Coherent quantum processes with wave packets

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Quantum optics has recently devised many experiments, where the special quantum correlations have been utilized. Multi-photon systems have been used in quantum communication and teleportation experiments. In cavity QED photon states have become entangled with atomic states and in atom optics interferometers have been constructed. Photons are ideal quantum particles, they do not dephase nor interact in free space. With massive particles, their dispersion cause spreading and diffraction, and they usually interact when close enough.

In our research we have considered many applications of coherent wave packets in molecules, traps and solid state heterostructures. It has been possible to look at microscopic analogues of many macroscopic phenomena: interferometers, quantum amplifiers and control of the motion of particles. These can be the basis of quantum electronics devices or even quantum information transformations. Wave packet motion can also be used as a state preparation device to launch a particle into a desired motional state.

In this talk I wish to report on some work where wave packets have been used to implement simple optical devices but with massive particles. This is an extension of the ideas in atom optics, but we are considering configurations characteristic of Quantum Optics measurement and information manipulations. Our wave packet calculations include particle interactions, both for Coulomb repulsion and Van der Waals type interactions. In addition we look at the influence from the quantum statistics of the particles. Simple cases are presented and their possibilities and limitations are discussed.