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SUMMARY OF 1994 TESTS OF THE AST/RO INSTRUMENT

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The Antarctic Submillimeter Telescope and Remote Observatory (AST/RO) instrument has concluded a second season of testing at Boston University. This memorandum summarizes the results of tests made during the Winter and Spring of 1994. AST/RO Technical Memorandum #14 dated 25 May 1993 summarizes the pointing tests and skydip measurements made in 1993.

A pointing model was generated by observing several hundred stars with the CCD camera mounted to a 76 mm diameter f/10 lens with a carbon-fiber tube. The pointing model was not significantly different from that found in May 1993. Improved pointing procedures allowed the determination of a mount model with data collected in a few hours of star pointing. The mount model was found to be stable over periods of weeks at a level of 10 arcseconds, the residual problems coming mostly from the tilt of the building on which the telescope sits. We have not yet interfaced active tilt measurement and correction, because experience with the SPIREX telescope on the AST/RO pier at the South Pole indicates that the pier is very much more stable than the building at Boston University. The radio beam offsets were determined by observations of IRC+10216.

The Local Oscillator Phase Lock Loop and Intermediate Frequency systems were reconfigured as the result of preliminary and only partially successful receiver tests made in 1993. Two receivers were mounted on the telescope: 1) the 230 GHz SIS waveguide receiver used in 1993 and 2) a 470 to 500 GHz quasi-optical SIS receiver constructed at the University of Illinois and installed on the telescope in August 1993. One receiver was used at a time, and the coude´ focus beam was switched between them by mounting one of two mirrors at the center of the optical table (see AST/RO Technical Memorandum #12, *ASTRO Optics Specifications*).

Observing tests were restricted to periods of good weather, because unlike the South Pole, Boston is not well sited for millimeter- and submillimeter-wave observing. We were able to carry out several weeks of observational tests at 230 GHz. At 490 GHz, the Sun was detectable for a few hours on two days in February. A period of particularly good weather lasting several days began on 27 February 1994. Several hundred spectra were obtained with the 230 GHz receiver; some of these spectra are without apparent flaw, aside from the presence of noise. These data were obtained by position switching between the source and a reference position a degree or so away. Calibration was done by measuring absorbers at room temperature and at liquid nitrogen temperatures placed between the receivers and the telescope. Sky opacity was estimated by comparing the noise power of the blank sky at the elevation of the source with the liquid nitrogen load, and applying a two-component atmospheric model to relate ambient temperature and sky temperature to atmospheric opacity. Receiver temperatures with the test 230 GHz receiver were typically 400 K SSB. Total equivalent system temperatures varied upwards from 1200 K, depending on the weather.

Figure 1 is the result of a 10 minute position switch on the galactic HII region W3, one of the first good spectra obtained with AST/RO. The spectrum shown is raw T_A^*, with no baseline removed. Figure 2 shows the result of a 6 minute observation of the molecular cloud SgrA, which is superposed on the galactic center. A first-order (linear) baseline has been removed, and the baseline residuals are acceptably small. Despite the high opacity of the atmosphere ($\tau \sim 0.8$) and low elevation of the source (el $\sim 19^o$), the data quality is high and the calibration is reasonable. There is channel-to-channel correlated noise which is a natural result of the overlap in the channels of the Acousto-Optical Spectrometer (AOS). In addition, there is some hint of a $\sim$ 30MHz baseline ripple, a problem which is much worse in other spectra. This problem results from a combination of two imperfections in the chain of intermediate frequency amplifiers and frequency converters: the cables are imperfectly matched, resulting in standing waves, and the gain stages are not stable, so that the mis-matched power changes in time and does not calibrate out. Both of these imperfections can be reduced by future modifications of the IF chain and reduction of the microphonic response of the receiver dewars. Figure 3 shows the CO J=2-1 spectrum toward the high velocity outflow source in Orion A. Again, only a first-order baseline has been removed. The broad line wings from the high velocity flow are easily seen, extending $75\,\mathrm{km\,s^{-1}}$ to either side of the line core. This source is small compared to the 3.3 arcminute (at 230 GHz) AST/RO beam, and its detection here demonstrates that the pointing of the radio beam is at least adequate.

During our observing tests, we learned of the detection of faint high latitude J=1-0 CO emission from the galactic molecular ring by Dame and Thaddeus (1994). We were able to reproduce this result in the J=2-1 line, as shown in Figure 4. This is a comparison of the Dame and Thaddeus spectrum at $l = 30^o$, $b = -3.2^o$ with the AST/RO spectrum at the same position. The spectra are consistent within the noise. Note that the local maxima in the two spectra fall at the same velocities. Both spectra show moderately strong emission at $71\,\mathrm{km\,s^{-1}}$, even though gas emitting at that velocity and position would have to be over 250 pc from the galactic plane. The emission at low velocities is confused because of emission in the reference positions of the AST/RO spectrum. The off-axis optics and clean beam of the AST/RO telescope make it very unlikely that this emission is sidelobe pickup from lower latitude material even though the galactic plane is only a few degrees away and very much brighter. If the calibration is correct, then the factor of two ratio in brightness between the J=1-0 and J=2-1 lines is an indication that this unusual gas is optically thin, an interesting result.

On 14 February 1994, the weather was sufficiently clear to allow the detection of the Sun at 490 GHz. The zenith opacity was, at times, as small as 6, as measured by a total power skydip procedure. The limb of the Sun was found, and the convolution of the beam and the limb of the Sun was consistent with a 1.6 arcminute beam, as expected.

These observing tests indicate that the AST/RO telescope is capable of acquiring high quality spectra at a wavelength near 1 millimeter, and can therefore be considered operational.

REFERENCES

Dame, T. M., and Thaddeus, P., 1994, Detection of a thick galactic disk in CO., *Ap. J.* (*Letters*), , submitted.