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PIC Simulation of Surface Waves

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This is a description of the work David Cooperberg has done as a graduate student in the last year supported by an ONR AASERT in Professor C. K. Birdsall's Plasma Theory and Simulation Group.

Surface waves are being investigated via electrostatic particle simulation of a warm, unmagnetized, bounded $2\frac{1}{2}$d plasma. Our study focuses on a slab configuration in which the y direction is periodic and the x direction is bounded by grounded conducting walls. Simulation has yielded the main or series resonance and secondary Tonks-Dattner resonances for $k_y = 0$. These resonances have also been observed in (R–Θ) simulation, and are in agreement with theory presented by Parker, Nickel, and Gould[1] in which Tonks-Dattner resonances are shown to arise from density gradients at the edge of the system. In addition, for the X–Y simulation, the main and secondary resonances have been shown to represent cutoffs for propagation in the y direction[2]. Both symmetric and asymmetric surface waves analogous to Gould-Trivelpiece waves[3] have been observed. Also, the secondary resonances have been shown to define cutoffs for additional branches. Waves are excited both thermally and by driving the walls. The dispersion relation for all branches as well as the eigenfunctions for several modes have been determined by simulation. This investigation is important for both basic sheath understanding and for applications in plasma assisted materials processing, new light sources, lasers, and ion sources.

In order to further our study of surface waves as a mechanism for sustaining plasma discharges, work has been performed in modifying the Monte Carlo collision code written by Vahid Vahedi. Enhancements have been made by allowing simulation particles to have their own variable weights. The reasoning for this work is as follows.

In order to use particle-in-cell (PIC) simulation codes for modeling collisional plasmas such as self-sustained discharges, it is necessary to add interactions between charged and neutral particles. In conventional Monte-Carlo schemes, the time or distance between collisions for each particle is calculated using

random numbers. This procedure allows for efficient algorithms but is not compatible with PIC simulations where the charged particle trajectories are all integrated simultaneously in time. A Monte-Carlo collision (MCC) package including the null collision method has been developed, as an addition to the usual PIC charged particle scheme developed by V. Vahedi and M. Surendra. By incorporating variable particle weights into this scheme, we reduce the number of computer particles needed to represent selected species and therefore decrease runtime.

References

[1] J. V. Parker, J. C. Nickel and R. W. Gould, Phys. Fluids **7**, 1489 (1964).

[2] B. O'Brien, R. W. Gould and J. Parker, Phys. Rev. Letters **14**, 630, (1965)

[3] A. W. Trivelpiece and R. W. Gould, J. Appl. Phys. **30**, 1784 (1959)