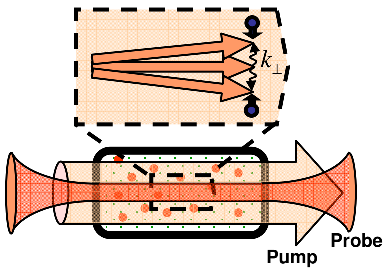
Diffraction Manipulation with Atomic Diffusion

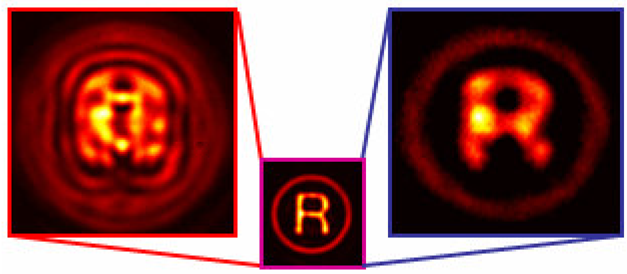
O. Firstenberg,[1] P. London,[1] M. Shuker,[1] A. Ron,[1] and N. Davidson[2]

1. Department of Physics, Technion-Israel Institute of Technology, Haifa 32000, Israel
2. Department of Physics of Complex Systems, Weizmann Institute of Science, Rehovot 76100, Israel

Any image, imprinted on a wave field and propagating in free space, undergoes a paraxial diffraction spreading and eventually blurs. The possibility to reduce or manipulate the diffraction is explored in many disciplines, for purposes such as imaging, wave guiding, microlithography, and all-optical light processing. As was recently demonstrated, arbitrary images can be imprinted on light pulses which are dramatically slowed when traversing a medium of room-temperature atoms, via the process of electromagnetically induced transparency. Having a combined nature of light and matter, the slow-light images undergo diffusion due to the thermal atomic motion [1], in addition to the optical free-space diffraction. Here, we present an experimental demonstration of a novel technique to eliminate the paraxial free-space diffraction and the diffusion of slow-light polaritons, regardless of their position and shape [2]. The scheme is linear and occurs only in the wave-vector space, rendering elimination of diffraction for arbitrary images all throughout their propagation. By properly tuning the light-matter interaction, the diffraction can be increased, reduced, eliminated completely, or even reversed [3]. The interaction may be inverted, to accelerate the diffraction in the medium, or biased, to inflict asymmetric diffraction and deflection. Doubling the strength of the interaction surpasses the regular diffraction and effectively reverses it, allowing an implementation of a negative-diffraction lens. We will also present recent experimental and theoretical results on self-similar modes of complex diffusion [4] and on implementation of vector potentials for slow light polaritons.



(a)



(b)

(a) The principle of diffraction elimination using atomic diffusion [2]. (b) A comparison between regular diffraction (left) and non-diffraction (right) of the symbol ® (centre) after 50 mm of propagation [3].

References

1. M. Shuker, O. Firstenberg, R. Pugatch, A. Ron & N. Davidson, *Phys. Rev. Lett.* **100**, 223601 (2008).

2. O. Firstenberg, M. Shuker, N. Davidson & A. Ron, *Phys. Rev. Lett.* **102**, 043601 (2009).

3. O. Firstenberg, P. London, M. Shuker, A. Ron & N. Davidson, *Nature Phys.* **5**, 665-668 (2009).

4. O. Firstenberg, R. Pugatch, P. London, M. Shuker, A. Ron & N. Davidson, *Submitted*.