Studies of solar atmosphere density and charged particle spectrum in the process of flare by means of neutron capture line time profile analysis

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In the preceding works we have studied the character of density distribution in the solar atmosphere for three solar flares (22 March 1991, 6 November 1997 and 16 December 1988). The studies have been based on the time histories of 2.223 MeV gamma-line emissions and their modeling. In all cases we have revealed the condensations of matter under the flare region [1]. In the case of the 16 December 1988 flare we have found the hardening of charged particle spectrum during the flare in the assumption of Bessel spectrum. Hua et al. [2] have shown that new data on neutron generation reaction cross sections and more realistic kinematics may be consistent with power-law spectrum.

In the present work we assume the power-law spectrum of particles. We derive the density under the region of the flare and spectral index of accelerated particles for the 3rd burst of the 16 December 1988 event. Separately, we calculate the gamma-ray line time profiles for neutron spectra deduced in [2] for new kinematics, for which we consider both cases, Bessel and power-law spectra. The position of neutron source was either at the top of the photosphere or above it (1200 km or higher). The analysis shows that in all cases under study, the density in the photosphere is enhanced in comparison with that of the standard model of undisturbed solar atmosphere, as it have been previously found for three above flares. Under considered assumptions, the density in sub-flare region is found to be 2.5 10^{17} cm^{-3} through the complete thickness of the photosphere, arising to (5-6)10^{17} cm^{-3} in some cases at initial phase of the flare. We have shown that the previously proposed method leads to the conclusions about density enhancement and hardening of charged particle spectrum that, in general, are independent on the form of their initial spectrum (Bessel or power-law) and on the initial altitude distribution of neutrons if they are distributed at the top of photosphere or higher. In the second part of the work, by the same method, we analyze the proton spectrum and solar atmosphere density for powerful solar flare 28 October 2003.

References: 1. Kuzhevskij B.M. et al. Astronomy Reports (Russian), 2005, v.82(7), p.637; 2) Hua, X.-M. et al. 2002, Ap.J. Suppl. Ser., v.140, p.563.