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Phase Engineering of Entangled Number States (aka Schrödinger cats) in Gaseous Bose-Einstein Condensates in "Two," and "Many" Wells[1]

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It has been demonstrated that a phase offset may be imprinted on "part" of a single ground state Bose-Einstein condensate (BEC), and that such a phase imprint can then, via the natural subsequent dynamics of the condensate, generate both solitons and vortices. A similar phase imprint on one or more wells of a coherently connected (Josephson regime) set of BECs yields, again simply from the natural time evolution of the condensate ground state following the phase imprinting, highly entangled number states, the extreme version of which would be the macroscopic N-body superposition state: $|$N,0,0,0...$>$ $+|$0,N,0,0...$> +|$0,0,N,0...$> +|$0,0,0N,....$> +\ldots$ with appropriate normalization. The notation is intended to indicate that all N particles are in all wells simultaneously. A simple physical model is introduced for the two well case allowing control of both the extremity and sharpness of the number entangled states. Less extreme states are rather more robust than the extreme superposition illustrated above. Similar results are found in systems with 3,4, and 8 wells indicating the generality of the proposed methods, although visualization of the results becomes progressively more difficult, and the computations become intractable surprisingly quickly. Extension of the Bose-Hubbard model where fully coupled GP wavefuctions are combined with exact solution of the correlation problem for the two mode system shows the importance of strong mean-field effects in the understanding and modeling of such systems. Time allowing, a discussion of "detection" of such states may be included. The author delightedly acknowledges collaboration with Heidi Perry, Khan Mahmud, Mary Ann Leung and David Masiello.

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