Isoscalar-isovector instabilities of a hot and dilute nuclear droplet

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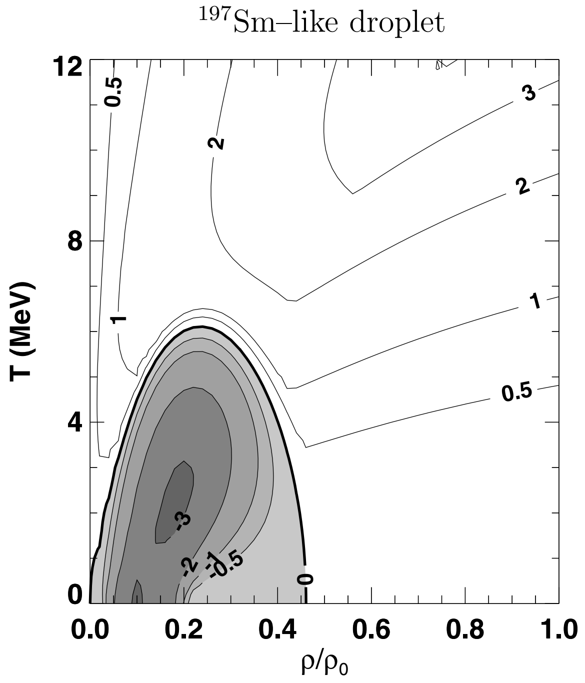

Figure 1: Contour plot (values in MeV) of largest growth rates in the unstable (shaded) region and smallest relaxation rates in the stable region for a nuclear droplet with Z=62, A=197 near the neutron drip line.

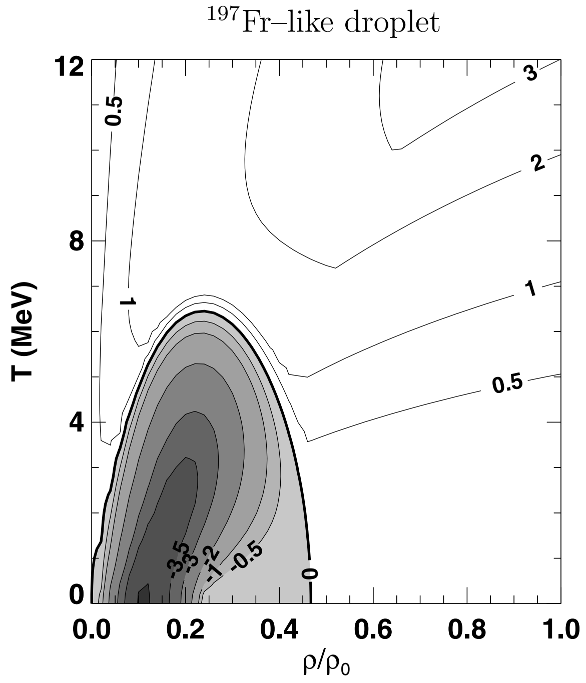

Figure 2: Contour plot (values in MeV) of largest growth rates in the unstable (shaded) region and smallest relaxation rates in the stable region for a nuclear droplet with Z=87, A=197 near the proton drip line.

In [1] we have introduced a collective model which allows to study the bulk and surface modes of a nuclear droplet as function of its density ϱ and temperature T. The description is based on the diabatic approach to dissipative collective motion and – in the local density approximation – yields equations of motion for small amplitudes, where the mass and stiffness tensors are obtained analytically. The model is suited to explore systematically characteristic properties of hot nuclear droplets as function of their densities. Dissipation has been included and examined in [2]. This is essential, because realistic values for the relaxation times are of the same order as the characteristic times of collective motion in the region of the liquid-gas phase transition. While the spinodals remain unchanged the growth rates of unstable modes are reduced from their adiabatic (i.e. non-dissipative) values by factors 1/2 to 1/4 in the region of interest.

We have now extended our studies to the inclusion of isovector modes by introducing two independent displacement fields for protons and neutrons, respectively [3]. This approach still allows to obtain analytical expressions for the mass and stiffness tensors and is applicable not only in the region of instability, but also to vibrations of pure as well as coupled isoscalar and isovector modes at arbitrary densities and temperatures.

We have calculated the eigenfrequencies of the coupled isoscalar and isovector vibrations for a soft equation of state using the Skyrme energy functional SLy10 [4] which does not give an unphysical isovector instability at large densities like SkM*. We have chosen the same values for the relaxation time as in [2]. The results are summarized as follows.

- Due to the coupling between isoscalar and isovector modes the lowest eigenmode is pushed down in energy.
- However, the mixing between these modes is small for neutron-to-proton ratios within the drip lines. This is illustrated in the figures. Only for very asymmetric nuclear matter (e.g. relevant in some astrophysical problems) the coupling between isoscalar and isovector modes becomes large [5].

References

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