Interest Group Stream: AOS

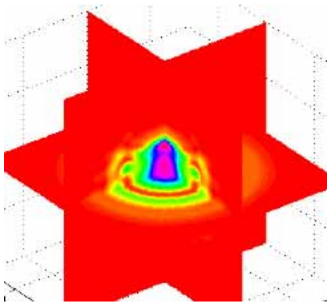
Title: The Physics of Collapsing and Exploding Dilute Gas Bose-Einstein Condensates.

Authors: Craig SAVAGE, Joe HOPE, Nicholas ROBINS, Douglas GRIMM

Institution: Dept. of Physics & Theoretical Physics, The Australian National University

ABSTRACT
Dilute gas Bose-Einstein condensates of ^{85}Rb have been made to collapse by rapidly changing the atomic interactions from repulsive to attractive. This is possible due a magnetically tunable Feshbach resonance which allows an unprecedented precision and range of control of the interactions. The collapses are observed to be accompanied by complex and surprising dynamics including explosions, which have been referred to as Bosenovas [1].

There are a number of theoretical studies of the physics of these collapses and explosions. We are exploring two complementary models: the simplest mean-field approach, and quantum field theory. There are claims in the literature that mean-field, or Gross-Pitaevskii, physics is adequate [2,3]. However we present evidence that although good qualitative agreement is possible, certain quantitative details of the experiments are not consistent with the Gross-Pitaevskii model.



We solve the Gross-Pitaevskii dynamics numerically, in three dimensions, with the complete physics and correct parameters for the Bosenova experiments. These simulations require the APAC National Facility parallel supercomputer. We will present dynamical visualisations of the Gross-Pitaevskii dynamics which explain the qualitative features of the Bosenova explosions. The figure shows slices through the (colour coded) density of a 3D Bosenova just after it has blown off a torus of condensate, as a result of an induced collapse.

In order to study quantum field theoretical corrections to the mean-field model we use the generalised P-function approach of Drummond and Gardiner. This requires the solution of ensembles of stochastic Gross-Pitaevskii equations. The Bosenova experiments are particularly interesting from a quantum field perspective because they are in the attractive atomic interaction regime where the usual argument against fragmentation into multiple condensates fails.

[1] E.A. Donley *et al*., Dyanmics of collapsing and exploding Bose-Einstein condensates, Nature **412**, 295 (2001).

[2] H. Saito and M. Ueda, Mean-field analysis of collapsing and exploding Bose-Einstein condensates, cond-mat/0107248.

[3] S.K. Adhikari, Mean-field theory for collapsing and exploding Bose-Einstein condensates, cond-mat/0201586.