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ON THE ENHANCEMENT OF IMPURITY COLLISIONS IN A BOSE–EINSTEIN CONDENSATE

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We present a possible explanation of the discrepancy between theory and experiment (observed by Chikkatur *et al.*) in the collisional density of impurities in a Bose–Einstein condensate of sodium atoms. The discrepancy is ascribed to the fact that the experiment was carried out in a situation of strong instability, where small variations of the initial number of impurities in the condensate may give rise to a large variation in the number of colliding atoms.

Keywords: Bose–Einstein condensation; impurities; collisional density.

1. Introduction

The Bose–Einstein (BE) condensation phenomenon has received a great deal of attention, from both the theoretical and the experimental viewpoints.[1] Atomic BE condensates behave as superfluid gases. In particular, a BE condensate exhibits a Landau critical speed v_L (below which particles propagate through a superfluid without dissipation)[2] that is equal to the sound speed in the condensate ($v_L = c = \sqrt{\mu/M}$, where μ and M are the chemical potential and the mass of the condensate atoms, respectively). However, the Landau behavior can only be observed for the motion of microscopic particles through the condensate; for macroscopic objects, one observes a Landau velocity much lower than the speed of sound.[3]

In a recent paper,[4] Chikkatur *et al.* studied the motion of impurity atoms (produced using a stimulated Raman transition) through a trapped BE condensate of sodium atoms. The impurities propagated at variable velocities, and their collisions with the condensate atoms produced a redistribution of their momenta. Two main effects were observed: a reduction of the collisional cross-section for impurity velocity lower than the condensate speed of sound, and an enhancement of atomic collisions for large numbers of impurity atoms (due to bosonic stimulation).