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 at finite temperature. The techniques being utilised are approximate; however they are aimed at performing non-perturbative calculations for realistic experimental systems.

1. We have continued with work on a 1D model of a continuously pumped atom laser using a stochastic Gross-Pitaevskii equation. 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 from this by Raman outcoupling. The project focuses 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. 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. A joint paper is currently in preparation.

3. A recent experiment by the Engels group at Washington State University has observed evidence for a superfluid critical velocity in dragging a both attractive and repulsive obstacles through a cigar-shpaed BEC [2]. We have been modelling these experiments with both the 1D and 3D Gross-Pitaevskii equation in order to try and interpret their data.

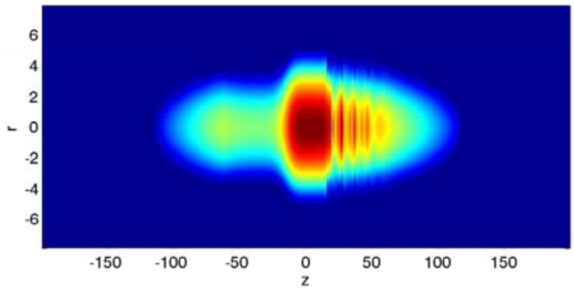

Fig.1: A laser beam passing through a cigar-shaped BEC.

4. This year saw the completion and publication of a comprehensive review paper on the development and application of c-field techniques to the dynamics and statistical mechanics of Bose gases [3].

5. Lastly, our study of the formation of vortex lattices from a rotating 2D gas was published [4].

References

[1] C. W. Gardiner and M. J. Davis, J. Phys. B **36**, 4731 (2003).
[2] P. Engels and C. Atherton, Phys. Rev. Lett. **99**, 160405 (2007).
[3] P. B. Blakie, A. S. Bradley, M. J. Davis, R. J. Ballagh and C. W. Gardiner, Advances in Physics **57**, 363 (2008).
[4] A. S. Bradley, C. W. Gardiner and M. J. Davis, Phys. Rev. A **77**, 033616 (2008).