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# Optimized coupling of cold atoms into a fiber using a blue-detuned hollow-beam funnel

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(Submitted on 24 Jul 2011)

We theoretically investigate the process of coupling cold atoms into the core of a hollow-core photonic-crystal optical fiber using a blue-detuned Laguerre-Gaussian beam. In contrast to the use of a red-detuned Gaussian beam to couple the atoms, the blue-detuned hollow-beam can confine cold atoms to the darkest regions of the beam thereby minimizing shifts in the internal states and making the guide highly robust to heating effects. This single optical beam is used as both a funnel and guide to maximize the number of atoms into the fiber. In the proposed experiment, Rb atoms are loaded into a magneto-optical trap (MOT) above a vertically-oriented optical fiber. We observe a gravito-optical trapping effect for atoms with high orbital momentum around the trap axis, which prevents atoms from coupling to the fiber: these atoms lack the kinetic energy to escape the potential and are thus trapped in the laser funnel indefinitely. We find that by reducing the dipolar force to the point at which the trapping effect just vanishes, it is possible to optimize the coupling of atoms into the fiber. Our simulations predict that by using a low-power (2.5 mW) and far-detuned (300 GHz) Laguerre-Gaussian beam with a 20-{\mu}m radius core hollow-fiber it is possible to couple 11% of the atoms from a MOT 9 mm away from the fiber. When MOT is positioned further away, coupling efficiencies over 50% can be achieved with larger core fibers.

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| Comments: | 11 pages, 12 figures, 1 table |
| Subjects: | **Atomic Physics (physics.atom-ph)**; Optics (physics.optics); Quantum Physics (quant-ph) |
| Cite as: | **arXiv:1107.4746 [physics.atom-ph]** |
| | (or **arXiv:1107.4746v1 [physics.atom-ph]** for this version) |

## Submission history

From: Jerome Poulin [view email]
**[v1]** Sun, 24 Jul 2011 11:19:36 GMT (2444kb)