Matter-Wave Rings and Shells: Experiment and Theory with Optical and Radio-Frequency Fields

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The motivations behind this work are the analysis of systems that may be used to make Sagnac interferometers [1–3] for rotation meansurements, and the analysis of idealised shell states of a Bose-Einstein condensates. For the latter case, experiments on the Cold Atom laboratory in space, or CAL [4,5], have stimulated wide interest in the creation and physics of bubbles of quantum gas [6]. This includes the collapse and expansion of bubbles, vortices on closed surfaces, and vibration of the shell. This presentation will start with a very brief introduction and overview.

We have developed techniques for the analysis of wave packet dynamics in 2D and 3D. We use a Gaussian approximation to a wave-packet in a ring potential and show how the orientation of the wave-packet changes as it propagates around the ring. Further to this, a method to obtain corrections to the Gaussian wave-packet is obtained by transforming the Hamiltonian of the system to a local co-moving and rotating harmonic basis [7].

Further, by using a method of representing a wave-function by a swarm of Gaussian wave-packets we also analyse the dynamics of matter-wave rings and shell states expanding in free space. This uses simplified expansions based on a method inspired by quantum optics.

Finally, a report will be given on an all-optical approach to making the shell states. This is based on a double-dressing of atoms with optical fields [8].

References

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