Axisymmetric eigenmodes of spheroidal pure electron plasmas

Y. Kawai, J. Aoki[1] and Y. Kiwamoto[2]

Graduate school of Human and Environmental Studies, Kyoto University, Yoshida Nihonmatsu-cho, Sakyo-ku, Kyoto 606-8501, Japan

kwaiyosuke@h01a0395.mbox.media.kyoto-u.ac.jp

A non-neutral plasma in a homogeneous magnetic field and a harmonic electrostatic potential well evolves to thermal equilibrium with a uniform-density spheroid at low temperature [1]. The electrostatic eigenmodes of the spheroidal plasma can be determined analytically to be dependent on the plasma density and shape [2]. And the properties have been employed as a nondestructive diagnostic of the plasma characteristics, particularly in experiments with antimatter plasmas [3,4]. The dispersion relation was derived for a zero temperature (and corrections due to finite temperature [5]) with a uniform-density and for a free boundary condition. However, in practice, the profiles are observed to differ from uniform, and its effect on the mode frequencies has not been examined sufficiently.

In this experiment, we examined the axisymmetric mode properties excited in a pure electron plasma confined in a multi-ring electrode trap [6] with a uniform magnetic field and a harmonic-well potential. From the density distribution obtained by solving the Poisson-Boltzmann equation with the measured line-integrated density profile [7], the observed plasmas are found to attain thermal equilibrium. However, the detected mode frequencies shift upwards from those predicted by the Ref.[2]'s theory. The correlation between the several plasma parameters and the frequency shift shows that this discrepancy can not be explained only by the finite temperature effect, which has been considered previously, and is largely effected by the image charges induced on the wall electrodes and the resulting ununiformity of the density distribution.

This result indicates that it is necessary to develop the dispersion relation with the actual experimental conditions for the application of the eigenmode properties to a nondestructive diagnostic.

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[1]Present Affiliation: *Graduate School of Science, Osaka University, Toyonaka-shi, Osaka, 560-0043, Japan.*
[2]Present Affiliation: *Professor Emeritus at Kyoto University*