CONCERNING THE DYNAMICS OF ENERGETIC PROTONS IN CORONAL MAGNETIC LOOPS: DISPERSION EFFECTS OF ALFVEN WAVES

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It is shown that the existence of plasma density inhomogeneities (ducts) elongated along the magnetic field in coronal loops, and of Alfven wave dispersion, associated with the taking into account of gyrotropy $U \equiv \omega/\omega_i \ll 1$ (Leonovich et al., 1983), leads to the possibility of a quasi-longitudinal $k_\perp < \sqrt{U}\, k_\parallel$ propagation (wave guiding) of Alfven waves. Here ω is the frequency of Alfven waves, ω_i is the proton gyrofrequency, and k is the wave number. It is found that with the parameter $\xi = \omega^2 R/\omega_i A > 1$, where R is the inhomogeneity scale of a loop across the magnetic field, and A is the Alfven wave velocity, refraction of Alfven waves does not lead, as contrasted to Wentzel's inference (1976), to the waves going out of the regime of quasi-longitudinal propagation. As the result, the amplification of Alfven waves in solar coronal loops can be important. A study is made of the cyclotron instability of Alfven waves under solar coronal conditions.

A typical value of the parameter ξ in flaring loops is $\xi \gtrsim 10^2$. Hence isotropization of the protons accelerated in loops, $\gtrsim 10$ MeV, on Alfven waves, causes the protons to escape into the loss cone and to decay in the solar chromosphere. This explains the deficit of energetic protons, observable in some flares, in the interplanetary medium, as compared to the number of particles expected to come from the gamma-ray emission. Pitch-angle diffusion of protons on Alfven waves determines the duration of a pulsation train (of several minutes). Tail ($\sim 1\ R_\odot$) coronal magnetic loops without ducts are good candidates for storage of energetic protons for a long time ($\gtrsim 10$ hours).

References

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