Realization of a lattice of ring traps

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Optical lattices are a key system in the fields where an accurate control of atoms is necessary, as in quantum computing, atomic Mott transition or quantum chaos. However, one of the main limitations of optical lattices is their poor filling rate, smaller than unity, reducing drastically the effective number of interactions between atoms in a same site or in neighboring sites. One of the reasons of this small filling rate is the relative weak atomic density of the magneto-optical trap used to cool initially the atoms, as compared to the relative high density of sites in the lattice. A possibility is to limit the number of sites by using e.g. a 1D lattice, but this solution requires the use of a bright lattice, increasing the decoherence of atoms, another limitation in these studies dealing with the quantum transport of atoms. Until today, the only lattices able to confine atoms with fluorescence rate of the order of 1 s, were the 3D dark lattices. Therefore, a solution for a high filling rate is to increase the density of the atoms dropped in a 3D dark lattice, using e.g. a Bose-Einstein condensate. We propose here an alternative, technically simpler, consisting in using a dark lattice with a small density of 3D traps.

Each individual trap is a 3D dark ring, and the lattice is a 1D stack of such rings. Thus, the global shape of the potential is a bright full cylinder with a pile of ring wells inside. We show here how to make such a lattice by making the interference between a hollow beam and a gaussian beam. We discuss about the possible applications, and in particular about the realization of a quantum gate with the ring lattice. Finally, we present the experimental realization of the lattice and the first experimental results obtained with it.

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