Stream structure of solar wind beyond Earth's orbit by IPS observations with low frequency Ukrainian radio telescopes UTR-2, URAN and GURT

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This report is devoted to the investigations of the solar wind beyond Earth's orbit by observations of the interplanetary scintillation (IPS) at low frequencies. It is known that IPS observations are very useful for the solar wind studies. At high frequencies, they allow one to obtain the solar wind parameters at distances less than 1 a.u. At the large solar elongations (at distances more than 1 a.u. from the sun), the high frequencies are weakly scattered due to decrease of electron density with radial distance while the low frequencies still show measurable scintillations index. This fact allows us to carry out the complex investigations of the solar wind in the outer heliosphere by nightside IPS observations at low frequencies. Our investigations include the elaboration of the scintillation theory applied to low frequencies and the synchronic observations of IPS with the radio telescope UTR-2, several radio telescopes of URAN system and the new generation radio telescope GURT.

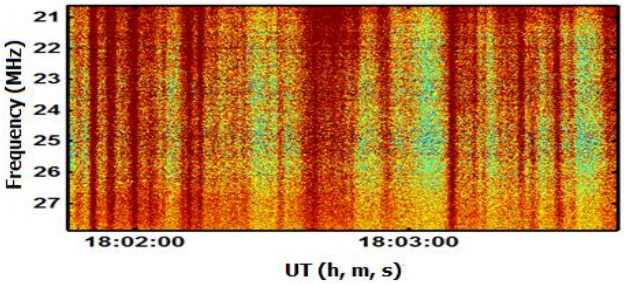

Figure. Dynamic spectrum of IPS in the frequency range 20 to 28 MHz. Radio telescope UTR-2.

The report describes the results of these investigations which were obtained during the last several years. Firstly, we elaborated a technique for IPS data interpretation based on Feynman path-integral technique and used the multi-flow model of the solar wind. At high frequencies for the calculations of the theoretical characteristics the phase screen model is usually used. However, at the large elongations and at the low frequencies the scattering medium is essentially expanded and the most scattering layer is situated near an observer, so the use of the phase screen model is not correct. Also we developed method that allows us to separate the interplanetary and ionospheric scintillations. Ionospheric influence is known to be one of the most harmful effects at low frequency observations. The brief results of the observational data processing are the next. In most cases we detected the presence of several solar wind flows with different velocities, densities and thicknesses along the line of sight. It was found the dynamics of such stream structures of the solar wind. We managed to trace the movements of high-speed streams of different origins. The variations of the solar wind velocity and the scintillation index were usually in good agreement with the behavior of the plasma parameters measured by spacecrafts on Earth orbit. Large enough volume of experimental data also allowed us to obtain the annual statistic of the solar wind parameters and found some interesting features for years corresponding to the different phases of the solar cycle.
Future investigations will require improvement in spatial resolution which can be reached by using the larger number of scintillating radio sources and more radio telescopes. In this connection the creation of Giant Ukrainian Radio Telescopes (GURT) (frequency range 10 – 80 MHz, Gracove, Ukraine) arouses considerable interest. Also in report we will discuss perspectives of joint synchronous nightside observations of the same radio sources with UTR-2 (8 - 32 MHz) - URAN (8 - 32 MHz) - GURT (10 - 80 MHz) and LOFAR - KAIRA (10 - 80 MHz) radio telescopes. Such observations allow us to answer several important questions connected with interplanetary and ionospheric scintillations.