Bulk and isospin instabilities in hot nuclear matter

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We have considered [1] the appearance and the development of instabilities in an asymmetric nuclear matter in both the isoscalar and the isovector channels. Our analysis is based on the equations of motion for the quantum Fermi liquid in the presence of the Fermi-surface distortion effects and the relaxation processes. We point out that a realistic description of the unstable modes in a homogeneous nuclear matter requires the extension of the equation of state by taking into consideration the gradient corrections to the total energy functional. The presence of the gradient corrections leads to the anomalous dispersion term in the equation of motion and influences significantly the behavior of the instability growth rate.

Studying the appearance of the bulk and isospin instabilities, we have performed numerical calculations of the dependence of the incompressibility coefficient, $K(\rho_0)$, and the symmetry energy coefficient, $C_{\rm sym}(\rho_0)$, on the nuclear density, ρ_0. To evaluate the values of $K(\rho_0)$ and, $C_{\rm sym}(\rho_0)$, at non-equilibrium density, $\rho_0 \neq \rho_{\rm eq}$, we have applied the cranking approach. The external cranking field was used in the form which excludes the direct contribution of the cranking field to the incompressibility coefficient $K(\rho_0)$ for the Skyrme interactions SkM*, KDE0v1 and Sly230b for different temperatures and particle densities, we have established the critical temperature $T_{\rm crit} = 14\ to\ 15$ MeV where the nuclear matter becomes unstable at the equilibrium density $\rho_{\rm eq}(T)$. A peculiarity of the isovector mode is that the instability of nuclear matter with respect to isovector density fluctuation, i.e. regime $C_{\rm sym}(T) < 0$, can occur in the superdense nuclear matter only and depends significantly on the choice of the Skyrme interaction parameterization, such as the case of SkM*.

We have shown that the Fermi-surface distortion effects strongly hinder the development of instabilities in nuclear matter. The dependence of the instability growth rate $\Gamma_+(q)$ on the wave number q has a specific non-monotonic behavior which is caused by the anomalous dispersion term. Different slopes of the curve $\Gamma_+(q)$ reflect different regimes (fission or multifragmentation) of instability. To illustrate this fact, we have considered the behavior of instability growth rate $\Gamma_+(q)$ in the finite nucleus ^{208}Pb for different multipolarities L of particle density fluctuations and different temperatures T. The results presented in Fig. 1 show that the fission mode (low L) is preferable at low temperatures. The instability with respect to multifragmentation (high L) increases with temperatures. Moreover, one can expect that the yield of small fragments, which correspond to the highest values of L, is strongly increasing for high temperatures, see corresponding lines 4, 6 and 8 MeV in Fig. 1.

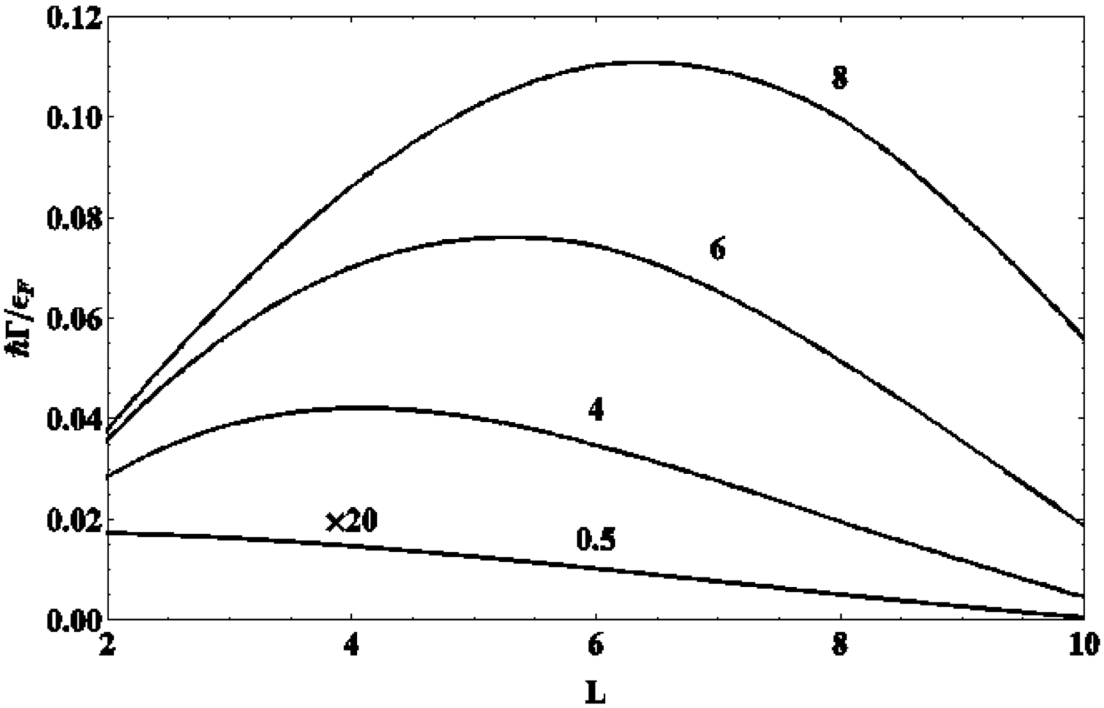

FIG. 1. The dependence of the isoscalar instability growth rate $\boldsymbol{\Gamma_+(L)}$ on the multipolarity $\boldsymbol{L}$ of the particle density fluctuations for the nucleus ^{208}Pb for different temperatures. 0.5, 4, 6 and 8 **MeV** which are shown near the curves. The calculations were performed for KDE0v1 [2] interaction.

[1] V.M. Kolomietz and S. Shlomo, Phys. Rev. C **95**, 054614 (2017).
[2] B.K. Agrawal, S. Shlomo, and V.K. Au, Phys. Rev. C **72**, 014310 (2005).