Final Report

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Reduction and Analysis of Magnetometer Data from Mariners 4 and 5

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The work supported under this grant is the analysis of data obtained with the Mariner 4 and Mariner 5 magnetometers.

In our recent studies of data from the Mariner 4 and Mariner 5 magnetometers we have found evidence that during the flights of Mariners 4 and 5, negative (toward the sun) polarity dominated at latitudes above the solar equatorial plane and positive polarity dominated at latitudes below this plane (Rosenberg and Coleman, 1969; Rosenberg, 1970a). A subsequent check of data taken with other spacecraft during 1964 through 1967 provided additional evidence of this effect. We suggested that the dominant polarity of the interplanetary magnetic field follows the hemisphere-dependent dipolar field of the sun. Thus, the photospheric dipolar field may be an important source of the interplanetary magnetic field, especially at quiet times. We also suggested that one effect of high northern activity near the solar maximum in late 1968 and 1969 may be to move the layer that separates the two dominant polarity regions to a position southward of the solar equatorial plane.

We have also found that, for an interplanetary magnetic field of a given polarity, the north-south component, B_θ, has a nonzero mean value (Coleman and Rosenberg, 1971; Rosenberg et al., 1971) in regions above and below the solar equatorial plane. For a field of outward (+) polarity, the mean value $\langle B_\theta \rangle$ is less than zero above the solar equatorial plane and greater than zero below this plane (27-day means were used). The magnitude of $\langle B_\theta \rangle$ apparently increases with angular separation from the equatorial

plane. The sign of $\langle B_\theta \rangle$ reverses for "towards the sun" polarity.

In work related to our studies of the latitude-dependence of the interplanetary magnetic field, Hundhausen has found, from Vela satellite plasma data from early 1965 to late 1967, that the magnitudes of the solar wind velocity and density have definite heliographic latitude dependences. Thus, there is a systematic difference between the magnitudes observed near $\theta = 0°$ and those observed at higher northern and southern heliographic latitudes to $\pm 7.3°$ (a six-month effect). Starting in very late 1967 Hundhausen reports that the velocity latitude dependence disappeared as active, higher velocity midlatitude streams with greater pressure pushed themselves and the streams below them toward the near equatorial regions in space. He noted that this time corresponded to the apparent change in our sinusoidal polarity pattern. His findings near solar maximum tend to support our 1968-9 interpretations in terms of non-radial flow.

A third phase of our work involves a study of the behavior of the spiral angle. If one expresses the magnetic field $\vec{B}$ and the solar wind velocity $\vec{V}$ in the right-handed, solar equatorial coordinate system with unit vectors $\hat{r}$, $\hat{\theta}$, and $\hat{\phi}$, the tangent of the spiral angle, $\tan \alpha_B = -B_\phi / B_r$, is given by the Parker model as $\tan \alpha_p = (\Omega r \sin \theta)/V_r$, where Ω is the sun's angular velocity and r is the spacecraft-sun distance. The results of the observations made with Mariners 2, 4, and 5 are that at quiet periods of low solar activity, i.e., when "slow" solar wind streams dominate the flow, $\tan \alpha_B > \tan \alpha_p$; and for disturbed periods of high solar activity, i.e., when "fast" solar wind

streams dominate, $\tan \alpha_B > \tan \alpha_p$ (Rosenberg, 1970b). The intervals of time during which these coherent deviations occur ranged in length from 3 days to 27 days and more.

At the California Institute of Technology, the magnetic field due to sources on the Mariner 5 spacecraft itself was removed from the magnetometer data using a method developed by Professor Leverett Davis, Jr. of CIT and Dr. Edward J. Smith of JPL. This method makes use of rotational discontinuities and/or Alfven waves in the interplanetary medium. We developed a general computer program (Rosenberg, 1971) that will determine the spacecraft field by the Davis-Smith method from the magnetic field data from any interplanetary spacecraft. The program is entirely automatic. Iterations are performed and optimization techniques are used to select the best values. The results along with running plots of the changing spacecraft field are printed out online. The program saves many man hours and can be used to analyze many months or years of data inexpensively.

We made a detailed study of the radial dependence (i.e., with distance from the sun) of the field components, the magnitude and the power spectra using the interplanetary magnetic field measurements taken with Mariner 4 (Coleman et al., 1969) and Mariner 5. Using a time series based on gaussian normalized random data, we also analyzed the effect of averaging harmonic components (the Fourier coefficients) in a band for power spectral estimates and the effect of differencing of the time series [Xi(t) to Xi(t) - Xi - 1(t)] on the shape of the recolored spectra. At low frequencies we found that band averaging causes the slope of the autospectra power density to be steepened when it should

not be. Differencing corrects this and some other improper effects at high frequencies, too.

Publications

The research discussed in the following papers was supported wholly or in part with funds from this grant:

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