RADIO DIAGNOSTICS OF THE INTERPLANETARY MEDIUM

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ABSTRACT

The practice of using radio waves for investigations of the solar wind and corona, which began with interplanetary scintillation (IPS) observations of natural radio sources, has expanded significantly in the past few decades by the advent of radio sounding with narrowband spacecraft signals. In addition to the amplitude fluctations of IPS measurements, radiometric parameters such as center frequency, linewidth and polarization of spacecraft signals can also be used to infer characteristics of the propagation medium. This paper describes the methodology of radio sounding investigations and summarizes some conclusions drawn about the interplanetary medium from analyses of these parameters.

INTRODUCTION

Radio remote sensing of natural sources [1] and interplanetary spacecraft [2] has been one technique available for bridging the observational gap between the optically active inner corona and *in situ* measurements on spacecraft in the still largely unexplored inner heliosphere (closest solar approach: 62 $R_\odot$ by the *Helios* probes).

RADIO DIAGNOSTIC METHODS AND MEASUREABLES

The characteristic signal parameters used for deep space radio communcation are altered during their propagation through the magnetically biased plasma of the interplanetary medium. The signals are typically recorded at tracking stations using receivers similar to the narrowband autocorrelators employed for radio astronomical observations. The received downlink can be either transponded from an established uplink signal in a so-called "two-way coherent" mode, or generated on-board the spacecraft ("one-way" mode). In the latter case it is advantageous to implement an ultrastable oscillator (present day USO capability: $\delta f/f \simeq 10^{-15}$) in order to reduce the instrumental noise for detection of tiny phase variations in the propagation medium.

Changes of the carrier signal's group and phase velocity on time scales from milliseconds to days are used to determine the 3-D *electron density distribution* of circumsolar space and its *spatial fluctuation spectrum*. Another quantity of interest is the *solar wind velocity*, which has been measured in its region of acceleration using various different methods [3,4]. These studies have clearly shown the different acceleration profiles of fast and slow solar wind streams and their redistribution over the solar surface during the course of the solar cycle.

Faraday rotation (FR) measurements, highlighted in this work, exploit signal polarization to infer properties of the backgound and fluctuating *magnetic field* of the corona [5]. The time scales of FR variations, in analogy with the other signal parameters, provide information on various physical phenomena: (a) slow rise and fall associated with the moving radio ray path and rotation of the quasi-static corona; (b) ubiquitous random oscillations with larger fluctuations at smaller solar distances, probably caused by coronal Alfvén waves; (c) occasional jumps in the polarization angle caused by transient events such as coronal mass ejections.

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