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# Frequency Sweeping Due to Phase Space Structure Formation in Plasmas

An overview of the theory of phase space structure formation in plasmas will be given with speculations of how this phenomenon can be applied to tokamak physics experiments. This investigation had its genesis at the Trieste summer school where Marshall proposed investigating anti-loss cone instabilities in tokamaks by using a step function distribution to make the first calculations of this phenomena. We observed that the evolution of these distributions required solving the eqPuations of motion for only markers at the phase space discontinuities. Together with Keith Roberts, a 'water bag' code was developed which graphically displayed the formation and evolution of hole phase space structures. However, the artificialness of the model gave pause to how much results from this model would translate to more realistic distribution functions. More recent work, with Breizman, described analytically and numerically the triggering condition that would allow a smooth bump-on-tail distribution to evolve into a phase space structure. A model, based on perturbative modes, was developed, that is applicable to many physical systems in larger phase space dimensions. This model accurately predicted the saturation amplitude and the rate of frequency sweeping, observed in hole-clump structures generated in numerical simulation. The results of this model was found to be compatible with directly measured results from chirping modes due to the spontaneous excitation of TAE modes on MAST. Recently, this model was extended to successfully describe the sweeping rate and saturation level of hole structures for non-perturbative modes that was generated in a simulation by Vann.