Linear and non-linear waves in a double plasma experiment

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Abstract

A double plasma device consists of two plasma volumes, electrically separated by a conducting grid and biased to different plasma potentials. By manipulating the potential difference, a controlled plasma flow from one volume into the other can be generated. With the help of a harmonically modulated potential difference, plasma waves can be excited. Using different modulation frequencies allows measuring the wave's dispersion relation and by increasing the amplitude a continuous transition from a linear wave to a non-linear behavior can be studied including wave steepening and solitons.

For the diagnostic of the plasma and the wave parameters Langmuir probes will be used. The Langmuir probe is a standard diagnostic applied in most plasma experiments to measure the electron temperature, the plasma density and the plasma potential. It consists of an electrically conducting filament connected to a power supply. The plasma parameters are deduced from measured current-voltage characteristics.

A first step of the experiment is to understand plasma generation by a thermionic discharge in the vacuum chamber of the double plasma device, which provides additional plasma confinement through a magnetic multipole field generated by rows of permanent magnets. The accessible plasma parameter range will be explored by varying the discharge parameters. The plasma density will be measured by Langmuir probes and by an oscillation method exciting the plasma frequency. The next step is to excite plasma waves and to deduce the phase velocity which gives an estimate for the electron temperature that will be compared with the Langmuir probe result, while the damping of the wave amplitude allows estimating the neutral particle background. Finally larger amplitude waves will be excited and the transition to a non-linear regime is studied.

The experiment gives the student an excellent insight in some characteristic plasma properties and experimental techniques. The study carried out on the plasma wave is exemplary for wave physics in general and for non-linear effects in wave propagation.