# A continuous source of spin-polarized cold atoms

T. Vanderbruggen[1], S. Palacios[1], S. Coop[1], N. Martinez[1], and M.W. Mitchell[1,2]

[1] *ICFO - Institut de Ciencies Fotoniques, Mediterranean Technology Park, 08860 Castelldefels (Barcelona), Spain*
[2] *ICREA - Institució Catalana de Recerca i Estudis Avancats, 08015 Barcelona, Spain*

Presenting Author: thomas.vanderbruggen@icfo.es

We propose a new method to produce a continuous source of spin-polarized cold atoms [1] which are all-optically guided after their extraction from a magneto-optical trap (MOT), as depicted in Fig. 1 (a). The technique combines several physical effects and relies on light-shift engineering [Fig. 1 (b)], implemented using two coaxially overlapped optical beams each one driving a given transition of a three-level atom in a ladder configuration (Ξ-system). In a well-chosen scenario, the light-shift creates a state-dependent potential which implements the atom-diode [2] responsible for the continuous extraction of the atoms from a MOT into an all-optical guide.

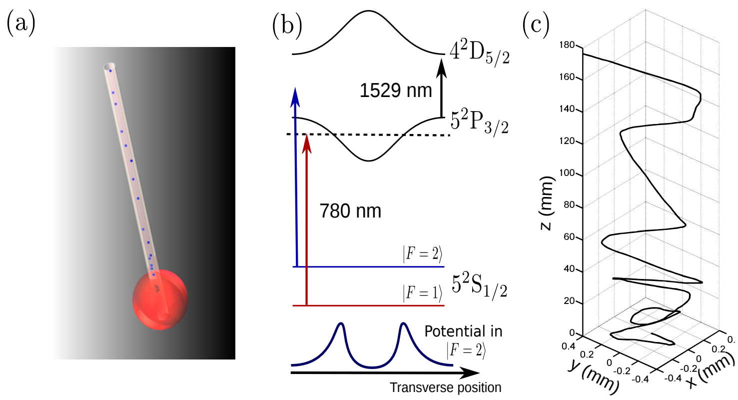


**Figure 1:** *(a) Concept: a pipe-like potential is generated all-optically. It continuously extracts the atoms from a magneto-optical trap and guide them. (b) Relevant atomic levels of $^{87}$Rb versus the transverse direction. (c) Simulation of the propagation of an atom along the guide.*

We performed a theoretical study by extending the Dalibard and Cohen-Tannoudji dressed-atom model [3] to the case of a doubly-driven Ξ-system. We analysed and quantified the dipole forces and the various sources of momentum diffusion in the resonant, non-perturbative, regime. In particular, from the Markovian evolution of the internal state, we obtain a general formula for the diffusion coefficient associated with the dipole force fluctuation.

We proposed and studied in detail the implementation of the method for $^{87}$Rb atoms. We show that, using $\sigma^+$-polarized fields driving the transitions $5^2S_{1/2} \rightarrow 5^2P_{3/2}$ and $5^2P_{3/2} \rightarrow 4^2D_{5/2}$ at 780 nm and 1529 nm respectively, a closed Ξ-system can be isolated within the complicated structure of $^{87}$Rb. Moreover, with this choice of transitions, the atoms will be optically pumped in a given Zeeman sub-state thus polarizing the atomic sample.

The theoretical results have then been used in a numerical simulation of Langevin-like equations [Fig. 1 (c)] to estimate the performance of the system both in terms of loading and guiding. We show that a large fraction of the atoms ($\sim 20\%$) is guided over at least 5 cm, the mean velocity at this distance being 3.9 m/s with a dispersion of 2.1 m/s. This guided distance could deliver the atoms inside a magnetic shield that blocks the continuously operated MOT magnetic field.

The proposed method thus creates a continuous source of guided spin-polarized cold atoms. Such a source can be of particular interest for atom interferometry.

## References

[1] T. Vanderbruggen and M. W. Mitchell, Phys. Rev. A **87**, 033410 (2013)
[2] J. J. Thorn, E. A. Schoene, T. Li and D. A. Steck, Phys. Rev. Lett. **100**, 240407 (2008).
[3] J. Dalibard and C. Cohen-Tannoudji, J. Opt. Soc. Am. B **2**, 1707 (1985).