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Experiments with a metastable Bose-Einstein condensate

An atomic Bose-Einstein condensate (BEC) occurs at very low temperatures (~ 100 nK) and high densities, and results in all the constituent atoms residing in the groundstate of the system. Moreover, atoms in the condensate comprise a single macroscopic wavefunction, that is they are all indelibly linked, giving a BEC coherence properties similar to an optical laser.

Since the experimental achievement of BEC in 1995, condensates have been used to probe a wide range of areas in physics, ranging from condense matter physics to non-linear physics. More recently, the advent of the metastable helium (He*) BEC offers the intriguing possibility of probing the quantum world, through the unique detection a metastable condensate offers. A metastable He* BEC is one in which the constituent atoms are not in their true electronic groundstate, but rather in a long lived excited state containing ~ 20 eV of energy. The large internal energy of He* enables single He* atoms to be detected on a near zero background level with nanosecond time resolution and micron spatial resolution. It is this fast, spatially, resolved single particle detection capability that makes a He* BEC truly unique.

Our group is one of only four groups worldwide to have achieved a metastable BEC. In this talk I will discuss how we make our BEC and our recent experiments in which we have produced a metastable ‘atom laser’ from our condensate and imaged the beam profile. The resulting beam profiles exhibit interference fringes, demonstrating for the first time transverse coherence of an atom laser.