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Holographically-generated optical traps for ultracold atoms

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The development of new laser-beam shaping methods is important in a variety of fields within optics, atomic physics and biophotonics. Spatial light modulators offer a highly versatile method of time-dependent beam shaping, based on imprinting a phase profile onto an incident laser beam which then determines the intensity in the far field, where the atoms are trapped. The calculation of the required phase is a well-known inverse problem, which can be tackled with different approaches. Our method based on conjugate gradient minimisation [1] not only allows the calculation of smooth and accurate intensity profiles suitable for trapping cold atoms, but can also be used to generate multi-wavelength traps [2] and for simultaneous control over both the intensity and the phase of the light [3], with exceptionally high reconstruction fidelity.
Here we describe our experimental progress of trapping ultracold atoms in arbitrary SLM-generated traps. In this experiment, we demonstrate two reservoirs connected by a channel, a guide interrupted by a junction, and a cross shape with a junction at the centre. The width of the junctions in these light patterns is determined by the diffraction limit of our optics. The cross pattern has a possible future application to the simulation of the topological Kondo effect with ultracold atoms [4].

[1] T Harte et al., Opt. Express 22, 26548 (2014).
[2] D. Bowman et al., Opt. Express 23, 8365 (2015).
[3] D. Bowman et al., Opt. Express 25, 11692 (2017).
[4] F. Buccheri et al., New J. Phys. 18, 075012 (2016).

Summary

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