A magnetic lens for cold atoms tuned by a rf field

E. Maréchal, B. Laburthe-Tolra, L. Vernac, J.-C. Keller, and O. Gorceix

Laboratoire de Physique des Lasers, UMR 7538 CNRS, Université Paris Nord, 99 Avenue J.-B. Clément, 93430 Villetaneuse, France
Email : marechal@galilee.univ-paris13.fr

The combination of static inhomogeneous magnetic fields with a strong resonant rf field has been recently used in many groups to realize new trapping geometries, like double well potentials, or bubble-like traps [1, 2]. A rf field allows indeed to distort static magnetic potentials into new 'adiabatic potentials' that can be continuously tailored and tuned by changing the rf field parameters [3]. Another possibility is to use rf fields to change the properties of atom-optics elements like magnetic lenses or magnetic mirrors. Following this idea, we have experimentally investigated how the focal length of a magnetic lens can be tuned with rf.

The experiment is performed using a spin polarized cloud of cold cesium atoms. The rf dressed lens is realized with two components : a static magnetic lens, made of a simple coil, and a rf field. The inhomogeneous static field defines a surface where atoms are resonant with the rf field. As atoms cross this surface, their spin is reversed, and the effect of the lens (initially converging or diverging, depending on the initial polarization) is reversed. The magnetic lens is separated by the rf interaction surface into two parts, and become equivalent to a doublet. The position of the interaction region, and therefore the focal length of the doublet can be tuned by changing the rf frequency.

After a 72 cm free fall, atoms cross the lens center, and are focused typically 10 cm below, in a 500 μm $1/e^2$ diameter spot. We show that by changing the rf frequency between 100 MHz and 250 MHz, the 10 cm magnetic focal length can be tuned over ± 2 cm. Depending on the rf antenna position, the magnetic lens can be made more converging than without rf, and can be changed by increasing the rf frequency from a converging lens to a converging mirror. The magnetic lens, in combination with a strong rf field, is conveniently described in the dressed-atom picture. The probability that atoms follow the adiabatic rf-dressed potentials can be evaluated by a Landau-Zener model, that determines the rf power requirements to get a lens with good performances. Under our experimental conditions, 10 W of rf is necessary.

Our experimental investigation of the rf-dressed lens, supported by numerical simulations is presented in [4]. This rf-dressing procedure can be combined with the well-developed integrated atom chip technology, to add coherent control to magnetic atom chips.

We acknowledge financial support by IFRAF (MOCA project).

References

[1] Y. Colombe, E. Knyazchyan, O. Morizot, B. Mercier, V. Lorent, H. Perrin, Europhys. Lett. **67**, 593 (2004)
[2] I. Lesanovsky, T. Schumm, S. Hofferberth, L. M. Andersson, P. Krüger, J. Schmiedmayer, Phys. Rev. A **73**, 033619 (2006)
[3] O. Zobay, B. M. Garraway, Phys. Rev. Lett. **86,** 1195 (2001)
[4] E. Maréchal, B. Laburthe-Tolra, L. Vernac, J.-C. Keller, O. Gorceix, Appl. Phys. B, **91**, 233 (2008)