Passive Radar Frequency Domain Interferometry for Observation of fine range structure in Meteor Trails and Auroral Electrojet Irregularities

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VHF and UHF commercial broadcasts provide substantial illumination of some geophysical phenomena which scatter meter scale radio waves. The illuminating waveforms are not selected for remote sensing applications. However waveforms that encode information in a spectrum-efficient way serendipitously offer essentially the same function and performance as dedicated radar waveforms, if sufficient computational resources can be brought to bear, and certain logistical issues are addressed.

Although it is not possible to select the waveforms broadcast, it is possible to impose a variety of radar techniques "after the fact." For example, we have successfully employed interferometry to provide very fine azimuth resolution, resulting in range and azimuth resolution of 1.5 km and 2 km, respectively. Since we retain detailed records of both the transmitted and received waveforms, and since the transmitted waveforms (usually) fill their spectral assignment, these techniques can be applied whenever they are conceived, months or years after the data were acquired. In a recent work, we showed that the transmitters could be effectively "turned off" to bypass the occasions in which the self-ambiguity of the transmitted signal was poor.

In this report we present an extension of the frequency-domain interferometry (FDI) technique to passive radar observations of FM broadcasts illuminating auroral electrojet irregularities and meteor trails. FDI achieves very fine range resolution of compact, underspread targets by carefully comparing the phase of echoes of somewhat different transmitter frequencies. In conventional radars this is achieved by sequentially transmitting two (or more) simple coherent pulses, each with its own frequency, and then estimating the phase and correlation function through some technique such as the normalized cross spectrum.

In conventional FDI approaches only a single freuency is transmitted at a time. This is done for many good reasons, including simplicity as well as transmitters which (usually) cannot be amplitude modulated (the sum of two sines of differing frequency necessarily lead to amplitude modulation).

In a passive radar, the spectrum is essentially filled, and it is possible to sequester the spectrum very effeciently through digital signal processing. As a practical matter some transmitter power (and sensitivity) will be lost. Nevertheless, this mode will permit discovery of compact scatterers in range whose size is smaller than that which can be resolved naturally. The technique is clearly applicable to meteor trails, however it should also be useful for auroral electrojet studies. Very high range resolution studies at the Jicamarca Radar Observatory have shown that meter-scale structure exists at very small spatial scales. With very large data sets, this technique may also permit estimation of the slope of spatial power spectrum of the irregularities.