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The Relative Phase of Two Spatially Separate Bose-Einstein Condensates

YONG-IL SHIN, Group of Ketterle and Pritchard, MIT

The relative phase of two Bose-Einstein condensates is a conclusive demonstration of the existence of phase coherence of Bose-Einstein condensates. Experimental control of the relative phase is an essential requirement for novel quantum applications using Bose-Einstein condensates, such as atom interferometry and quantum information processing. In this presentation, I describe our experimental works for studying coherent manipulation of the relative phase of two spatially separate condensates. We developed an optical double-well system having controllable well- separation and depth. Coherent dynamic splitting of trapped condensates was performed by deforming an optical single-well potential into a double-well potential. The relative phase of the two split condensates was shown to be reproducible and coherent phase evolution was observed for condensates held separated by 13 μm for up to 5 ms. We demonstrated trapped atom interferometry with this coherent beam splitter [1]. We developed an optical method for measuring the relative phase of two condensates. Coherent coupling between the two spatially separate condensates was established by using stimulated light scattering and the relative phase was continuously measured by monitoring the scattered photons. This continuous phase measurement presents a new type of atom interferometry without need for a conventional beam splitter or recombiner [2]. The Josephson-like phase dynamics of the coherent optical coupling was investigated and it was experimentally demonstrated that the induced atomic currents between the two condensates depend on the relative phase of the two condensates and an additional coupling phase which is experimentally controllable [3].

[1] Y. Shin et al., Physical Review Letters **92**, 050405 (2004).
[2] M. Saba et al., Science **307**, 1945 (2005).
[3] Y. Shin et al., Physical Review Letters **95**, 170402 (2005).