Grating chips for robust optical lattices

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More portable and robust optical lattice clocks are becoming increasingly sought-after devices with transportable versions of these traditionally lab-based devices now being demonstrated[1,2]. The experimental footprint of the optics required in these complex experiments is large due to several distinct wavelengths of light required to intersect in non-trivial geometries at the location of the atoms. Recently, much effort has gone into the extension of grating magneto-optical trap (GMOT) technology to allow a simplification of these optical systems[3] with two-color GMOTs in Sr now being demonstrated[4].

While some effort has gone into the development of more compact means of producing the optical lattices[5,6,7] these systems generally remain complex to manufacture often with multiple beam paths; variations in the relative phase of which can modulate the lattice geometry. We present a method for the generation of 1D, 2D and 3D optical lattices using a single input laser beam, interfering with the diffracted/ reflected secondary beams from a GMOT chip that is also used to trap and cool the atoms for loading into the lattice potentials. By aligning onto different regions of the grating chip and selecting an appropriate wavelength with respect to the grating period the dimensionality of the optical lattice potentials can be tailored as indicated in Fig. 1 where the optical overlap volume of the GMOT, 1D, 2D and 3D lattices are indicated. As all lattice beams originate from the same input beam these lattices are inherently robust against laser phase noise as any phase variation in the input beam is similarly mapped onto the secondary beams.

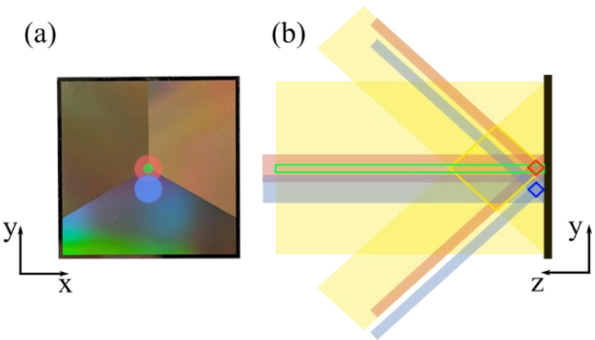

Fig. 1: (a) Image of grating chip used for trapping and cooling atoms before loading into the lattice potentials, formed from the same chip. Colored circles indicate the beam alignment position of the 1D (green), 2D (blue) and 3D (red) lattices. (b) Optical overlap volumes of the GMOT (yellow) and various lattice geometries in 2D highlighted as colored diamond shaped regions.

Here we experimentally demonstrate the 1D and 3D geometries in a cold cloud of ^{87}Rb atoms, loaded into the lattice directly from the GMOT. We believe this work will allow for more compact and robust optical lattice clocks by extending the technique to other elements such as Sr through careful grating chip design[2].

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