Archimedes is an INFN-funded pathfinder experiment aimed at verifying the feasibility of measuring the interaction of vacuum fluctuations with gravity. The final experiment will measure the force exerted by the gravitational field on a Casimir cavity whose vacuum energy is modulated with a superconductive transition, by using a balance as a small force detector. Archimedes is two-year project devoted to test the most critical experimental aspects, in particular the balance resonance frequency and quality factor, the thermal modulation efficiency and the superconductive sample realization.

From the cosmological constant problem:
why does vacuum energy exhibit a gravitational contribution enormously lower than the predicted one? Does vacuum gravitate or not?

The Casimir Energy

The Casimir effect is a macroscopic manifestation of vacuum fluctuations. It is derived considering the zero point e.m. energy contained in a Casimir cavity, i.e. in the volume defined by two perfectly reflecting parallel plates.

If the plates are perfectly reflecting the modes that can oscillate must have discrete wavenumbers on vertical axes, \( k_x \neq n_x \pi / a \) while all values are allowed for \( k_y \).

\[
E(a) = \frac{\hbar A}{2} \sum_{m=0}^{\infty} \frac{d^2 k}{(2\pi)^4} \left( k_x^2 + \frac{n_x^2}{a^2} \right) \rightarrow \infty
\]

The regularization is made by determining the Casimir Energy as the change in energy when the plates are at distance \( a \) with respect to the plates having a \( \infty \)

\[
E_c = E(a) - E(\infty) = -\frac{\pi^2 \hbar c}{720 a^3}
\]

The vacuum weight

If the vacuum «weights» then there is a force, directed upward, equal to the weight of the modes expelled from the cavity when it becomes superconducting.

\[
\vec{F}_{\text{tot}} = \frac{E_c}{c^2} \left[ 1 \right] g \left[ 2 \right]
\]

The Experiment

- Seismically isolated balance
- Temperature modulation around Tc
- Balance tilt possibly read with an optical lever

The Balance

\[ \text{Scheme of the balance with suspended samples} \]

Zoom on the frictional joints where the balance will be suspended

The thermal actuation

- FIM with only radiation
- FIM with conduction links

Temperature of the sample

Temperature of the sample with only radiation heat exchange

Temperature of the sample with conduction heat exchange

Conclusions

Archimedes is a two-year feasibility study concerning:
- Theory and modulation of vacuum energy in layered Superconducting systems
- Experimental improvement of basic performance at low frequency
- Experimental improvements of high performance superconductors temperature modulation

References