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Faint Coronal Radio Bursts Generated by Alfvén Waves

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We use high-resolution solar radio spectrograms obtained recently by large radio telescopes UTR-2 and URAN-2 (Ukraine) to study solar radio bursts and their emission mechanisms. Our particular focus is on the ALF bursts – faint narrow-band bursts with the frequency drift rates ~100 kHz/s. Such drift rates imply sources propagating with velocities close to the local Alfvén velocity, which suggests that the Alfvén waves are involved in the generation mechanism (hence the name ALF bursts). On the other hand, ALF bursts are closely associated with type III bursts and can therefore share a common energy source with them – fast electron beams accelerated in solar flares and propagating with velocities about 0.2 of the speed of light. Combining these two facts, and elaborating properties of oblique kinetic Alfvén waves (KAWs), we develop further the theory of ALF bursts and their generation mechanism. First, the electron beams generate Langmuir waves via bump-on-tail instability. In the coronal regions not perturbed by KAWs, where the plasma density gradually decreases with the heliocentric distance, the Langmuir waves propagate very fast, with the same velocity as the electron beams, and generate the well-known fast-drifting type III radio bursts. On the contrary, in the regions where the plasma density is perturbed by KAWs, the Langmuir waves are trapped in the density cavities propagating with much slower KAW velocities and generate slowly drifting ALF radio bursts.

We discuss three feasible mechanisms thereby the trapped LWs can generate ALF bursts: (i) antenna emission mechanism, (ii) fundamental emission by the fusion of Langmuir and ion-acoustic waves, and (iii) harmonic emission by the Langmuir-Langmuir wave fusion. Independently of the particular emission mechanism, the observed ALF properties allow to estimate characteristic parameters of KAWs. The observed bandwidth of ALFs, about 0.01 of the burst frequency, reflects the level of density perturbations, which allows estimating the KAW amplitudes. For KAWs with cross-field wavelengths of the order of ion inertial length, we obtain the reasonable KAW magnetic amplitudes about 0.01 of the background magnetic field. The burst duration, about 1-5 s, defines the Alfvén wave frequency at about 1 Hz. Pulsations at such frequencies are often observed in flare sites and can provide the energy source for such KAWs. These and other estimations, obtained from the observed ALF properties, provide us a useful tool for remote diagnostics of plasmas and waves above active regions of the solar corona during solar flares. Observations of ALFs and related phenomena can also be used to track the early evolution phases of geo-efficient solar eruptions improving predictivity of space weather around the Earth.