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非中性電子プラズマにおけるautoresonanceの実験
Experiments on autoresonances in nonneutral electron plasmas

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Autoresonance is a nonlinear phase locking phenomenon, which was originally studied for particle accelerators. As for the non-neutral plasmas are concerned, the autoresonance of $m=1$ diocotron oscillations have been reported [1,2] and the autoresonant excitation of axial harmonic oscillation for antiproton plasmas has been used to produce and confine anti-hydrogen atoms [3].

When a charged particle (of mass m and charge q) is confined in a potential $\phi=-V_0\cos z$, the equation of motion is given by $\ddot{z}+\omega_0^2\sin z=0$ ($\omega_0^2\equiv qV_0/m$) without a driving force. To consider the effect of the autoresonance [4,5], the driving force is introduced whose frequency changes linearly as a function of time. Then the equation of motion becomes as follows

$$\ddot{z}+\omega_0^2\sin z=\varepsilon\cos(\omega_0 t-\alpha t^2/2),$$

where a constant α is defined as a sweep rate and ε is proportional to the drive amplitude. The theory predicts that there is the threshold amplitude V_{th} for the autoresonance excitation and it is proportional to $\alpha^{3/4}$. Notice that this is a single particle model.

In ref.[3], the autoresonant excitation of axial oscillations was demonstrated for 5×10^4 anti-protons. The main concern of the present experiment is to confirm if the autoresonant excitation of the axial oscillation is applicable for a non-neutral plasma consisting of $10^6-2\times10^7$ electrons (or positrons).

As shown in Fig.(a), about 10^7 electrons are confined radially with a uniform magnetic field of B~190 G and axially by a quasi-harmonic potential, which is shown in Fig. (b). When the amplitude of axial oscillation is small, the linear oscillation frequency is about 9.5MHz in the harmonic potential $\propto(r^2-2z^2)$ and the frequency becomes smaller for the larger amplitude. So far, it was confirmed by the measurement of excited oscillation frequency that the threshold amplitude V_{th} is proportional to $\alpha^{3/4}$ as shown in Fig. (c). The details of experimental results will be reported.

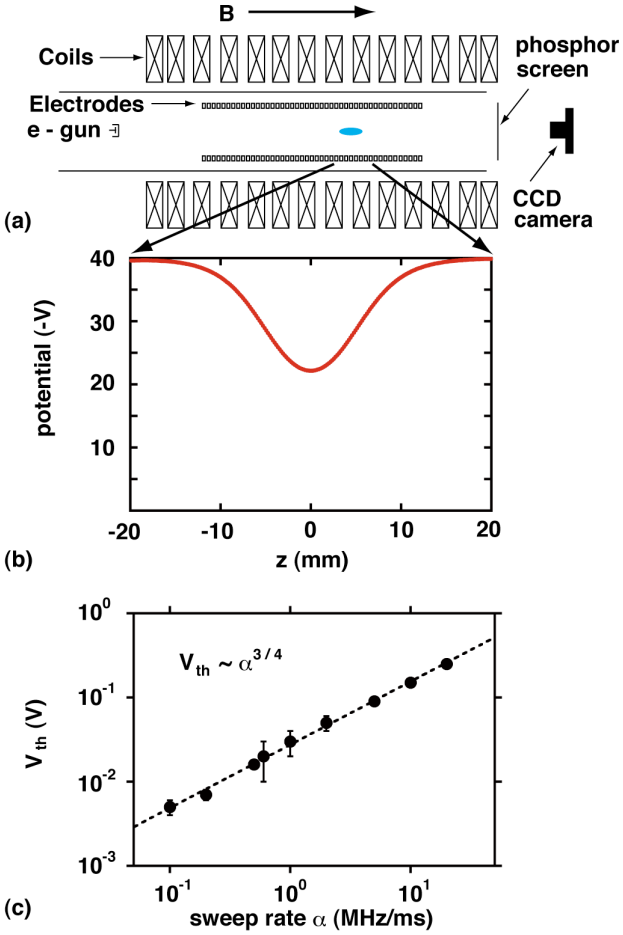

FIG.(a) A schematic of the experimental setup. (b) The confinement potential on the axis of symmetry. (c) The threshold amplitude of the autoresonant excitation is proportional to $\alpha^{3/4}$ for 2×10^7 electrons.

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