Phase-engineered Light Patterns for Ultracold Atom Experiments

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In recent years, there has been increasing interest in spatially-tailored optical patterns for use in manipulating ultracold neutral atoms. In this presentation we demonstrate our methods to produce smooth, high-accuracy and multi-wavelength light patterns by engineering the phase of light with a Spatial Light Modulator (SLM).

The calculation of phase-modulating holograms is an inverse problem, and is commonly performed by variants of the Gerchberg-Saxton Iterative Fourier Transform Algorithm. In addition to this approach, we have recently developed a new method for the generation of holograms based on the direct minimisation of a cost function by a conjugate gradient local search algorithm [1]. Smoothness of the light pattern (important in cold atom experiments to avoid heating the ensemble) is ensured by regional weightings in the cost function used to determine the accuracy of the resultant light pattern. This algorithm offers a high degree of control, as demonstrated by controlling optical vortex formation, and converges even from random initials conditions.

Light patterns are experimentally realised using a single SLM illuminated by a bichromatic laser beam at 670nm and 1064nm. In order to compensate for experimental aberrations, we have developed a simple and robust feedback-enhanced algorithm [2] to improve the accuracy, which reduces the RMS error to the percent level. The combination of regional calculation and feedback algorithm can be used to generate multi-wavelength holographic light patterns using just a single SLM [3], such as the ring-shaped potential with a repulsive barrier shown in Fig 1 and originally proposed in Ref [4] for soliton interferometry.

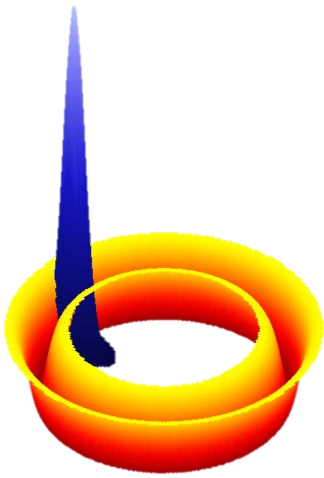

Fig. 1. Calculated ring trap with a repulsive barrier, which can be generated by illuminating a single SLM with overlapped 1064nm (red) and 670nm (blue) laser beams.

References

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