INTERNSHIP PROPOSAL

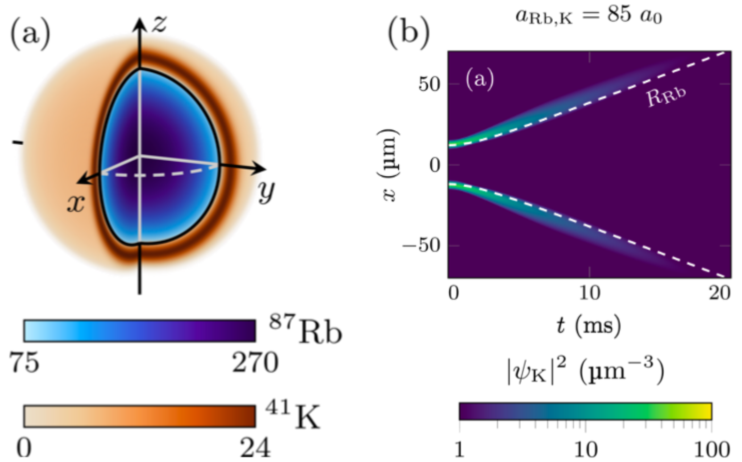
(One page maximum)

Laboratory name: ISMO – Université Paris-Saclay
CNRS identification code: UMR 8214
Internship director'surname: Eric CHARRON
e-mail: eric.charron@universite-paris-saclay.fr Phone number: 01 69 15 61 14
Web page: http://www.ismo.universite-paris-saclay.fr/spip.php?rubrique56
Internship location: ISMO – Université Paris-Saclay – Bâtiment 520 – 91405 Orsay cedex
Et : IQO – Leibniz Universität Hannover – Germany

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: DFG-ANR Funds

Quantum Bubbles with Degenerate Mixtures

Ultracold quantum gases confined in three-dimensional bubble traps are promising tools for exploring many-body effects on curved manifolds. As an alternative to the conventional technique of radio-frequency dressing, one could create such shell-shaped Bose-Einstein condensates in microgravity based on dual-species atomic mixtures [1]. Beyond similarities with the radio-frequency dressing method as in the collective-excitation spectrum, this approach has several natural advantages like the robustness of the created quantum bubbles and the possibility to magnify shell effects through an interaction-driven expansion. The internship proposed here, co-supervised by Prof. Eric Charron in Paris-Saclay University (France) and by Dr. Naceur Gaaloul at the Leibniz University of Hanover (Germany), aims to theoretically explore dynamical effects on the surface of quantum bubbles (collective oscillations, vortex physics, etc.) that are unique to this system with periodic boundary conditions. Proposals to implement these findings in existing microgravity and space experiments accessible to both groups [2,3] will be sought for.



(a) Shell-shaped ground state density distribution of a spherical-symmetric Rb-K mixture represented by a cut open 3D density plot (in μm-3) (b) Time evolution of the free expansion of a spherically symmetric K density distribution using the initial shell-shaped state represented in (a). Solely switching off the external confinement leads to an expanding shell with its size being proportional to the edge of the expanding inner Rb core (figure adapted from Ref. [1]).

References

[1] A. Wolf, P. Boegel, M. Meister, A. Balaž, N. Gaaloul and M. A. Efremov, Shell-shaped Bose-Einstein condensates based on dual-species mixtures, Phys. Rev. A 106, 013309 (2022).

[2] N. Gaaloul, M. Meister, R. Corgier, A. Pichery, P. Boegel, W. Herr, H. Ahlers, E. Charron, J. R Williams, R. J. Thompson, W. P. Schleich, E. M. Rasel and N. P. Bigelow, A space-based quantum gas laboratory at picokelvin energy scales, Nat. Comm. 13 7889 (2022).

[3] E. R. Elliot, D. C. Aveline, N. P. Bigelow, P. Boegel, S. Botsi, E. Charron, J. P. D'Incao, P. Engels, T. Estrampes, N. Gaaloul et al., Quantum Gas Mixtures and Dual-Species Atom Interferometry in Space, Arxiv:2306.15223, Accepted in Nature (2023).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: YES Theoretical Physics: NO