C-field simulations of thermal Bose-Einstein condensates

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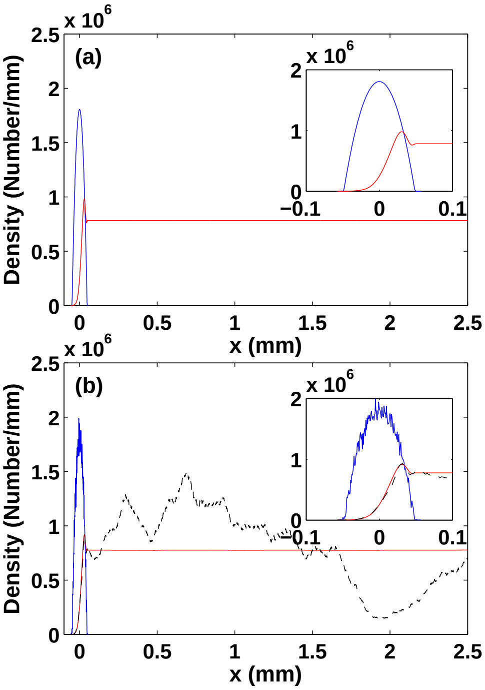
The aim of this project is to continue to develop and apply methods for describing the dynamics of Bose-Einstein condensates (BECs) at finite temperature. The techniques being utilised are approximate; however they are aimed at performing non-perturbative calculations for realistic experimental systems [1].

1. The project on developing a 1D model of a continuously pumped atom laser using a stochastic Gross-Pitaevskii equation is nearing completion. In this description the condensate is continuously replenished from a thermal atomic reservoir using a realistic growth scenario, and the atom laser beam is generated by Raman outcoupling. We have focused on the properties of the output beam and will provide realistic estimates of the linewidth and coherence limitations of a cw atom laser at finite temperature [2]. The figure shows a comparison of an atom laser at zero temperature (upper panel) and finite temperature (lower panel). The solid blue curves show the instantaneous condensate density, and the dashed black curves the instantaneous atom laser beam density. The red solid curves are the time averaged beam densities.



2. We have modelled experiments by the University of Queensland BEC group on the formation of condensates by combining a 1D laser sheet with a cigar-shaped BEC. The laser sheet can either be applied adiabatically (in which case entropy is conserved) or suddenly (following which the energy is conserved). We have calculated the expected final condensate fraction and temperature using Hartree-Fock theory, and found good agreement with the data. In the past twelve months we have modelled the condensate formation dynamics using quantum kinetic theory and are currently trying to understand the discrepancies with the experimental data.

3. Ongoing work on the pairing properties of vortices in two-dimensional homogeneous Bose gases was submitted for publication [3]. Other work on the properties of the Berezinskii-Kosterlitz-Thouless phase of the trapped 2D Bose gas was published in 2009 [4].

4. The numerical technique we have developed over the past several years for solving the projected Gross-Pitaevskii equation using an efficient harmonic oscillator representation was extended to incorporate dipolar interactions between the particles [5]. It was also extended and parallelised to be able to simulate spinor (multi-component) Bose systems.

References

[1] P. B. Blakie, *et al.*, Advances in Physics **57**, 363 (2008).

[2] G. M. Lee, S. A. Haine, A. S. Bradley, and M. J. Davis, in preparation.

[3] C. J. Foster, P. B. Blakie, and M. J. Davis, arXiv:0912.1675 (2009).

[4] R. N. Bisset, M. J. Davis, T. P. Simula, and P. B. Blakie, Phys. Rev. A **79**, 033626 (2009).

[5] P. B. Blakie *et al.*, Phys. Rev. E **80**, 016703 (2009).