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Dynamics of helium abundance in magnetic clouds

Alexander Khokhlachev, Maria Riazantseva, Liudmila Rakhmanova, Yuri Yermolaev, and Irina Lodkina
Space Research Institute (IKI) Russian Academy of Sciences, Moscow, Russia (aleks.xaa@yandex.ru)

Helium is the second most abundant ion component of the solar wind. The relative abundance of helium can differ significantly in various large-scale structures of the solar wind generated by the nonstationarity and inhomogeneity of the solar corona. For example the helium abundance is ~3% in slow streams and ~4% in fast streams. The maximum helium abundance is usually observed inside magnetic clouds and can reach >10%. The relative abundance of helium can also dynamically vary inside large-scale structures, which can be the result of local processes in plasma.

In magnetic clouds, the distribution of the helium abundance has an axisymmetric peak with a maximum in the central region of the magnetic cloud, where the ion current flows [Yermolaev et al., 2020]. This research examines the different-scale dynamics of the relative abundance of helium in magnetic clouds. For this purpose, the dependences of the helium abundance on some plasma parameters were studied on different datasets of the OMNI database from 1976 to 2018. It is shown that the helium abundance increases with an increase in the modulus of the interplanetary magnetic field B and with a decrease in the proton plasma parameter β in the center of the magnetic cloud. The scale of this region is ~1 million kilometers. Similar relations of the helium abundance to interplanetary magnetic field direction angles and other solar wind parameters were studied.

In addition, the work studied intermediate-scale changes (at scale <1 hour) in helium abundance inside magnetic clouds and compression regions in front of them in comparison with other large-scale wind types. For this aim, a correlation analysis of the time series of density and relative abundance of helium was carried out on base of measurements on SPEKTR-R and WIND spacecraft located at a considerable distance from each other. The dependences of the local correlation coefficients (at scale ~1 hour or less) between measurements at two points on the solar wind plasma parameters are considered. Meanwhile these dependencies are compared with the same for other types of solar wind. It is shown that the median values of the local correlation coefficient in the regions of compressed plasma ahead of magnetic clouds exceed the values in other types of wind by about 15%. In addition, the local correlation coefficient increases with an increase in the amplitude of fluctuations of the investigated parameter and the proton velocity. Thus, intermediate-scale fluctuations in the relative helium abundance observed in these structures are quite stable and apparently are formed in the corona acceleration region and then propagate without changes.
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References.

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