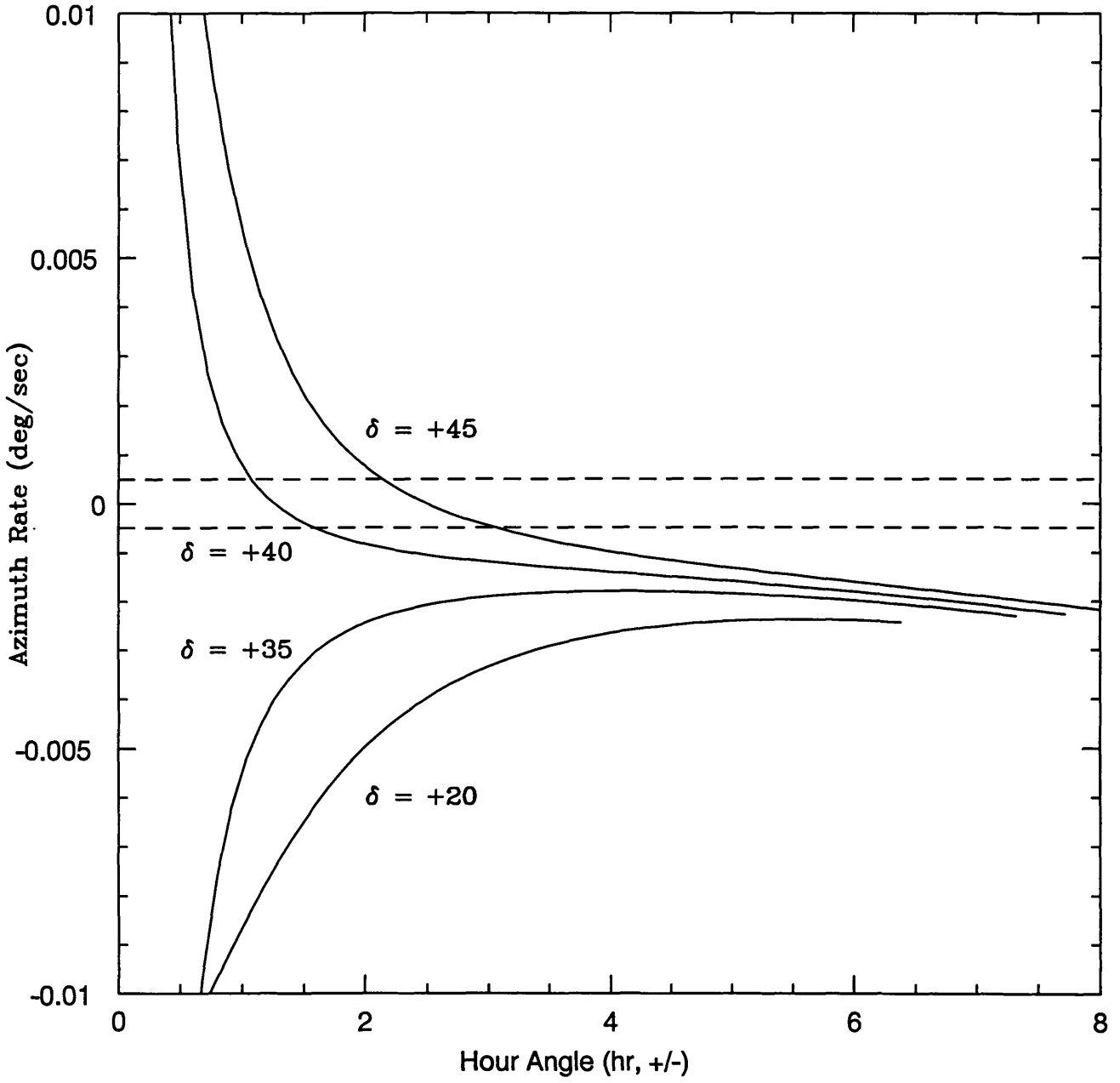

Figure 2: Azimuth tracking rates for sources with intermediate declinations

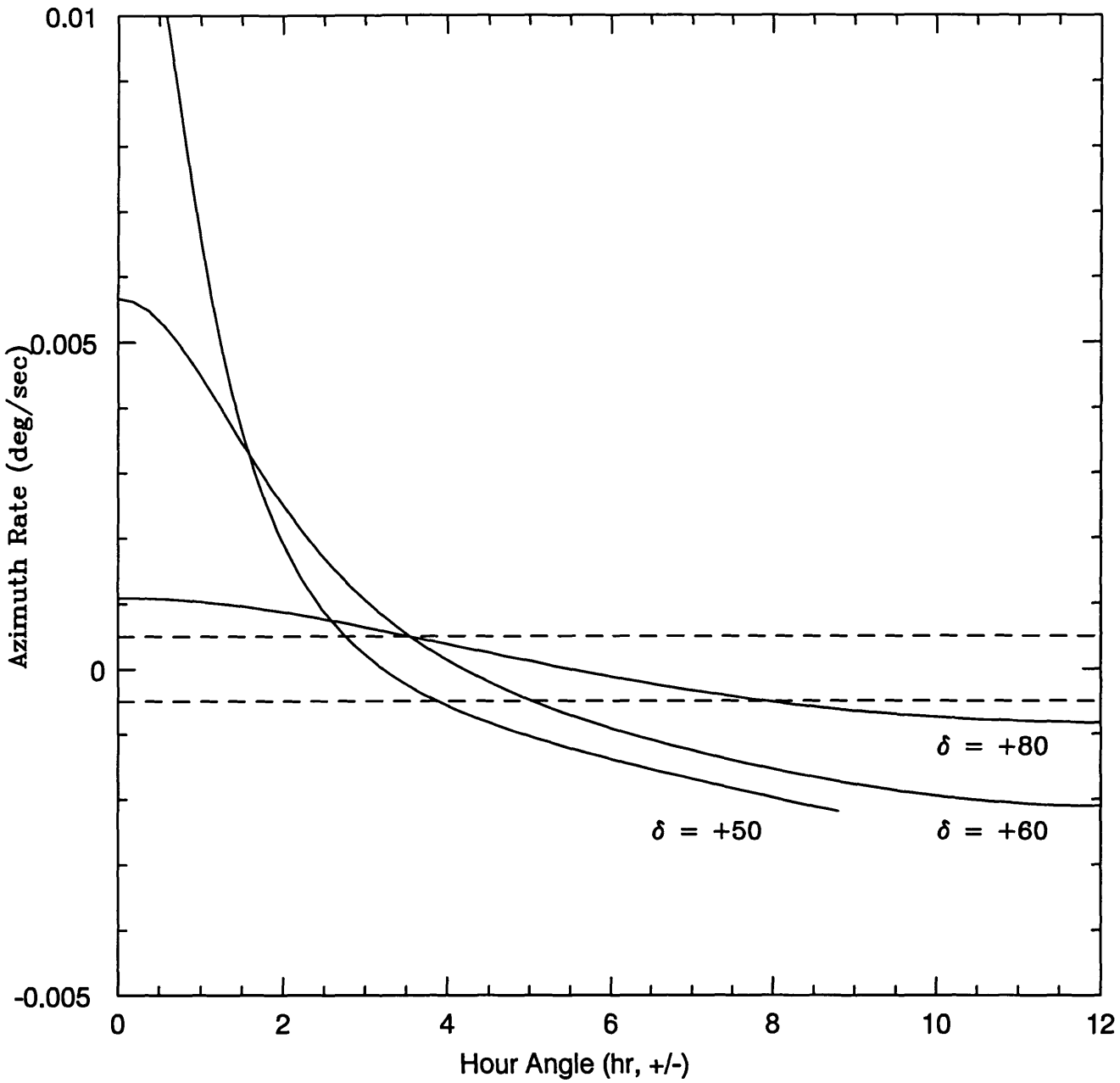

Figure 3: Azimuth tracking rates for sources with high declinations