Three-dimensional Bose-Fermi droplets at nonzero temperatures

Maciej Lewkowicz [1], Mirosław Brewczyk [2], Mariusz Gajda [3], Tomasz Karpiuk [2, †]

[1] Doctoral School of Exact and Natural Sciences, University of Białystok, ul. K. Ciołkowskiego 1K, 15-245 Białystok, Poland
[2] Wydział Fizyki, Uniwersytet w Białymstoku, ul. K. Ciołkowskiego 1L, 15-245 Białystok, Poland
[3] Institute of Physics, Polish Academy of Sciences, Aleja Lotników 32/46, PL-02668 Warsaw, Poland
†corresponding author's email: t.karpiuk@uwb.edu.pl

We numerically study the formation of self-bound quantum Bose-Fermi droplets at nonzero temperatures. We have previously shown that such droplets can exist at zero temperature [1, 2]. In this work the attractive atomic Bose- Fermi mixture is described in terms of quantum hydrodynamics, enriched by beyond mean-field corrections and thermal fluctuations, as well as by a simplified self-consistent Hartree-Fock model. Using the hydrodynamic de- scription, we find low-temperature relatively long-lived droplets in a free space as shown in Figure 1, provided that the attraction between bosons and fermions is strong enough. On the other hand, a simplified Hartree-Fock treatment supports the existence of Bose-Fermi droplets in equilibrium with the gas of thermal bosons and fermions, with the Bose-Einstein conden- sate itself being completely hidden inside a droplet. Both thermal and non-thermal droplets can be used to simulate astrophysical phenomena such as disruption of a white dwarf star by a black hole [3, 4].

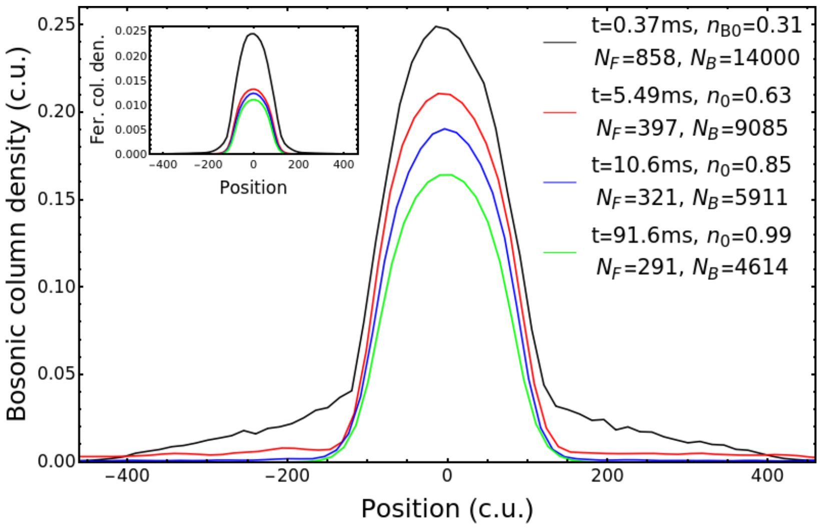

Figure 1: Column density of the bosonic and fermionic (inset) components as a function of time after release from the harmonic trap. Absorption boundary conditions are applied at the edges of the system. Initially, the condensate fraction in the bosonic component is about 0.3. As can be seen, the droplet cools down and after about 90 ms reaches zero temperature with the condensate fraction almost one.

References

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