Hydrodynamic modes in external fluctuating field

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Hydrodynamics of the liquid charged dielectric with constant dielectric permittivity in external potential electric field or neutral gas in the same gravitation field is studied. The field is characterized by the second correlation moment of strength $\vec{E}$. Motion of environment is described by the charge conservation law $\partial_t \rho + div\rho\vec{v} = 0$, mass one $\partial_t \sigma + div\sigma\vec{v} = 0$, which is a charge in case of gravitation interaction, and Euler equation, which for definiteness we write down for dielectric in electric field $d\sigma\vec{v}/dt = -\nabla P + \rho\vec{E}$. Generated by own motion selfconsistent field appears here besides external one. This field is determined by Poisson $div\varepsilon\vec{E} = 4\pi\rho$ and Maxwell equations [1] $\partial\varepsilon\vec{E}/\partial t = -4\pi(\rho\vec{v})^{\|}$, where it is taken into account, that $rot\vec{E} = 0$. Then it is possible to rewrite $\rho E_\alpha = \left\{\nabla_\beta \varepsilon E_\beta E_\alpha - \nabla_\alpha \varepsilon E^2/2\right\}/4\pi$. We average on the accidental phase of the fluctuating field. And we consider small amplitudes. $\sigma_0 \partial v_\alpha/\partial t = -\nabla_\alpha P + \rho_0 E_\alpha + \rho E_{\alpha 0} + \varepsilon\left\{\nabla_\beta \overline{E_\beta E_\alpha} - \nabla_\alpha \overline{E^2}/2\right\}/4\pi$. A new variable is entered in this equation - centered correlation of the electric field $\overline{E_\beta E_\alpha}$, for which we receives temporal equation, using Maxwell equation with current in hydrodynamic approximation. We assume that the centered correlation of external field is isotropic but nonhomogeneous set value $\overline{E_\beta E_\alpha}(r) = \delta_{\alpha\beta}\overline{E^2}(r)/3 + E_{\alpha 0}E_{\beta 0}$, then $\partial\overline{E_\gamma E_\alpha}/\partial t = \vec{v}_\gamma^{\|}\nabla_\alpha \overline{E^2}(r)/6 + \vec{v}_\alpha^{\|}\nabla_\gamma \overline{E^2}(r)/6$. And we consider long waves. Characteristic equation gives Langmuir frequencies $\omega^2 = 4\pi\rho_0^2/\varepsilon\sigma_0 - \varepsilon\Delta\overline{E^2}(r)/24\pi\sigma_0$ with correction from field correlation. For the case of gravitation field it is simply necessary to replace in all formulas $\varepsilon \to -1/G$ and $\rho \to \sigma$. And we obtain corrected Jeans frequency.

References

[1] A.A. Stupka, Gravitation Field Dynamics in Jeans Theory. *Journal of Astrophysics and Astronomy* Vol. 29. Num. 3-4. (2008), P. 379-386.