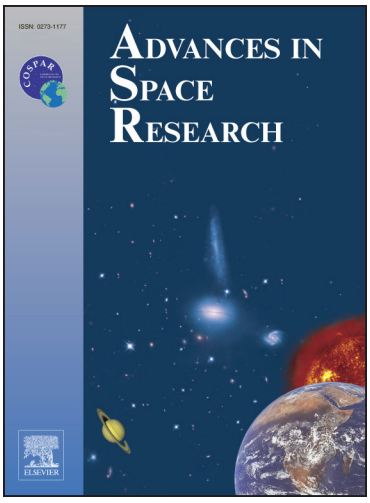

Radio Sounding of the Solar Wind Acceleration Region with Spacecraft Signals.

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PII: S0273-1177(17)30791-3
DOI: https://doi.org/10.1016/j.asr.2017.10.052
Reference: JASR 13484

To appear in: *Advances in Space Research*

Received Date: 5 April 2017
Revised Date: 14 August 2017
Accepted Date: 30 October 2017

Please cite this article as: Yakovlev, O.I., Pisanko, Y.V., Radio Sounding of the Solar Wind Acceleration Region with Spacecraft Signals., *Advances in Space Research* (2017), doi: https://doi.org/10.1016/j.asr.2017.10.052

Radio Sounding of the Solar Wind Acceleration Region with Spacecraft Signals.

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Abstract

Data from coronal radio-sounding experiments carried out on various interplanetary spacecraft are used to derive the empirical radial dependence of solar wind velocity and density at heliocentric distances from 3 to 60 solar radii for heliolatitudes below 60^o and for low solar activity. The radial dependencies of solar wind power and acceleration are derived from these results. Summaries of the radial behavior of characteristic parameters of the solar wind turbulence (e.g., the spectral index and the inner and outer turbulence scales), as well as the fractional density fluctuation, are also presented. These radio-sounding results provide a benchmark for models of the solar wind in its acceleration region.

Key words: solar wind; velocity; density; power; turbulence; plasma.

1. Introduction.

Spacecraft launched to planets and deep space radio-communication ground stations gave the opportunity to carry out unique experiments on radio sounding the solar plasma environment (Goldstein, 1969, Yakovlev et al., 1974). In such experiments deep space radio-communication ground stations were used as complex radio-physical installations with large parabolic antennas, high sensitive receivers, frequency standards, precise timing, signal filtering, measuring and registering. The facilities allowed obtaining detailed information on the propagation of decimeter and centimeter radio waves in space and determining plasma parameters in the solar wind acceleration region on this basis. The Russian system of deep space radio communication used two wavelengths λ_1=32 cm and λ_2=5.07 cm, the US one – three wavelengths λ_3=13 cm, λ_4=3.6 cm, λ_5=0.96 cm. Radio-sounding experiments were carried out using monochromatic spacecraft signals of high frequency stability during radio transmission sessions to the Earth lasting from a few minutes to many hours. Every experiment lasted 2-3 months, when the ray path approached the Sun and then moved away from the Sun. Based on these radio propagation data one may determine coronal plasma parameters at heliocentric distances from 3 to 60 solar radii.

To study solar plasma environment characteristics one uses the experimental data on radio delay and radio fluctuations as well as the theory of radio wave propagation in inhomogeneous medium. Exploiting the complex experimental technique along with the statistics of signal processing and the theory of radio wave propagation one derives the information on velocity, electron concentration and turbulence of medium in the solar wind acceleration region.

This paper presents an overview of the heliocentric distance dependence of solar plasma environment parameters as derived from radio sounding using spacecraft signals. The heliocentric distance, denoted r in the following, is expressed in solar radii units. The described solar plasma environment parameters are related to heliolatitudes below 60^o for relatively low and moderate solar activity.