www.onera.fr

ONERA
THE FRENCH AEROSPACE LAB

POST-DOCTORAL POSITION

Title : Quantum metrology with cold Rydberg atoms

Reference : **PDOC-DPHY-2023-01**

Start date: as soon as possible (published 28/03/2023)	**Deadline for applying :** until filled

Contract duration : 12 month, with possible extensions

Net salary : about 25 k€ yearly, with full ONERA employee benefits (including healthcare)

Key words : quantum metrology; Rydberg atoms; microwave sensors ; optical traps ; atom arrays ; spin squeezing

Requested profile : PhD in experimental atomic physics or quantum metrology, with a strong interest for the practical applications of quantum technologies. Experience with single-particle systems, optical trapping of cold atoms and/or Rydberg atoms would be an asset. Proficiency in French is not requested for this position

Context and scientific objectives

Rydberg atoms are by definition atoms with a very large principal quantum number, giving them some interesting properties for quantum technologies [1], such as large dipolar interactions making it possible to generate entanglement between atoms for quantum simulations [2], and a strong coupling to electromagnetic fields allowing the latter to be measured with very high precision [3, 4].

State-of-the-art electromagnetic field sensors based on Rydberg atoms typically use electromagnetically induced transparency in room temperature (or higher) vapor cells. We are investigating in our group a different approach based on cold Rydberg atoms. The idea is to combine the high sensitivity of Rydberg atoms with the very good degree of control and coherence that can be achieved with cold atoms controlled in optical tweezers. This could open the way to new applications in domains such as THz imaging, electromagnetic detection, calibration of light shifts in atomic clocks, but also quantum metrology experiments where the entanglement between atoms would be used to improve the sensitivity of the measurements (such as Rydberg-based spin squeezing [5, 6]).

The current experimental setup includes a magneto-optical trap of rubidium atoms and Rydberg lasers. Short-term improvements include stabilizing the Rydberg lasers to an ultrastable high-finesse reference cavity, and implementing arrays of optical tweezers to trap single or small groups of atoms.

This project is part of a joint ANR-funded project with Laboratoire Aimé Cotton (group of Patrick Cheinet) and LNE-SYRTE (group of Jérôme Lodewyck). The core ‘Rydberg’ team at ONERA, where the postdoctoral researcher will work, is composed of two permanent researchers (Alexis Bonnin and Sylvain Schwartz) and one PhD student. A second PhD student is expected to start in September 2023. We are also regularly interacting with experts from the Electromagnetism and Radar Department of ONERA.

The ‘Rydberg’ team is part of a larger group, ONERA’s ‘cold atom sensors’ group, with 6 permanent researchers, one technician and 3 PhD students. This group has about 20 years of experience in atomic inertial sensors, including the only transportable cold atom gravimeter prototype to date capable of performing airborne and seaborne measurements [7, 8]. The group holds weekly scientific meetings where we discuss scientific papers. We also have a monthly seminar with invited speakers on quantum technologies, and benefit from the intellectual environment of Paris-Saclay university (seminars, teaching, access to students and collaborations with fellow researchers).

Successful candidates are expected to hold a PhD in experimental atomic physics or quantum metrology, with a strong interest for the practical applications of quantum technologies. Experience with single-particle systems, optical trapping of cold atoms and/or Rydberg atoms would be an asset. Proficiency in French is not requested for this position.

References

[1] Adams, C. S., Pritchard, J. D., & Shaffer, J. P. (2019). Rydberg atom quantum technologies. Journal of Physics B: Atomic, Molecular and Optical Physics, 53(1), 012002.

[2] Browaeys, A., & Lahaye, T. (2020). Many-body physics with individually controlled Rydberg atoms. Nature Physics, 16(2), 132-142.

[3] Meyer, D. H., Castillo, Z. A., Cox, K. C., & Kunz, P. D. (2020). Assessment of Rydberg atoms for wideband electric field sensing. Journal of Physics B: Atomic, Molecular and Optical Physics, 53(3), 034001.

[4] Fancher, C. T., Scherer, D. R., John, M. C. S., & Marlow, B. L. S. (2021). Rydberg atom electric field sensors for communications and sensing. IEEE Transactions on Quantum Engineering, 2, 1-13.

[5] Gil, L. I. R., Mukherjee, R., Bridge, E. M., Jones, M. P. A., & Pohl, T. (2014). Spin squeezing in a Rydberg lattice clock. Physical Review Letters, 112(10), 103601.

[6] Hines, J., Rajagopal, S., Moreau, G., Koyluoglu, N., & Schleier-Smith, M. (2022). Rydberg-Dressed Ising Interactions for Floquet-Enhanced Spin Squeezing. In APS Division of Atomic, Molecular and Optical Physics Meeting Abstracts (Vol. 2022, pp. V01-023).

[7] Bidel, Y., Zahzam, N., Blanchard, C., Bonnin, A., Cadoret, M., Bresson, A., ... & Lequentrec-Lalancette, M. F. (2018). Absolute marine gravimetry with matter-wave interferometry. Nature communications, 9(1), 627.

[8] Bidel, Y., Zahzam, N., Bresson, A., Blanchard, C., Cadoret, M., Olesen, A. V., & Forsberg, R. (2020). Absolute airborne gravimetry with a cold atom sensor. Journal of Geodesy, 94, 1-9.

Collaborations : joint ANR project with Laboratoire Aimé Cotton (group of Patrick Cheinet) and SYRTE (group of Jérôme Lodewyck)

Contact information at ONERA

Department : Physics Instrumentation Environment Space

Location : Palaiseau, France (< 20 km from downtown Paris)

Contact : Sylvain Schwartz / Alexis Bonnin

Tel. : +33180386163 Email : sylvain.schwartz@onera.fr / alexis.bonnin@onera.fr