Isothermal compressibility of strongly coupled dust component with varying grain charge

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An effect of dust particle charge variation on wave phenomena in cold and ideal dusty plasmas was intensively investigated, see for instance [1,2], by incorporating the particle charging dynamics. It is argued in the sequel that such a detailed description is essentially unnecessary for dust acoustic waves because the recharging time in ordinary dusty plasmas is estimated to be much less in magnitude than the corresponding inversed frequency of dust acoustic waves, which actually implies that in the course of propagation dust grains are almost instantly recharged. Herein we are primarily interested in the strongly coupled regime in which the dust charge variation for dust acoustic waves must play much more significant role because the thermal pressure is predominated by the mutual interaction of likely charged dust grains. It has to be stressed that dust acoustic waves in strongly coupled dusty plasmas with varying grain charge were also studied in the literature [3,4] but, unfortunately, the isothermal compressibility of the dust component was calculated under the assumption of the constant grain charge. The present consideration is intended to amend this situation.
In order to correctly evaluate the isothermal compressibility of the dust component we propose to use an unconventional parametrization in which the dust particle charge is no longer an independent quantity and is determined by the ambient plasma characteristics as well as by the dust grain size and number density. To this end we start from the examination of the charging process and proceed to the evaluation of the thermodynamic properties of the strongly coupled dust component. The final goal pursued is to demonstrate that the isothermal compressibility accounts for the variation of dust grain charge, which has crucial influence on the dust acoustic waves spectrum in strongly coupled regime.

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