Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: **ONERA-DPHY**
CNRS identification code: /
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Thesis possibility after internship: **YES**
Funding: **YES** Type of funding: **CNES, ESA, DGA, ONERA**

Title

Development of a hybrid multi-species cold atom interferometer

ONERA has been participating for about fifteen years now in the development of inertial matter wave sensors (accelerometer, gyrometer and gradiometer). These instruments, with excellent performance, rely on the interaction between cold atoms and a laser to create an interferometer that is highly sensitive to inertial effects.

The research team in which the proposed work will take place is currently playing a pioneering role in the development of atomic inertial sensors manipulating several atomic species simultaneously. Moreover, ONERA has demonstrated the realization of the first dual atom interferometer allowing simultaneous acceleration measurements of two different atomic species (85Rb and 87Rb). Today, the instrument is developed to also allow the manipulation of a third atomic species (133Cs). The use of three species within the same instrument offers many perspectives to improve the current performances of atomic inertial sensors, such as for example to benefit from a continuous measurement without dead time. The multi-species character of the instrument gives it a great potential for applications in the field of fundamental physics as well as in the more applied fields of navigation, geophysics, ...

The cold atom instrument will also allow to study the operation of a so-called hybrid inertial sensor, combining the performances of an electrostatic accelerometer, dedicated to space environment, with those of an atomic interferometer whose technology seems very promising for future space geodesy missions. This study is part of the development of increasingly high-performance instruments to meet the needs of future space missions. Note that in this original hybrid scheme, the proof-mass of the electrostatic accelerometer could act as a measurement reference for the atomic instrument. This proof-mass can be rotated synchronously during satellite rotation in orbit to compensate for the detrimental effects of rotation on the atomic signal.

At this stage of development, the experiment includes a fully operational lab prototype of electrostatic accelerometer combined with a one atomic species cold atom gravimeter. Concerning the hybridization, some analysis have already been led but should be pushed further to assess the full potential of such innovative instruments, more especially concerning rotation compensation and simultaneous measurement of acceleration. Concerning the multi-species atomic instrument, all the sub-systems including the lasers, microwaves or vacuum chamber have been realized. A triple species Magneto-Optical-Trap has been obtained but should still be characterized in detail. A next step will be the implementation of laser manipulation sequences of atomic wave packets to form an atom interferometer with each atomic species which should lead ultimately to the realization of the first cold atom accelerometer with no dead time. A reflection will be conducted to evaluate the best strategy for combining interferometric signals from the three atomic species 87Rb, 85Rb and 133Cs to achieve optimal performance.

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