Tunneling, self-trapping and manipulation of higher modes of a BEC in a double well

J. Gillet[1], M. A. Garcia-March[1], Th. Bush[1], Lincoln D. Carr[2,3], F. Sols[4], I. Zapata[4]

[1] *Department of Physics, University College Cork, Cork, Republic of Ireland*

[2] *Universität Heidelberg, Physikalisches Institut, Philosophenweg 12, D-69120 Heidelberg, Germany*

[3] *Department of Physics, Colorado School of Mines, Golden, CO 80401, U.S.A.*

[4] *Departamento de Fìsica de Materiales Universidad Complutense de Madrid, E-28040 Madrid, Spain*

Abstract

We consider a BEC trapped in a Duffing potential $V_0(1-4(z/a)^2)^2$, described by a second quantized Hamiltonian [1]. We consider the four mode solution of the wavefunction $\Psi(z) = \sum_{j,l} \sqrt{N_{j,l}} e^{i\phi_{j,l}} \psi_l(z-z_j)$, where $\psi_l(z-z_j)$ is the localized wavefunction of a single particle in the well $j \in \{L, R\}$ in the mode $l \in \{0, 1\}$ and $N_{j,l}, \phi_{j,l}$ are the number of atoms and phase of each mode. For given forms of the potential, we study the dynamical behavior of population and phase imbalances such as $z_1 \equiv N_{L,1} - N_{R,1}$ and $\theta_l \equiv \phi_{L,1} - \phi_{R,1}$, which can be plotted on phase space diagrams. In Fig. 1 a) and b), we show that the excited modes can exhibit a similar behavior as the ground modes such as tunneling and self-trapping [2] and we also show the influence of the difference of population in the ground modes in Fig. 1 c) and d).

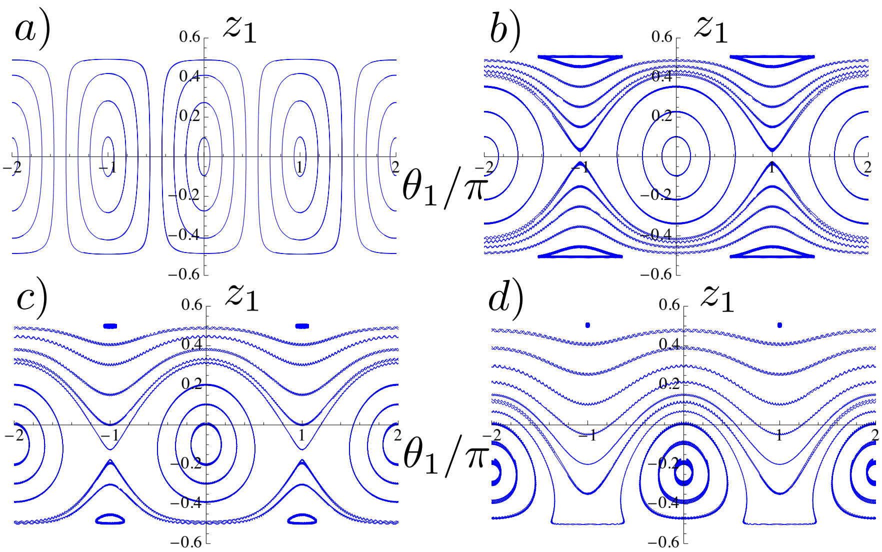

Figure 1: In a), the dynamics of the excited modes is entirely due to tunneling. In b), the increased atomic self-interaction within each well allows for more complex features, such as self-trapping, for equal population in the ground modes. In c) and d), the difference of population in the ground modes is gradually increased.

References

[1] M. A. Garcia-March, D. R. Dounas-Frazer, Lincoln D. Carr, Frontiers of Physics **7**, 131 (2012).

[2] A. Smerzi, *et al.* Phys. Rev. Lett. **79**, 4950 (1997).