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PROPERTIES OF AKR FROM AN INTERFEROMETER ANALYSIS OF THE ISEE-1 AND -2 PLASMA WAVE DATA

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ABSTRACT

Both ISEE-1 and -2 are equipped with identical wide-band analog plasma wave receivers which makes long baseline interferometry possible. A cross-correlation of the received signals from each spacecraft during periods of intense Auroral Kilometric Radiation (AKR) provides information on the source size of AKR. From the magnitude of the cross-correlation coefficient, measured over baselines from 40 Km to 8000 Km, an upper limit to the statistical source size can be determined. Thirty-five AKR events at 125 kHz are being analyzed. Preliminary results indicate that the apparent source sizes are smaller than .1 Re.

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1.0 INTRODUCTION

Over the last few years there has been considerable interest in Auroral Kilometric Radiation (AKR). The sporadic nature of AKR has made it difficult to study the instantaneous features of the bursts. In the past, most studies of AKR have averaged large quantities of data to determine properties such as the average source location of AKR. The instantaneous source size of AKR is of theoretical interest since it may shed some light on the possible generation mechanisms of the bursts. The interferometer method being utilized offers the possibility to obtain an absolute statistical source size and an instantaneous relative source size for AKR. The work described below was carried out during the grant period. Results will constitute a part of a Ph.D. thesis for M. Baumback.

2.0 DESCRIPTION OF WORK

Both ISEE-1 and -2 are equipped with identical wide-band analog plasma wave receivers. The receivers are single-sideband single-conversion receivers. In each receiver a local oscillator beats a 10 kHz segment of the wave spectrum down to the range of 0 to 10 kHz and phase modulates an analog transmitter. The transmitted signal is demodulated at the telemetry station and recorded on adjacent tracks on a tape. Both spacecraft are in nearly identical orbits, with the spacecraft separations controllable. It is possible to use both spacecraft as a very long baseline interferometer with a variable baseline length. From the magnitude of the cross-correlation coefficient between the two received signals the upper limit to the source size can be determined.

2.1 Processing Scheme

After a prospective AKR event has been identified from a search of the ISEE-1 and -2 digital spectrum plots, the wide-band analog tapes from both spacecraft are processed. The wide-band data is first processed with a Federal Scientific spectrum analyzer, producing two types of plots on 70 mm film. The first type of output is a spectral plot of data from each spacecraft. The top two panels of Figure 1 are spectograms of this type. The top panel shows 80 seconds of ISEE-2 data from June 12, 1978 centered about 1725 UT. The second panel shows 80 seconds of ISEE-1 data from the same time period. Approximately 250 hours of ISEE-1 and-2 analog data have been processed to produce spectral plots of this type. Events for further processing are chosen by searching these wide-band spectral plots for intense, structurally simple bursts which are received by both spacecraft. The magnitude of the correlation coefficient is reduced when the signal-to-noise ratio is poor; corrections for a poor signal-to-noise ratio introduce uncertainty in the calculation of the source size. The correlation of spatially separated multiple bursts occurring simultaneously gives a result which is difficult, if not impossible, to interpret. To further increase the signal-to-noise ratio, bursts are chosen which are relatively constant in frequency, allowing the signal to be filtered over a narrow bandwidth containing the burst.

The second type of output from the Federal Scientific spectrum analyzer is a correlogram. The third and fourth panels of Figure 1 display plots of this type. The 10 kHz bandwidth is separated into 256 frequency channels, each with a 40 Hz bandwidth--a correlation is performed on each of the frequency channels. The third panel of Figure 1 displays the out-of-phase components of the ISEE-1 and -2 signals, while panel 4 of Figure 1 displays the in-phase components of the signals. Upon careful inspection of the correlograms one notices some areas where there are nearly vertical striations in the display (especially from 1724:45 to 1724:50 UT.) These striations are caused primarily by a small frequency difference between the local oscillators in each of the wide-band receivers. The repetition rate of the striations is approximately at this local oscillator frequency difference. Since each spacecraft is located in a different position, the propagation time of the signals from the AKR source region to the spacecraft and from the spacecraft to the telemetry station will be different. To maximize the correlation coefficient, the delay of the signals must be adjusted to compensate for any delays introduced during reception and recording processes. Delays between the two signals may also be introduced by other causes such as tape recorder head misalignment. Thus calculating the correct delay is not as simple as just computing the propagation delays, since the delay may be different for different tapes from the same telemetry station. From the slope of the striations in the correlogram it is possible to calculate the delay necessary to maximize the correlation coefficient.

An analog correlator is used to perform the final correlations. The output from each tape recorder channel containing the ISEE-1 and -2 signals is bandpass filtered so that it contains only the desired frequency range. The signals are then passed through a delay network with delays of up to ± 10.0 ms in increments of 1 microsecond. The outputs of the delay network are phase shifted to generate a quadrature signal and then are correlated with a one-bit correlator. Figure 2 shows the analog processing flowchart. The output of the correlator is recorded on a two channel strip chart recorder. One channel of the strip chart contains a correlation of the in-phase ISEE-1 and -2 signals (identified as SIN1 X SIN2 in Figure 1) and the other channel contains a correlation of the ISEE-1 signal with the quadrature phase shifted ISEE-2 signal (identified as SIN1 X COS2 in Figure 1). To determine the exact delay necessary to maximize the correlation each burst is processed with a series of different delays until the maximum correlation is found. Thirty-five events have been processed to find the correct delay for maximum correlation. Panel 5 in Figure 1 displays the correlation of the ISEE-1 and 2 signals over the full 10 kHz bandwidth. The uncorrected correlation is approximately 50%. Panel 6 displays the correlation of the same event for the 2 kHz bandwidth containing the event. The better signal-to-noise ratio achieved by narrowing the bandwidth increases the uncorrected correlation to 75%.

2.2 Signal-to-Noise Corrections

To accurately determine the source size of the AKR bursts the correlations must be corrected for the signal-to-noise ratios. Initially the signal-to-noise ratio was estimated by measuring the amplitude of the AKR burst over a narrow bandwidth containing only the burst and comparing that amplitude to the amplitude of the signal over a comparable bandwidth but at a frequency not containing the burst. This method assumes that the noise is roughly constant over the measured frequency range. Thus the measured noise should be representative of the actual noise at the frequency of the burst. However this method proved to not work satisfactorily. A new method to accurately measure the noise is currently being developed. With this method, the output of a Federal Scientific spectrum analyzer will be digitized and integrated over the actual frequency range that the correlation is performed.

2.3 Preliminary Results

Eight events at three spacecraft separations have been completely analyzed. For a baseline of 143 Km the average corrected correlation of three events is 84% ± 12%. For a baseline of 498 Km the average corrected correlation of three events is 76% ± 6%. For a baseline of 598 Km the average corrected correlation of two events is 55% ± 15%. The approximate error in the magnitude of the correlation coefficients is 6% to 15%. Figure 3 displays the correlation for these events as a function of baseline separation. The new method of correcting the correlation coefficients will reduce the errors in the present corrected data. The correlation coefficients of the eight events analyzed indicate that the source size of the AKR bursts is less than .1 Re, with the assumption of a spatially distributed gaussian source.

3.0 PAPERS PRESENTED AND WORKS IN PROGRESS

Papers presented:

U.R.S.I. XXth General Assembly
August 10, 1981
Washington D. C.

Long baseline interferometer measurements of auroral kilometric radiation, M. M. Baumback and S.D. Shawhan

Works in progress:

Ph.D. Thesis
University of Iowa
Iowa City, Iowa 52242

Properties of Auroral Kilometric Radiation from an Interferometer Analysis of ISEE-1 and -2 Plasma Wave Data, M. M. Baumback

4.0 PERSONNEL SUPPORTED

Mark M. Baumback	Research Assistant	15 months 50% time
Ron J. Pieper	Research Assistant	8 months 50% time
Stanley D. Shawhan	Professor	(No Salary)

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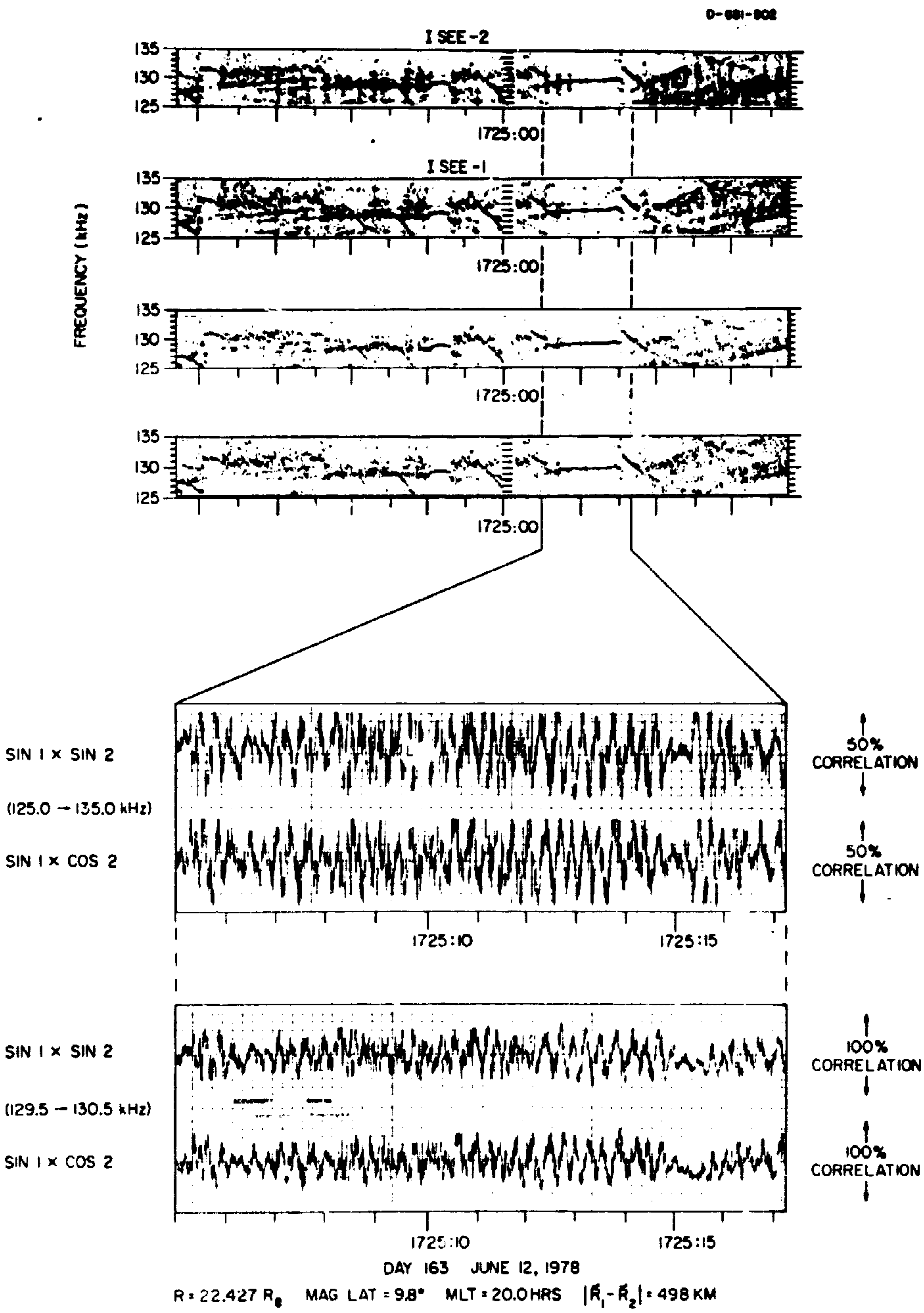

Fig. 1

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ISEE GROUND PROCESSING SCHEME

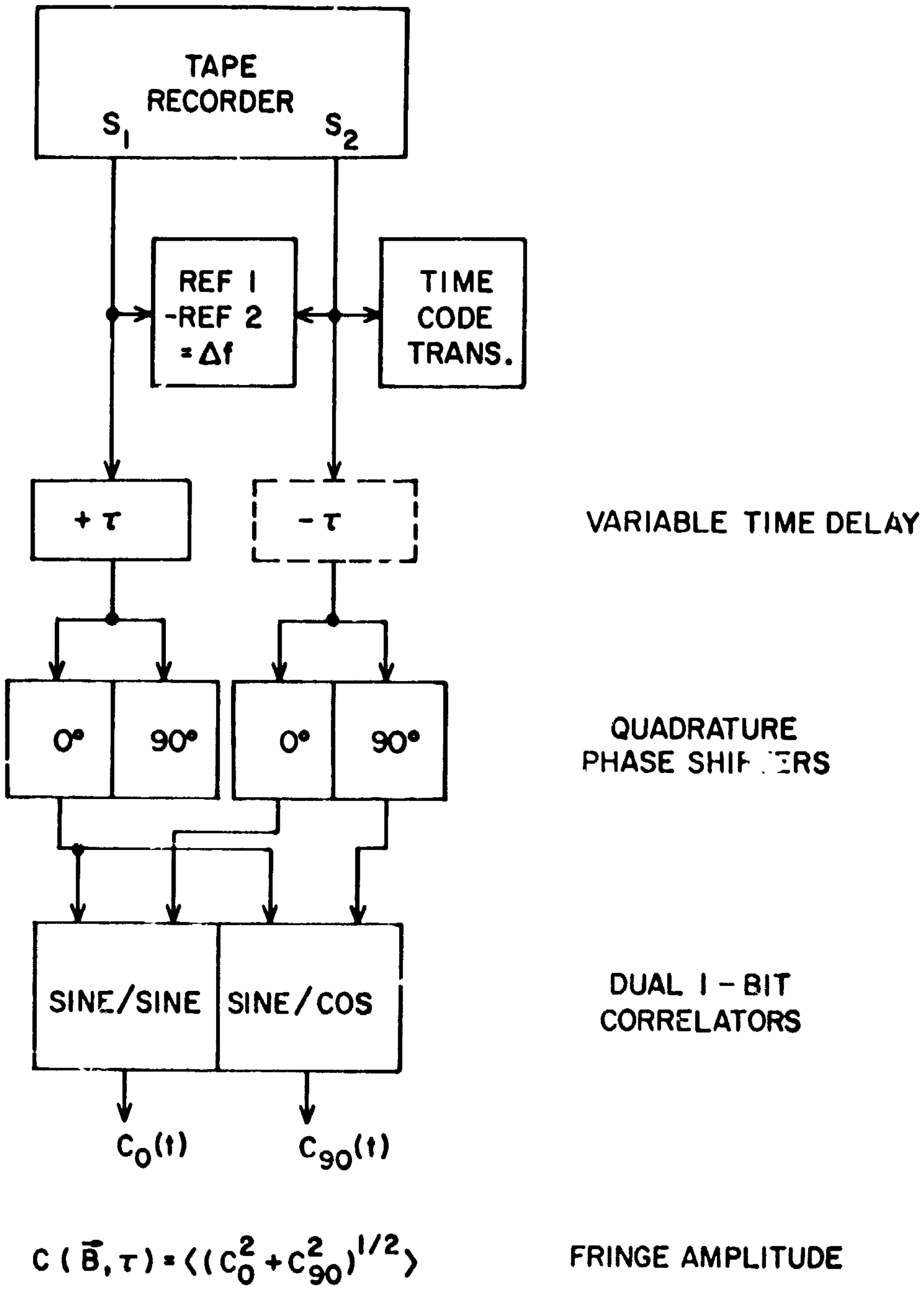

Fig. 2

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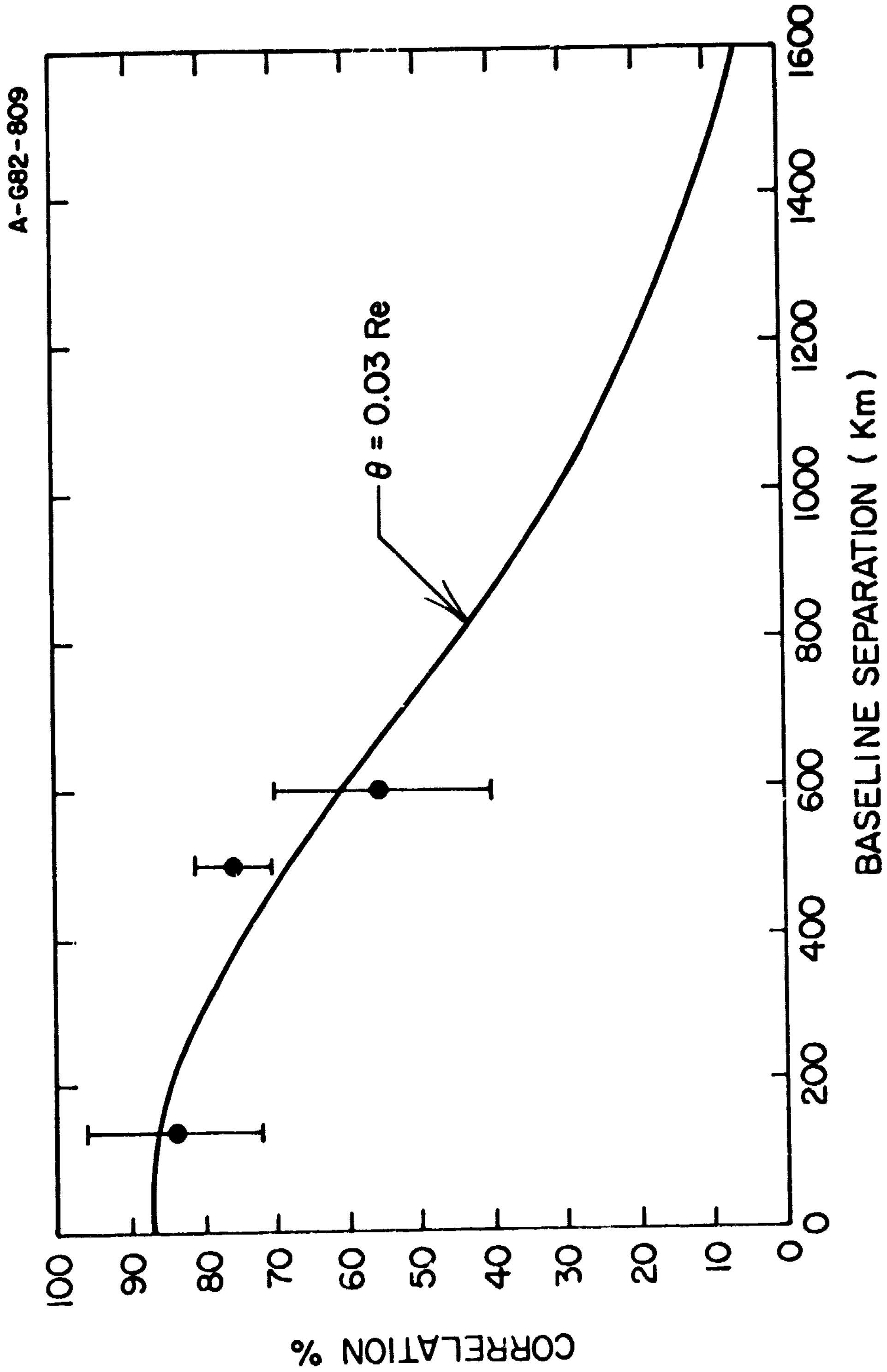

Fig. 3