GBT Com. Memo 20

GBT X-band (9 GHz): Pointing Stability

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Abstract

The pointing stability of the GBT is evaluated by tracking the half-power point of 3C123 over a duration of 30 min offset in both azimuth and elevation during benign weather conditions. The *rms* variations of the telescope beam on the sky are on the order of $1''$, although peak-to-peak variations as large as $5''$ are present. A power spectrum analysis reveals natural frequency modes less than 0.5 Hz which are significantly lower than predicted by theory or measured by laser ranging and accelerometers.

1 Introduction

The pointing stability of the GBT is tested using the X-band receiver. The pointing stability is probed by tracking the half-power position of a point source. The brightness distribution of a point source is approximately a Gaussian. The maximum slope of a Gaussian occurs at the half-power position where variations in the system temperature are most sensitive. This procedure has been discussed in GBT Com. Memo 9 for observations at S-band (2 GHz). The observations and results are discussed in §2. The conclusions are in §3.

2 Observations and Results

2.1 Half-Power Point Test

The half-power point test provides a sensitive probe of how well the telescope's beam tracks a specified position with time. It therefore not only tests the pointing model but is also sensitive to problems in the focus tracking. For example, significant movements in the feed-arm should be detected. These observations were performed with the new focus trakcing

Table 1: Locked Rotor Frequencies†

Mode	Frequency (Hz)	Description
1	0.57	Translation along elevation axis
2	0.75	Coupled positive azimuth and positive elevation rotations
3	0.76	Coupled positive azimuth and negative elevation rotations
4	1.15	Second elevation rotation mode with positvie feed-arm and negative reflector x-axis rotation
5	1.19	Azimuth and cross-elevation rotation mode with positve elevation roating structure and negative alidade y-axis rotations
6	1.33	Azimuth rotation with some opposite y-axis rotation of feed-arm and reflector structures
7	1.65	Third elevation mode with feed-arm bending and alidade vertical translation
8	1.98	Forth elevation mode with reflector and elevation box structures and alidade vertical translations and some x-axis rotations

† Taken from Loral Tech. Memo 49.

model which included tilts of the sub-reflector (GBT Com. Memo 18), a refined model for refraction (GBT Com. Memo 16), and a new pointing model (GBT Com. Memo 17).

The pointing stability was measured on 2002 January 20 (project pnt_highgreg_10) by tracking the half-power position of 3C123 by offsetting in azimuth and elevation by half of the FWHM beamwidth ($0'.7$). Before each track the GO procedure *peak* was used to update the local pointing corrections (LPCs). Then the GO procedure *track* was used to track the half-power position for 30 min offset $0'.7$ in elevation and then for 30 min offset $0'.7$ in azimuth.

The results are summarized in Figures 1 and 2 where the antenna temperature and the wind speed are shown for the half-power point tracks offset in azimuth and elevation, respectively. Only the RCP channel is shown. Notice that the wind speed is typically less than 5 miles per hour during the entire period. Using Equation (2) of GBT Com. Memo 9, the antenna temperature is converted into arcsec on the sky using $T_o = 4.2$ (in units of $T_{\rm CAL}$), and $\Delta = 1'.4$. Figures 3 and 4 show the offset beam position as a function of time. The antenna elevation was $\sim 60\,^\circ$. An *rms* of $1''.3$ and $1''.0$ are determined for the offset position in azimuth and elevation, respectively. The peak-to-peak variations are as large as 5 arcsec. The *rms* variations in the offset position are about a factor of two smaller than previous measurements at S-band (GBT Com. Memo 9). This is probably due to (i) improvements in the focus tracking and pointing models; and (ii) the benign weather conditions.

Because the sample period was set to 0.15 seconds the fundamental modes of the feed-arm

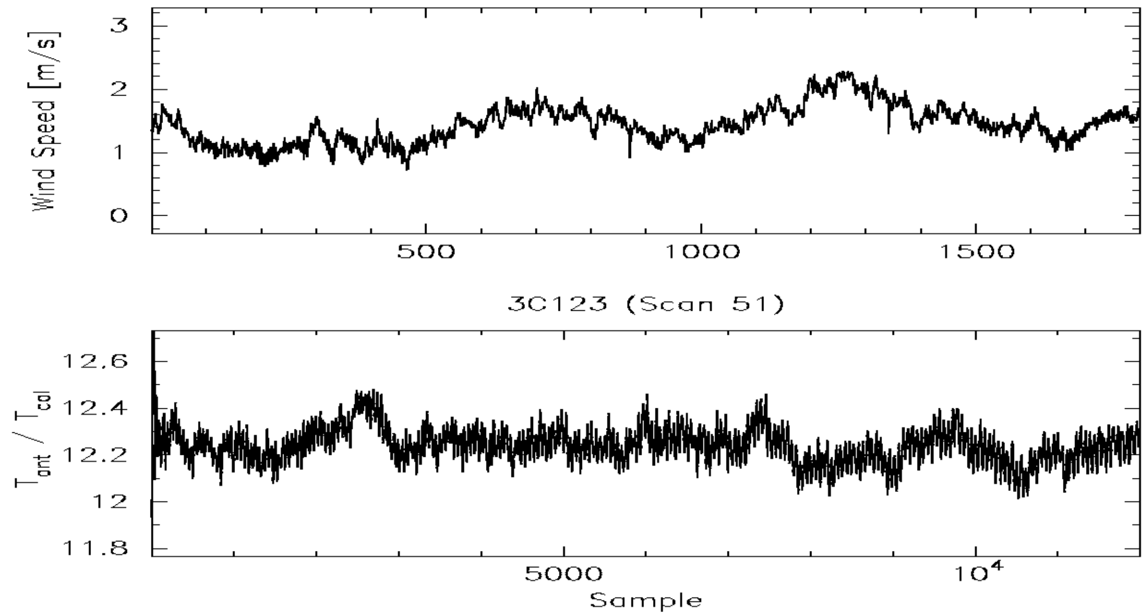

Figure 1: Half-power point track of 3C123 in azimuth. The antenna positions was offset $0\overset{\prime}{.}7$ in azimuth. The top panel plots the wind speed while the bottom panel plots the antenna temperature in units of $T_{\rm CAL}$. The sample period was 1 and 0.15 seconds for the weather station and digital continuum receiver, respectively, for a total time of 30 min.

can be analyzed. The predicted GBT modes are shown in Table 1 which is reproduced from Loral Tech. Memo 49. The results in Table 1 are based on a finite element analysis using the NISA II structural analysis code. The lowest natural frequency is 0.57 Hz.

Figures 5 and 6 show the power spectra for the azimuth and elevation series, respectively. The lower panels of each figure show an expanded scale. The modes measured in azimuth are 0.12, 0.63, and 0.85 Hz. The modes measured in elevation are 0.15, 0.30, and 1.14 Hz. Notice that most of the power is contained in modes which are at frequencies significantly lower than 0.5 Hz. The modes above 0.5 Hz probably correspond to the modes in Table 1.

Vibrations in the feed-arm were analyzed using laser ranging and accelerometers (GBT Memo 204). The lowest observed frequency was 0.7 Hz although the telescope was not yet complete and the total mass was smaller at that time. Also the telescope was not tracking but locked down. Do the modes below 0.5 Hz correspond to problems in the servo system?

3 Conclusion

Under benign weather conditions the *rms* variations of the telescope's beam is on the order of $1''$ with variations as large as $5''$. A power spectrum analysis reveals significant power in vibrational modes with frequencies less than 0.5 Hz.

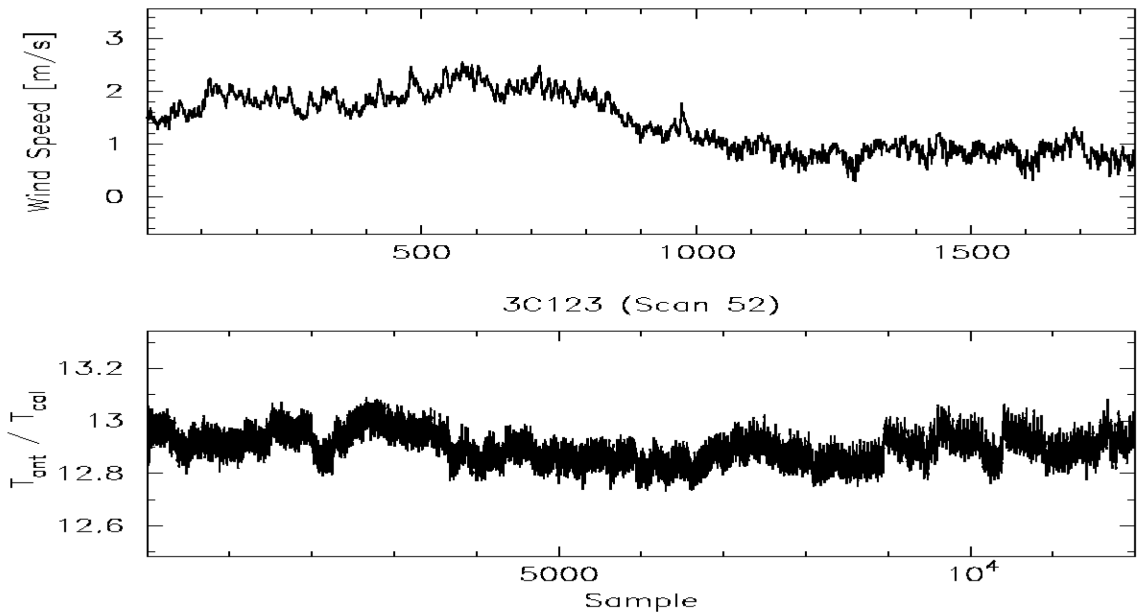

Figure 2: Half-power point track of 3C123 in elevation. The antenna positions was offset 0.′7 in azimuth. The top panel plots the wind speed while the bottom panel plots the antenna temperature in units of $T_{\rm CAL}$. The sample period was 1 and 0.15 seconds for the weather station and digital continuum receiver, respectively, for a total time of 30 min.

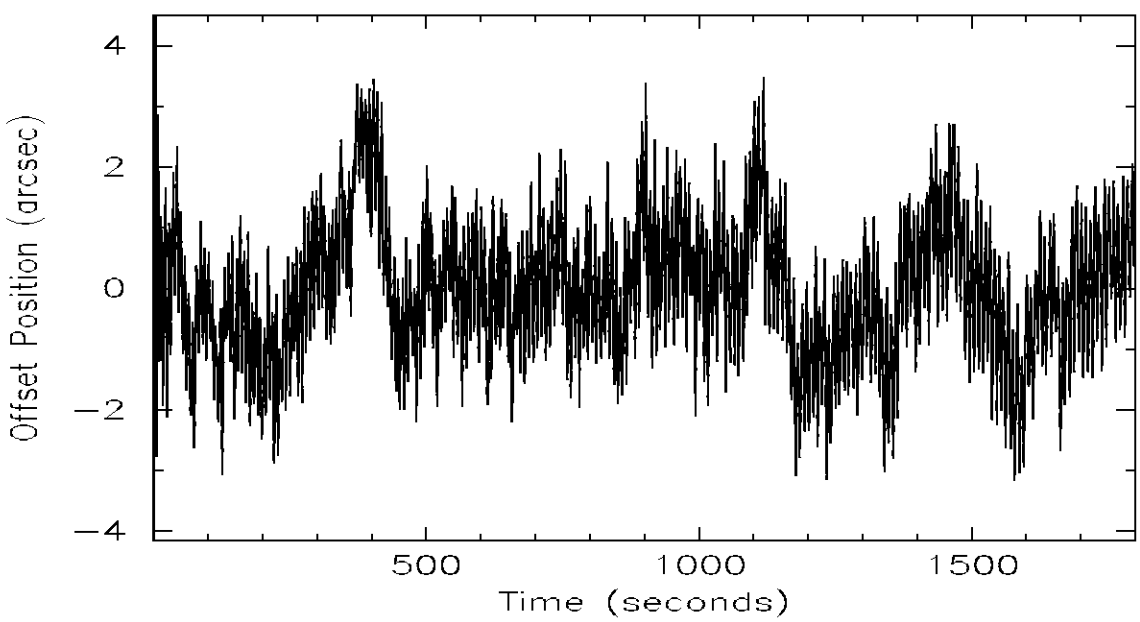

Figure 3: The offset position in azimuth of the beam in arcsec as a funtion of time.

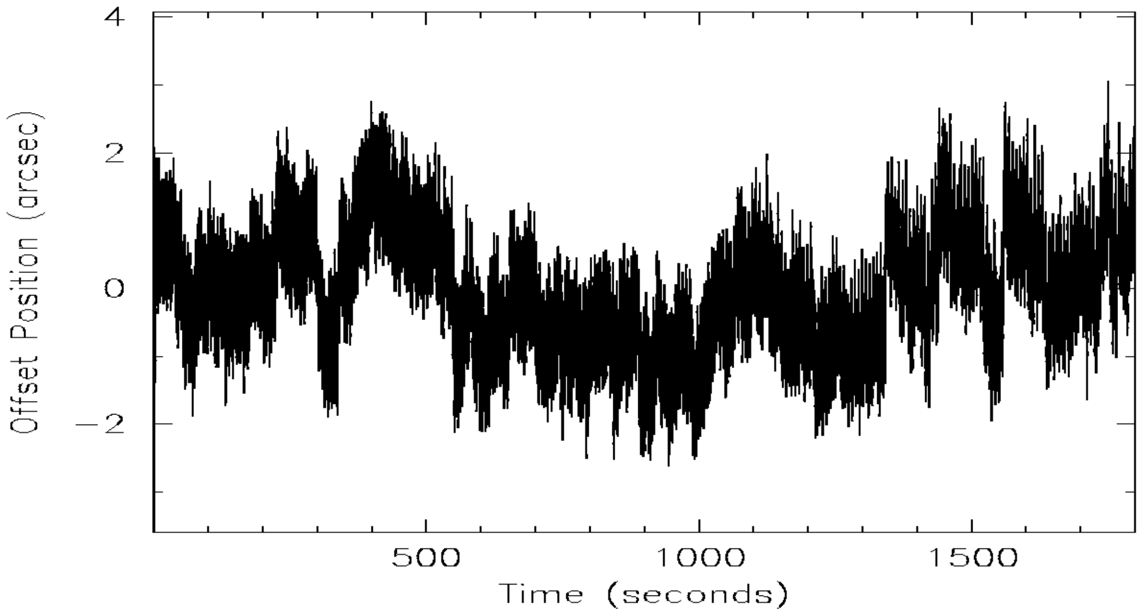

Figure 4: The offset position in elevation of the beam in arcsec as a funtion of time.

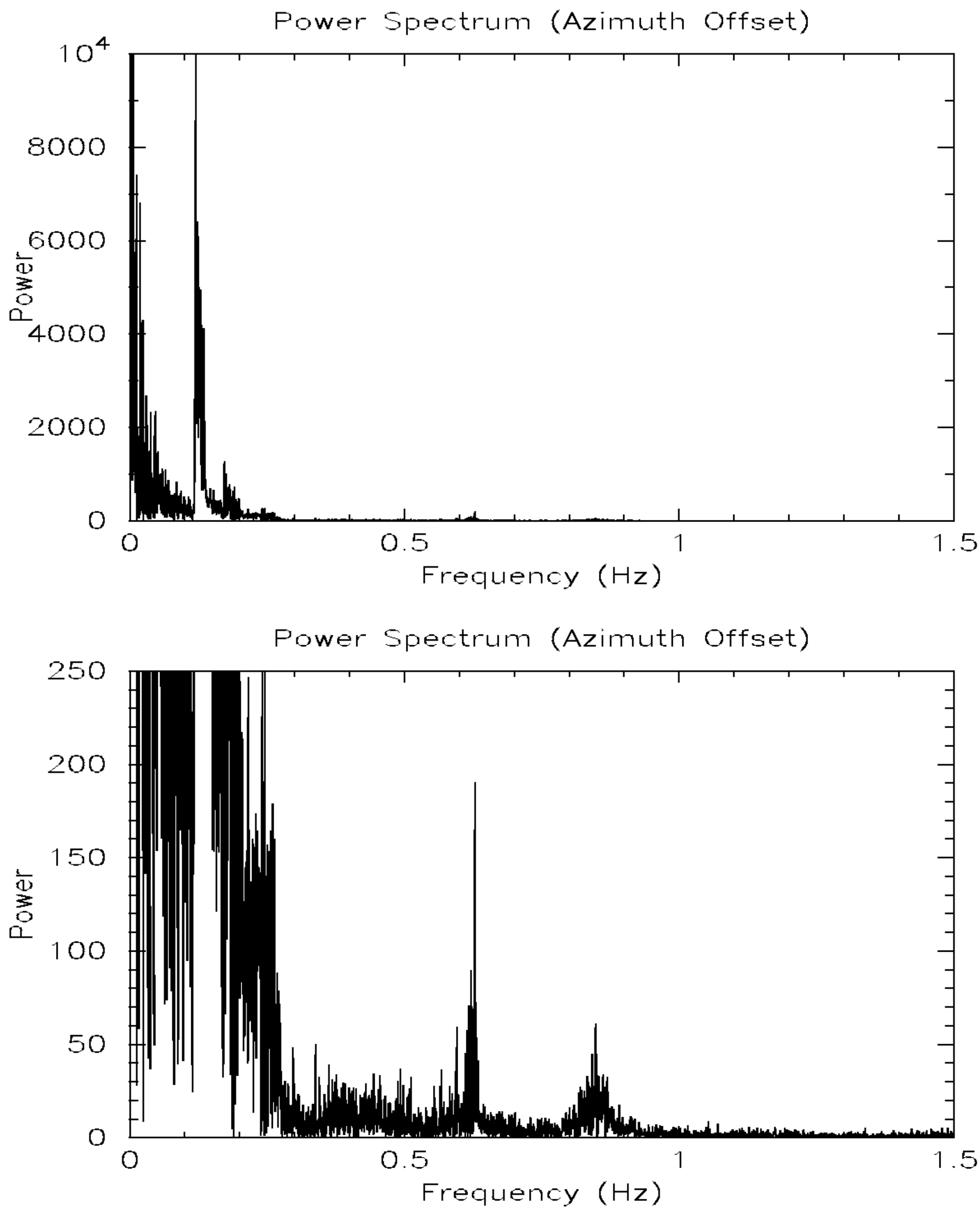

Figure 5: Power spectrum of the half-power point time series in azimuth. The upper and lower panels are the same data with different scales.

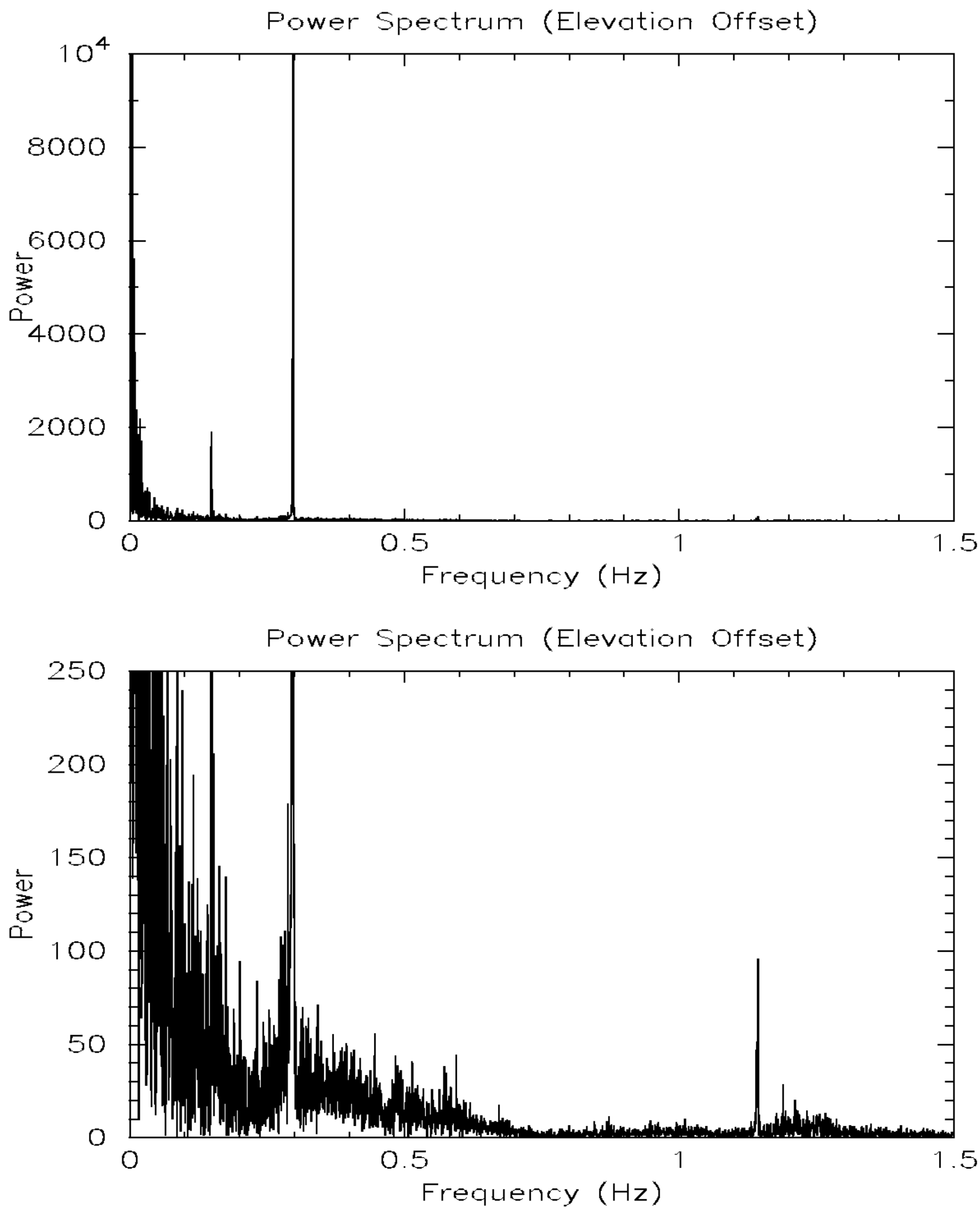

Figure 6: Power spectrum of the half-power point time series in elevation. The upper and lower panels are the same data with different scales.