Correlation Between Radar Observations Of Field Line Resonances And Discrete Oscillations In The Solar Wind Using Multitaper Methods

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Abstract

Three events where coherent oscillations in the solar wind are correlated with Pc5 field line resonance oscillations observed by SHARE, the SuperDARN radar at Sanae Antarctica, are analyzed using multitaper methods. The existence of coherent oscillations in the solar wind preceding the ULF pulsations is significant at better than the 95% confidence level. Estimates of the coherence between oscillations observed at WIND and ACE, $200R_E$ apart are significant at the 95% level or better. There is strong correlation between the Antarctic radar and solar wind observations. We conclude that on occasion coherent oscillations in the solar wind can drive ULF pulsations.

Summary

Several authors have reported correlation between coherent oscillations observed in the solar wind and ULF pulsations in the Pc5 band within the magnetosphere [1–7]. The existence of such correlations has been the subject of controversy and, indeed, the identification of coherent oscillations in the solar wind has been controversial. This paper reports the results of the comparison of HF radar observations of field line resonances with simultaneous observations of coherent solar wind observations by ACE and WIND, using the multitaper methods (MTM) of Thomson [8].

Radar data is taken from the SHARE radar at Sanae Antarctica. It consists of Doppler velocity data taken from a single beam as in the example shown in Figure 1. We consider this example as typical of several observed. At this time ACE was located near the solar libration point while WIND was much closer to the magnetosphere near $X\sim 30R_E$, $Y\sim -30R_E$, $Z\sim -10R_E$. Oscillations were observed in both the ACE and WIND data.

The multitaper method uses a set of orthogonal tapers (discrete prolate spheriodal sequences) to window the data. These supply essentially independent samples of the data from which statistical estimates of significance can be made. They also have the advantage that the signal is sampled throughout the time period rather than being tapered by a window such as a Hanning window.

Multitaper methods have been used to compare the observations of ACE and WIND in the solar wind and SHARE on the ground. The magnitude squared coherence found by such methods allows us to estimate the significance of coincidences between oscillation frequencies of parameters measured by the various instruments. For example Figure 2 shows the magnitude-squared coherence between oscillations in the x component of the solar wind velocity (towards the Sun) at ACE and WIND. The satellites are separated by about 200 Earth radii yet there is a correlation between the two oscillations near 2.1 and 2.5 mHz with a confidence level of better than 99.8%. Figure 3 shows the correlation between the same parameter at ACE and the Doppler velocity in beam 4 of SHARE. There is strong correlation at 2.1mHz – better than 99% - but not so strong at the other frequencies. On the other hand the radar oscillations at 2.6 and 2.9 mHz show strong correlations with the corresponding oscillations in the ACE density data. The other events are discussed and show similar behavior.

We conclude that in some circumstances there is strong evidence that Pc5 field line resonances can be excited by coherent oscillations at the same frequency in the solar wind.

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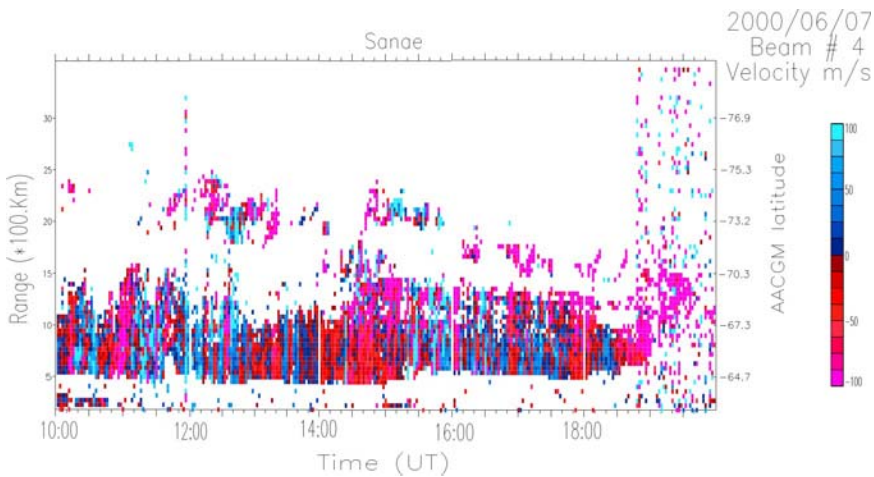

Figure 1. Doppler Velocity in Beam 4 of Sanae radar on June 7, 2000

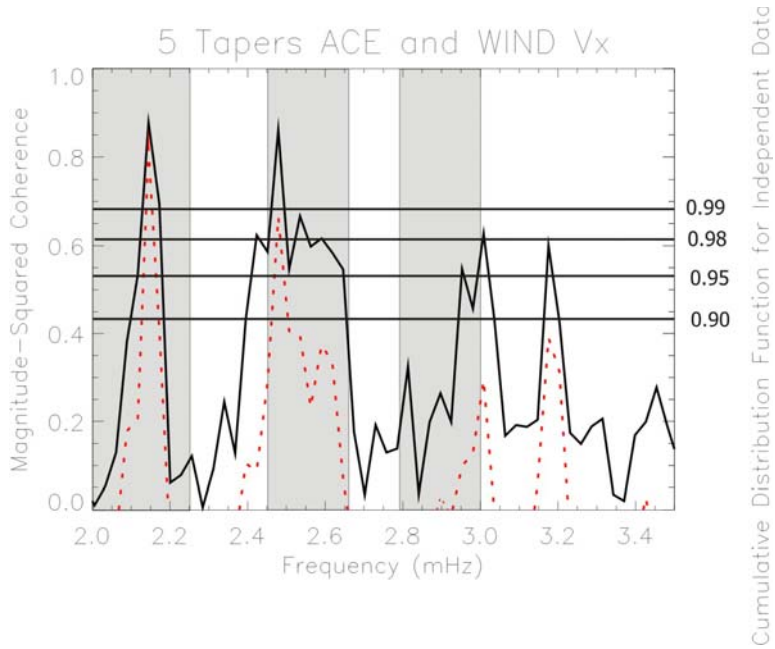

Figure 2. Magnitude squared coherence between ACE Vx and WIND Vx; June 7 2000.

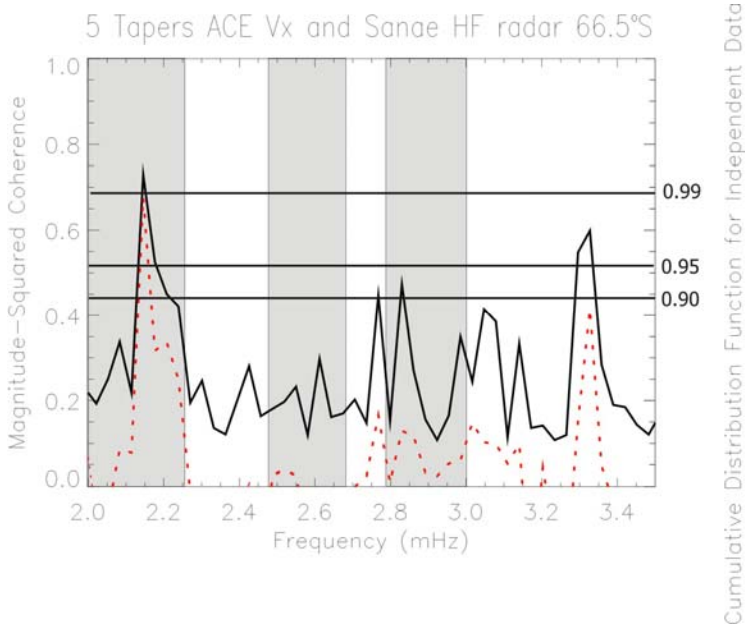

Figure 3. Magnitude squared coherence between ACE Vx and the Doppler velocity in beam 4 of the SHARE radar