ON THE MECHANISM OF GENERATION OF SOLAR COSMIC RAYS ENRICHED BY HELIUM-3 AND HEAVY ELEMENTS

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The possible mechanism of helium isotopes separation in the solar atmosphere due to plasma effects have been proposed by G.E. Kocharov (1977), I. Ibragimov and G. Kocharov (1977). The cycle of papers: G. Kocharov and L. Kocharov (1978); L. Kocharov (1979 a,b,c,d, 1980); G. Kocharov, L. Kocharov and Yu. Charikov (1980) is devoted to the development of the theory and to the search of concrete model of corresponding physical processes in the solar plasma. Here we consider briefly the modern state of this problem.

According to our consideration to generate Solar Cosmic Rays with large enrichment of He^3 the following conditions are required. At first high non-isothermality $T_e/T_i \simeq 100$ has been formed over the acceleration region. Then for a short time ion-acoustic turbulence has been excited with the energy density $\sim 10^{-4} \div 10^{-3}$ of thermal energy density. During the existence of ion-acoustic turbulence, H and the main part of He are fully ionized and the degree of ionisation C, N, O does not exceed the equilibrium one at the temperature $T_e = 8 \cdot 10^4$K, so $Z^{*4} \cdot A^{-2} \lesssim 1$, where Z^* is the ion's charge and A is its mass number. The total number of thermal protons in the acceleration region have to be rather large to provide the observed He^3 nuclei flux. Sometimes it may attain $10^{39}\ n^{-1}$, where n is the number of acceleration cycles for one event.

The joint analysis of these conditions and the experimental data on the X-ray radiation and the shape of the energy spectrum of protons, He^3, He^4 and other isotopes shows, that the acceleration occurs at the region with the characteristics of upper chromosphere.

According to the conventional notion if enough number of electrons accelerated in the corona with energy of about 10 keV penetrates the cold plasma of the upper chromosphere, the electron shock has to be formed. And ion-acoustic turbulence in the front of wave exists. Moreover the parameters of the generated turbulence may be in accordance with the parameters required to the preferentially acceleration of He^3 (L.G. Kocharov, 1980). High-energy electrons ($\sim$ 15 keV) will shoot through ion-acoustic front, generating before the front of the dense beam, which is unstable. As a result, strong Langmuir turbulence have been generated. It heats quickly thermal electrons and forms the

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required nonisothermality. The above considered ion-acoustic front have been propagated through this non-isothermality medium and provides the preferentially pre-acceleration of He^3 and also the injection of small part of protons, He^4, C, N, O to the mode of further acceleration. It is significant that the degree of ionisation of all elements except H in the front is nonequilibrium, so that the high non-isothermality is connected here with very quick heating of electrons. So, the enrichment of elements heavier than He as large as the He^3 enrichment has not been observed. It is essential that in the corona, where the degree of ionisation of heavy elements is high, the mechanism proposed by I. Ibragimov and G. Kocharov (1977) may provide the enrichment of solar cosmic rays by elements of Fe-group. The smaller enrichment of heavier elements as compared with He^3 is connected with the fact that in the corona the possible degree of non-isothermality is lower than in cold region of He^3 acceleration.

The natural consequence of our model is the generation of X-ray radiation. Really, the analysis of available data shows that He^3 rich events are accompanied by hard X-rays and a sufficient agreement between the intensity of X-ray and He^3 fluxes is available (G. Kocharov, L. Kocharov and Yu.Charikov). A very important peculiarity is the occurence of X-ray precursors of the flares (2-10 keV) in all He^3 rich events, for which the measurements of soft X-rays have been carried out. A mention should be made that 50% of He^3 rich events are accompanied by II-type radiobursts (L. Kocharov, 1979 b,c).

In the frame of the model discussed, all of these accompanying phenomena have a quality or quantity explanation. At last mention should be made that the heating of chromosphere should be accompanied by emission of UV radiation in He II lines. So it should be very important to carry out correlated experiments on SCR isotope composition, ultraviolet and X-ray solar radiation investigations especially with good spatial resolution.

References

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