THE UNIVERSITY OF MICHIGAN

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DEPARTMENT OF ASTRONOMY
DEPARTMENT OF ELECTRICAL ENGINEERING

"SOME RESULTS ON THE USE OF A TUNNEL DIODE AMPLIFIER ON A RADIO ASTRONOMY RECEIVER"

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In December of 1962, a tunnel diode amplifier (TDA) was installed on the broadband radio astronomy receiver of The University of Michigan's 85-foot Radio Telescope. The TDA had the following characteristics:

Pass Band (1 db points)	7500 - 8500 mc
Noise Figure	5 db
Average Gain	10.8 db
Size	6" x 6" x 4" approximate

Although the gain of this unit is modest, it was selected on the following basis:

1. Low noise
2. Simplicity of operation
3. Reliability
4. Small size
5. Low cost.

These advantages permitted the TDA to be integrated into the receiver system by adding only provisions for a remote on-off switch, and inserting the TDA in the transmission line between the RF switch and the travelling wave tube (TWT) receiver.

Operation of the amplifier only requires the application of bias voltage to the tunnel diode. In this application, the bias is supplied by a mercury battery. The only servicing and adjustment of the TDA is a periodic replacement of the battery and perhaps an adjustment of the bias potentiometer. Normally, this adjustment is not required since the mercury battery has a fairly constant output voltage with time.

On the 85-foot radio telescope, the equipment is arranged in the following manner. The RF switch, comparison load, test signal and noise balancing circuits are located at the focus of the antenna. The modulated received signal is sent via waveguide to the TWT amplifiers which are mounted on the back of the reflecting surface. This arrangement is necessary since the TWT amplifiers, power supplies, and control circuits are too heavy and bulky to mount at the focus.

The initial installation of the TDA was in the TWT receiver, at the back of the antenna, directly ahead of the first low noise TWT. The following improvement was made:

Overall receiver noise temperature without the TDA	2900°K
Overall receiver noise temperature with the TDA	1700°K

This arrangement permitted removal of the TDA for testing, but yet it could be easily reinstalled for observations.

The final installation of the TDA is at the focus directly following the RF switch. This location gives an additional improvement in noise temperature by reducing the effect of the losses in the waveguide between the focus and the TWT receiver. After installation at the focus, the following improvement was realized.

Overall Receiver noise temperature without the TDA	2900°K
Overall Receiver noise temperature with TDA at the TWT Receiver	1700°K
Overall Receiver noise temperature with TDA at the Focus	1300°K

These noise temperatures include the contribution of the reference termination at ambient temperature. The frequency response of the TDA is shown in Figure 1.

Some results of observations using the TDA are shown in Figures 2, 3, and 4. Figure 2 is a drift curve of radio source Cygnus A. This source has a maximum antenna temperature of 17°K. The data was taken with a time constant of one second. This record demonstrates the short term stability of the system. Figure 3 is a drift curve of a weak radio source 3C353. This radio source has a maximum antenna temperature of 0.75°K and demonstrates the low noise level of the system. The time constant used in this observation was 10 seconds. Random fluctuations in this recording are on the order of 0.1°K. Prior to the installation of the TDA, this source was barely detectable with a single drift curve.

Figure 4 also demonstrates the high sensitivity of the system. This record is of a drift curve of the extremely distant and weak radio source 3C295. The maximum antenna temperature of this source is 0.15°K. The time constant used in this measurement was 10 seconds. Without the TDA, detection of this source would not be possible except by averaging several drift scans. Accurate measurement would have required averaging of many more drift scans.

No problems have been experienced with the TDA during the operating period of over a year. The short term gain stability appears to be excellent. The long term gain stability is dependent on the ambient temperature variations primarily. These effects are small and in this application are removed by the use of an Automatic Gain Control System.

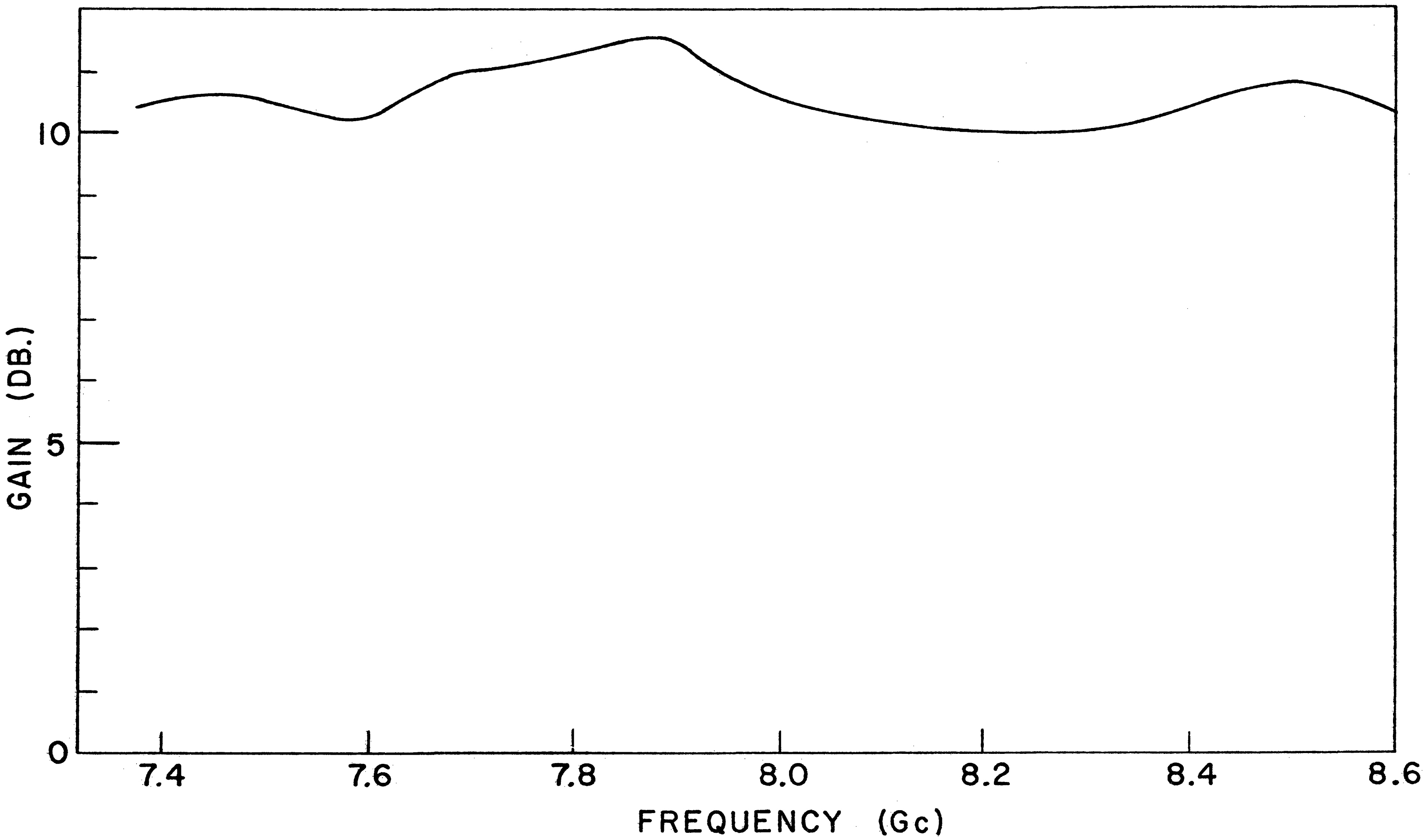

FIG. I. TUNNEL DIODE AMPLIFIER FREQUENCY RESPONSE.

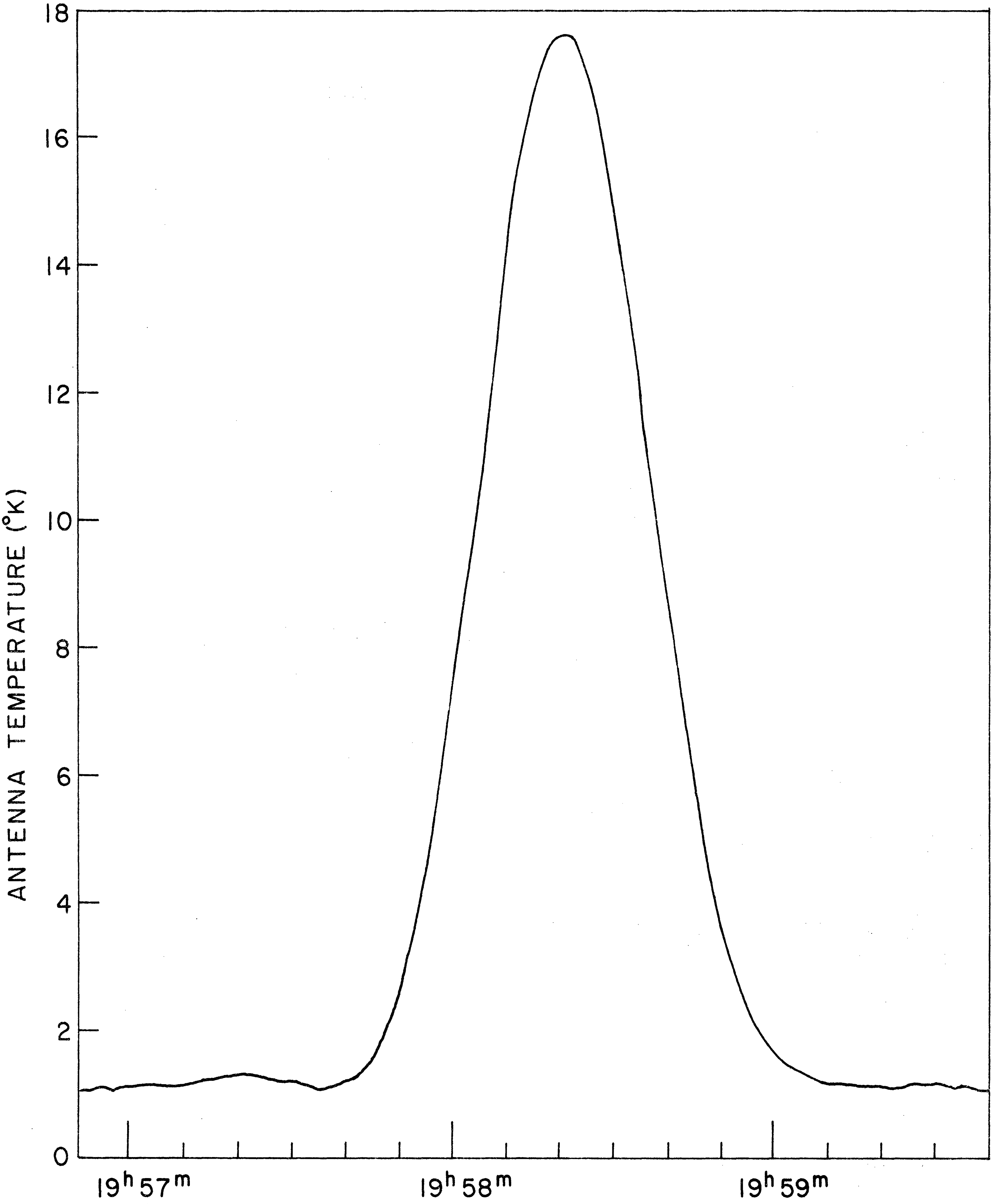

FIG. 2. CYGNUS A, 3C405, R.A. $19^h 58^m 12^s$, DEC. 40° 37.9', $\tau = 1^s$.

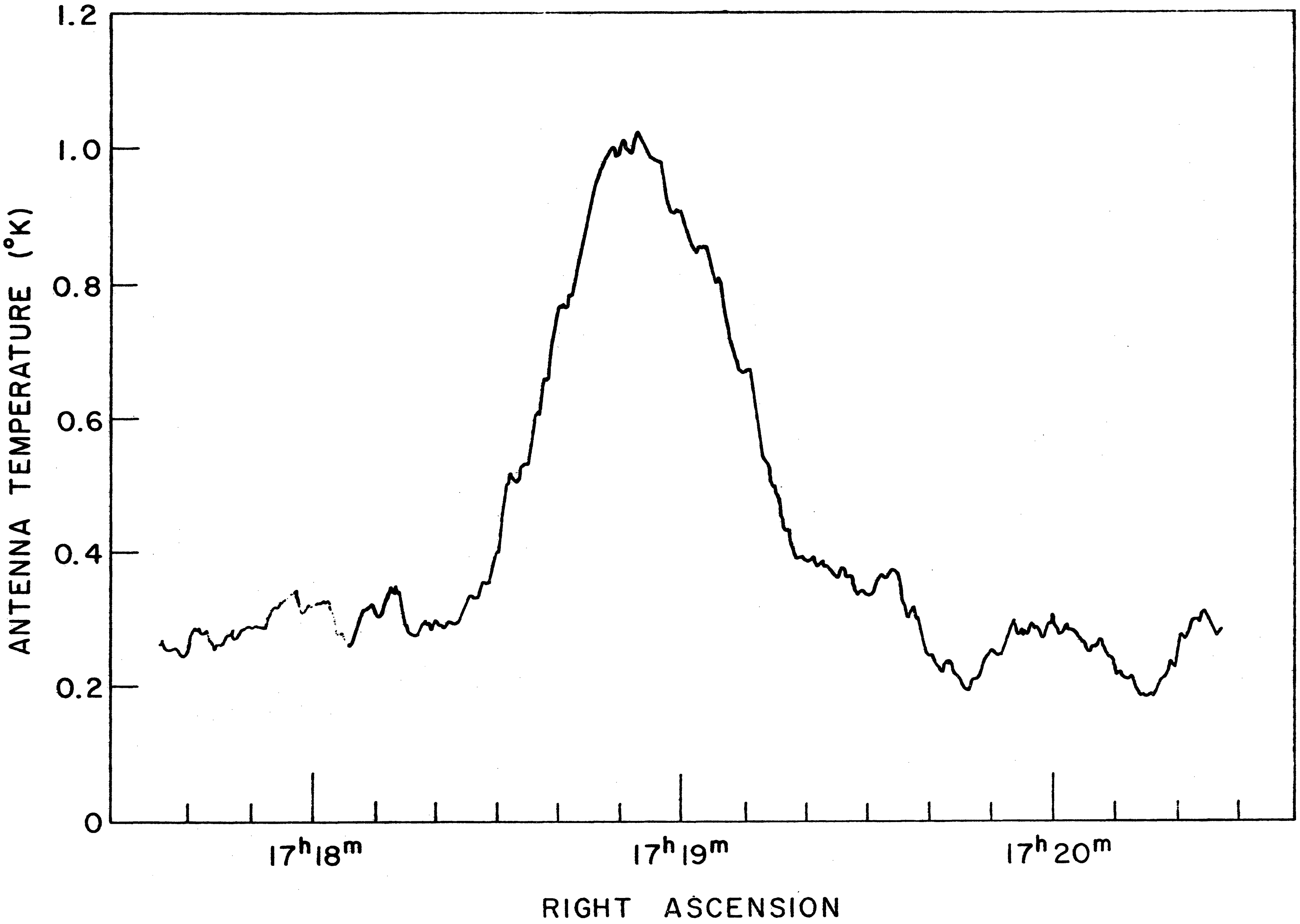

FIG. 3. 3C353, R.A. $17^h 18^m 39^s$, DEC. $-0° 56.3'$, $\tau = 10^s$

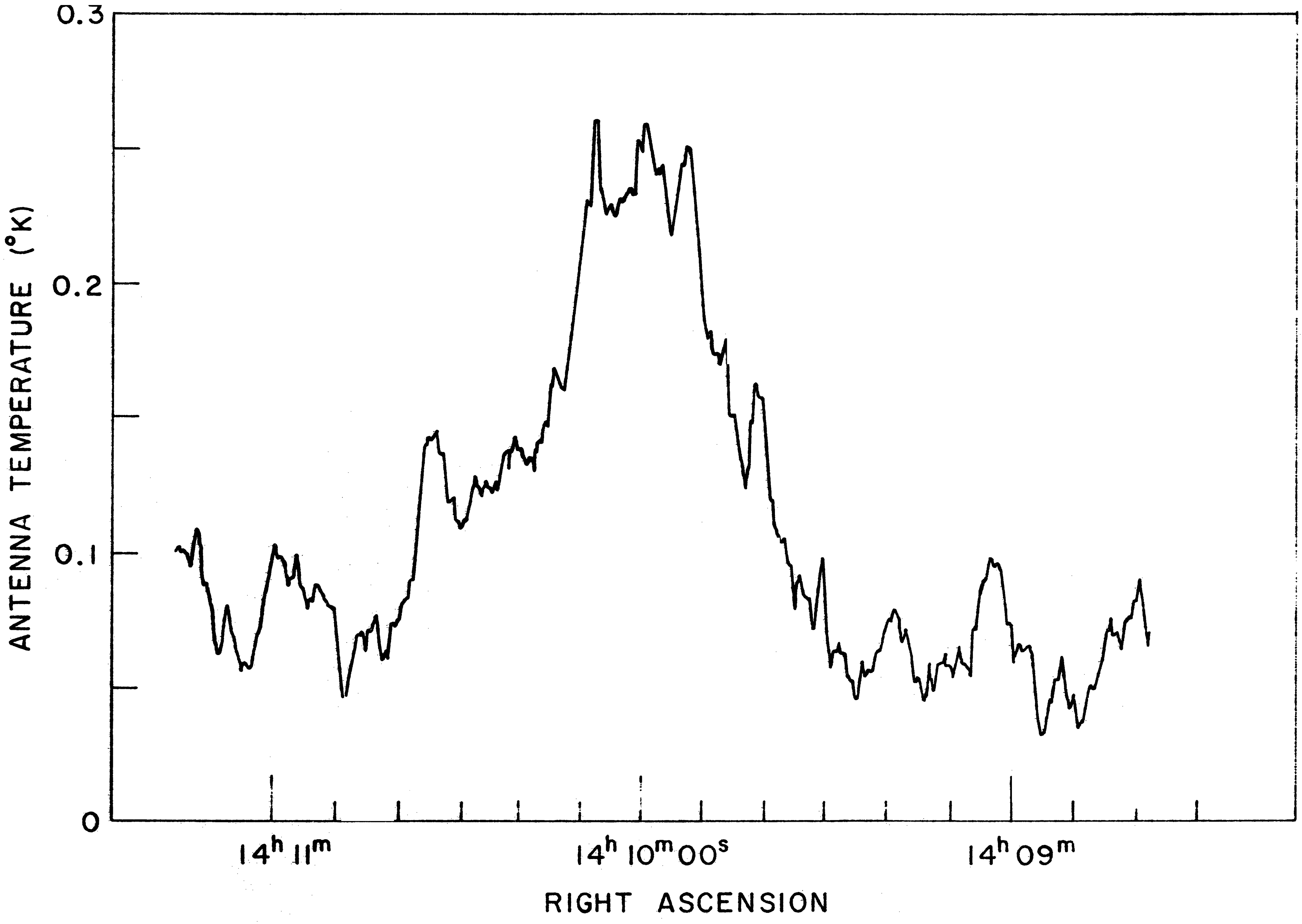

FIG. 4. 3C295, R.A. $14^h 10^m 01^s$, DEC. 55° 22.9', $\tau = 10^s$.