BIMA Memoranda Series #15

The Effect of Light Wind on Antenna 3

Stephen White
University of Maryland
July 25, 1991

Abstract

It is well known that the drives on antenna 3 are presently unable to maintain pointing in the presence of even a small amount of wind. However the effect this has on data is probably not widely appreciated. This memo uses solar observations to point out that on a typical summer afternoon antenna 3 may be pointing off the source (i.e., the source is outside the primary beam) for up to 50% of the time without the data being flagged bad. These pointing errors must produce high noise levels on the baselines including antenna 3.

1 Solar Observations

There is presently no antibacklash mechanism on the drives for antenna 3. Many people are aware that even a mild level of wind is enough to send antenna 3 wildly off the source. There is apparently no flagging of the data presently carried out, so that observers are receiving a lot of bad data on 2 out of their 3 baselines. This problem has been noted but not received much attention, since it persists. The purpose of this memo is to demonstrate the extent of the problem.

Let me note at the outset that it is much more of a problem for normal galactic sources than for our solar observations. The reason is that it may not be immediately obvious to the average observer that the pointing is badly off. If it only occurs for 10 seconds out of a 30 second integration then the data will seem a lot noisier but fringes may still be seen. However for observations of the Sun at high time resolution the effect is readily apparent: since the Sun is brighter than the system noise it dominates the signal, and if the antenna is blown off the Sun then the total power measurements immediately show it. To show examples, Figures 1, 2 and 3 present the total power measurements at 3 second intervals for antennas 1, 2 and 3, respectively, from five days in 1991 June. In all cases the horizontal axis is UT seconds and the vertical axis is the total power (voltage) measurement at the receiver (note that attenuation is present on all antennas). Sunrise is roughly at the beginning of the time range and sunset at the end, so that the second half of each plot is the afternoon period.

Comparison of the plots for antenna 3 with those of antennas 1 and 2 immediately shows the problem. Large dropouts (sudden drops in the voltage level due to the fact that the Sun is no longer in the primary beam) are common on antenna 3 but relatively rare on antennas 1 and 2. On the first day (June 8) there are few dropouts and they occur only in the afternoon, but on the subsequent days the problem is more severe. Typically the dropouts last somewhat less than 30 seconds, but they can be much longer. Many small dropouts of about 0.2 V are present but not readily evident in these long-term plots, which emphasize the largest dropouts. To display this effect, in Figure 4 we present one hour's data from the afternoon of June 11. The top panel shows the correlated amplitude on baseline 31, while the bottom panel shows the total power on antenna

3. This was a particularly bad period, and it is clear from the correlated amplitude plot that very little of the data are usable. However, none of it was flagged bad and there was no corresponding problem with antennas 1 and 2.

It is difficult to quantify the effects of these dropouts. For one thing, they only mark large pointing errors (i.e. the 2 arcmin field of view has been driven off the 30 arcmin-wide Sun). However I have tried to estimate the amount of time that antenna 3 was giving bad data by going through the data, taking the maximum reading over 10 points, and rejecting data below 98% of the maximum voltage, which is an ad hoc formulation which keeps nearly all the data when applied to antennas 1 and 2. I find that 12% of all the data on June 10 (the second mildest day) are bad; on June 13, after mid-morning, over 20% of the data are bad. There are one-hour periods in which over 50% of the data are bad. These numbers are lower bounds since they only represent the largest excursions (> 10 arcmin) in pointing: for example, for the period of Figure 4 the fraction rejected by the above procedure was 58%, and inspection of the correlated amplitude indicates that this does appear to be an underestimate.

As an aside, I note also that a number of solar flares can also be seen in the total power data, particularly the extremely large events (amongst the largest flares ever recorded) at the end of June 8 and 10 which saturated antenna 3. There also seems to be a low-level modulation in the total power on antenna 2, which is sinusoidal with a period of about 300 seconds (a period identical to that of the dominant solar oscillation modes, unfortunately), which is not present on the other antennas and therefore appears to be instrumental.

2 Wind Data

To some extent the wind data are irrelevant: the point is that this is a problem which affects antenna 3 in winds not strong enough to affect antennas 1 and 2, and hence is an entirely correctable problem. I have looked at the wind data from the *WATCH* plots for the month of June 1991, firstly to try to determine what level of wind was present during the bad-tracking periods of Figure 3, and secondly to try to estimate the fraction of days in a typical month that such winds are present.

In Figure 5 I present comparisons of wind data with total power plots for antenna 3 for 1991 June 10 (a day of relatively mild problems) and June 13 (a day of bad tracking problems). Unfortunately the conclusion of this figure and the comparisons for the other days for which we have solar data is that the tracking problems are much worse when winds are high, specifically gusts in excess of 10 mph, but that the tracking problems do not correlate closely with the wind speed: winds actually appear to have been somewhat stronger on June 10 than on June 13 during the period shown (14 - 24 UT). It has been suggested that one cause of this lack of close correlation is that backlash tracking problems are sensitive to wind direction: when the wind is blowing in the direction that the telescope is tracking the effect is probably worse than when wind is blowing against the direction of tracking.

Looking now at the month of June (data for 25 days), I find that there were only two days on which the wind was milder than on June 8 (June 21 and 24). I find altogether 5 days on which the wind did not gust above 10 mph during the daytime hours (including June 8). I find 20 days on which gusts above 10 mph were frequent during the period 16 UT - 05 UT (roughly 9 am to 10 pm, local time); June 13 was one of the milder days in this group. There were no days when gusts above 10 mph occurred between 5 UT and 15 UT, and only one day (June 6) when gusts above 5 mph occurred during these nighttime hours. Thus I find that winds bad enough to produce tracking problems at the level seen here on June 11 - 13 occurred on 80% of the days during June.

3 Conclusions

With typical weather conditions, wind will drive antenna 3 off the source for a significant fraction of the time during daylight hours (there is probably no problem for night observations). This introduces bad data into the observations *which are not being flagged*. It has two effects: not only is the effective integration time and therefore telescope efficiency down by a significant amount, but since the bad data are not being flagged an unnecessary noise source is being added to the data. As a crude estimate, for an afternoon observation 20% of the data could typically be bad, and this will appear as increased noise in the data, confined to baselines 23 and 31. For weak sources baselines 23 and 31 may well be useless, leaving a typical daytime observation with just the 5 configurations of baseline 12 with which to make maps.

To some extent the excess noise due to bad data in existing observations can be dealt with by making more use of the uv-variable "axisrms", present in both RALINT and MIRIAD formats, which is the rms tracking error. However, a quick survey of Maryland observers indicates that the information in this variable is not normally inspected in the course of calibration at present.