Arbitrary Light Beam Shapping for Ultracold Atom Experiments

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An ultracold three-dimensional (3D) gas can be brought into a quasi-bidimensional (2D) regime by strong confinement in one of its spatial directions, so that its dynamics is practically reduced to a plane of atoms. These 2D systems are of great interest due to their ability to exhibit a superfluid state, which arises via the so-called Berenzinskii-Kosterlitz-Thouless (BKT) phase transition. One of the major problems encountered since the first creation of Bose-Einstein condensates has been the creation of box-like potentials to confine such systems in homogeneous traps, which has made a direct comparison with theory difficult. It is therefore essential to develop techniques that allow us to create not only such potentials, but any other type of configuration to analyze these systems. We present here the first efforts in the development of an arbitrary light beam shaping trap for 2D ultracold atom experiments at the Institute of Physics of São Carlos, which is done by modeling a laser beam using a digital micromirror device (DMD). This modeling consists of using an Error Diffusion method to generate the masks that are printed on the DMD and thus on the beam profile. It also uses an interactive feedback that improves the printed masks based on the direct interaction of the reflected beam with the physical environment – atoms and optics.