MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Gravity and Fundamental Physics (1)

Author: Mr. Stéphane Thomin
SODERN, France, stephane.thomin@sodern.fr

Mr. Olivier Grosjean
Centre National d'Etudes Spatiales (CNES), France, olivier.grosjean@cnes.fr
Mr. Philippe Laurent
LNE-SYRTE, France, philippe.laurent@obspm.fr
Mr. Arnaud Colmon
SODERN, France, arnaud.colmon@sodern.fr

PHARAO'S CESIUM TUBE

Abstract

PHARAO (Projet d'Horloge Atomique à Refroidissement d'Atomes en Orbite), a scientific project funded by the French Centre National d'Etudes Spatiales, together with a Hydrogen Maser, are two atomic clocks on board ESA's ACES (Atomic Clock Ensemble in Space) platform which will dock on the International Space Station.

PHARAO will be the first space atomic clock to use the physical principle of atoms cooling, to make it one of the most accurate and precise clock ever built.

SODERN was selected to design, integrate and test two main clock equipments, namely the Cesium Tube and the Laser Source, before final instrument integration by CNES in Toulouse and test with the SYRTE (Systèmes de Référence Temps Espace) researchers.

The main challenges in the development of the Cesium Tube were simultaneous engineering, development of specific innovative technologies which are compatible with amagnetism and ultra-high vacuum and mass reduction.

The Cesium Tube is mainly made of:

- The Ultra-High Vacuum Tube where the Cs atoms are manipulated. The pressure in the tube must be maintained down to 1.5 x 10-10 mbar. Specific developments were needed in order to reach this value : preparation of titanium surfaces, use of getters, development of a 3 l/s space qualified ion pump connected to a proprietary 5 kV power supply. Also a specific silica/titanium brazing process for the windows was developed and qualified.

- The magnetic subsystem is made of three concentric cylindrical magnetic shields and an original active compensation coil and servo-loop with a magnetometer in order to attenuate the outer Earth magnetic field by a factor of 400 000.

- The optical subsystem comprises 10 collimators fixed to the Ultra-High Vacuum tube and equipped with optical fibres for laser injection. Precise positioning of the laser beams is obtained by adjusting rotation and translation wedges on top of each collimator. The six degrees of freedom of each optical fibre may need to be adjusted independently on every collimator.

The flight model of the Cesium Tube is being integrated in SODERN for a delivery scheduled mid-2012.

The paper emphasizes some of the technological challenges encountered during the development of the Cesium Tube. It also shows some of the flight model integration progress phases. Finally, it states how PHARAO developed technologies can be used by SODERN for some other space equipments.