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$k-$space drift due to the density variation as a cause of electromagnetic emission generation of type III solar radio bursts by a non-gyrotropic electron beam

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It is widely accepted that there is a correlation between super-thermal electron beams and type III solar radio bursts. Whilst the correlation is an established fact, the actual mechanism that generates the type III burst emission is not yet fully determined. The main source of the uncertainty is current inability to send in-situ probes at distances $0.15 - 1.5R_{sun}$ from the solar surface (photosphere). The most widely accepted mechanism, that historically appeared first is the *plasma emission*. In plasma emission mechanism quasilinear theory, kinetic Fokker-Planck type equation for describing the dynamics of an electron beam is used, in conjunction with the spectral energy density evolutionary equations for Langmuir and ion-sound waves. Further, non-linear wave-wave interactions between Langmuir, ion-acoustic and EM waves produce emission at electron plasma frequency, ω_{pe} or the second harmonic, $2\omega_{pe}$. A variant of the plasma emission mechanism is the stochastic growth theory, where density irregularities produce a random growth, in such a way that Langmuir waves are generated stochastically and quasilinear interactions within the Langmuir clumps cause the beam to fluctuate about marginal stability. The latter models have been used for producing the solar type III burst observable parameters. Other possible mechanisms include: linear mode conversion, antenna radiation and non-gyrotropic electron beam emission [1].

Recent works [2,3] elucidated further the non-gyrotropic electron beam emission, first proposed in Ref.[1]. In particular, the effect of electron beam pitch angle and density gradient on solar type III radio bursts was studied [2] and the role of electron cyclotron maser (ECM) emission with a possible mode coupling to the z-mode was explored [3]. In this contribution and paper [4], using large-scale Particle-In-Cell simulations, we explore the non-gyrotropic electron beam emission mechanism by studying the effects of electron beam kinetics and $k-$space drift, in long term evolution of electromagnetic emission generation of type III solar radio bursts. The following improvements and progress in understanding of the radio emission mechanism are made: (i) Improved numerical simulations with larger spatial domain and longer end-simulation times; (ii) The electron beam injection on a density plateau followed by a decreasing density gradient that mimics the Sun-earth system; (iii) Consideration of a ring and shifted ring electron initial velocity distribution functions; (iv) The role of the $k-$space drift in the radio emission; (v) Estimation of the ECM growth rate and its role in the emission generation. It is worthwhile to note that Ref.[3] proposed mode coupling on the density gradient as a source of radio emission as opposed to the $k-$space drift advocated in the present work. The situation is analogous to the auroral waves emitted near the plasma frequency in Earth auroral ionosphere [A. Layden, I. H. Cairns, P. A. Robinson, and J. LaBelle, J. Geophys. Res. 116, A12328 (2011)].

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[3] R. Pechhacker, D. Tsiklauri, "Electron cyclotron maser emission mode coupling to the z-mode on a longitudinal density gradient in the context of solar type III bursts", Phys. Plasmas 19, 110702 (2012)

[4] H. Schmitz, D. Tsiklauri, "$k-$space drift due to the density variation as a cause of electromagnetic emission generation of type III solar radio bursts by a non-gyrotropic electron beam", Phys. Plasmas, in preparation, (2013)