HARMONIC SPECTRAL EMISSION FROM SOLAR CORONAL & LABORATORY PLASMAS

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Solar radio bursts of various types (II to V) observed on the earth having different harmonic spectral characteristics have been investigated thoroughly after the 2nd world war. The purpose of the intense study was to model and mitigate the effects of electromagnetic noise and interference (from HF to EHF bands) into the long haul radio communication channels. In particular, type III and V radio bursts have been the subject of great interest of study due to their common occurrences and quadrupole radiation patterns during solar active conditions. The physical mechanism for generation of type III burst was first theorized[1] in 1959 using Rayleigh and Raman scattering of thermally excited electron and ion density fluctuations (i.e., normal mode of electrostatic waves, L and S respectively) against each other producing transverse wave (T). The theory explained the observed type III radiation pattern but not the comparable magnitudes of the fundamental and the second harmonic radiation at the coronal plasma frequency. This theory was significantly modified much later[2, 3] that showed that the second harmonic could be much larger in magnitude than the fundamental and in fact reference[3] explained the published laboratory measurement of the second harmonic radiation peak in the theta-pinch plasma experiment[4] as well as most of the measured results of harmonic spectra (fundamental and second but not the third harmonic) observed in a low pressure gas discharge (glass) tube of plasma glow experiment [5] that simulated the type III burst conditions in the laboratory. Based on the results of the improved theory and the plasma glow experiments simulating the conditions of type III and V radio burst in the laboratory two US patents [6, 7] were published. The underlying concepts of the patented devices were put to testing in a triple plasma machine (DOLI II) at the University of Wisconsin plasma physics laboratory and results published [8] in 1984. The published results of the experiments of reference [8] were starling that could not be explained by the classical plasma parametric amplification theory or the non-linear plasma kinetic theory for one and two opposing electron beam pumped plasma gas radiating in its steady state at twice the plasma frequency, $2f_p$ with quadrupole radiation pattern. The experiment clearly showed that the output power of the $2f_p$ radiation was an exponential function of the average input energy of the one or two opposing electron beam pumped plasma systems. On the other hand a decade long work (1977 -89)[9, 10] of scientists at university of Sydney, Australia fully developed a new theory (using a semi-quantum formalism) for generation of the second , third and higher harmonic spectral emission from 3-wave interaction processes, denoted by (L ± S ? L' ; L + L' ? T ; L' +T ? T' ; L' ± S ? L'' ; L'' + T' ? T'' and so on). All the observed parameters of the type II to V have been explained qualitatively and quantitatively by this theory. Employing the above 3- wave interaction process in the laboratory for one and two counter-streaming electron beam–plasma system of reference[8] all the measured results have been fully explained and a classical MASER action at the laboratory scale has been established[11]. Also the last theory for $2f_p$ radiation has been extended to produce the third and higher harmonic spectral emission (waveform and magnitude) from the electron beam-pumped plasma gasses[12]. Thus by properly scaling (in the laboratory or otherwise) of the electron beam and plasma parameters, it is possible to produce high power micro- to millimeter wave sources for various applications.

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