

# **The Low-Energy Frontier of Particle Physics**

## **Report of Contributions**

Contribution ID: 1

Type: **not specified**

## **Lunch at LNF canteen**

Contribution ID: 2

Type: **not specified**

## **Fifth Force and Fundamental Constants**

Contribution ID: 3

Type: **not specified**

## The Low Energy Frontier of Particle Physics

*Monday, 10 February 2025 14:30 (40 minutes)*

opening Talk

**Presenter:** BUDKER, DMITRY (Helmholtz Institute Mainz)

Contribution ID: 4

Type: **not specified**

## Opto-mechanical Resonators

*Monday, 10 February 2025 15:10 (40 minutes)*

**Presenter:** MARIN, Francesco (INFN Firenze)

**Session Classification:** Gravity and Quantum Mechanics

Contribution ID: 5

Type: **not specified**

## **The Archimedes Experiment: a way for exploring the Vacuum-Gravity Interaction**

*Monday, 10 February 2025 15:50 (40 minutes)*

The Archimedes experiment has the goal to measure the vacuum fluctuations interaction with Gravity. A high sensitive balance is employed to measure the small weight variations of high  $T_c$  superconducting samples when they pass to their superconductive status.

We describe the challenging experimental solutions adopted for having a very efficient heat exchange with the samples only through the radiation mechanism and we present the first promising results to reach the goal of this experiment.

**Presenter:** Dr PUPPO, Paola (INFN - ROMA)

**Session Classification:** Gravity and Quantum Mechanics

Contribution ID: 6

Type: **not specified**

## Quantum effects in gravity from a delocalised quantum source

*Monday, 10 February 2025 17:00 (40 minutes)*

Understanding the fundamental nature of gravity at the interface with quantum theory is a major open question in theoretical physics. Recently, the study of gravitating quantum systems, for instance a massive quantum system prepared in a quantum superposition of positions and sourcing a gravitational field, has attracted a lot of attention: quantum optics experiments are working towards realising such a scenario in the laboratory, and measuring the gravitational field associated to a quantum source is expected to give some information about the nature of gravity. On the theory side, quantum information tools are used to interpret the results. However, there are still open questions concerning the precise conclusions that these experiments could draw on the quantum nature of gravity, such as whether experiments in this regime will be able to test more than the Newtonian part of the gravitational field.

In my talk, I will present a new result, where a delocalised quantum source gives rise to effects that cannot be reproduced using the Newton potential nor as a limit of classical General Relativity. These effects can in principle be measured by performing an interference experiment, and are independent of graviton emission.

Identifying stronger quantum aspects of gravity than those reproducible with the Newton potential is crucial to prove the nonclassicality of the gravitational field and to plan a new generation of experiments testing quantum aspects of gravity in a broader sense than what proposed so far.

**Presenter:** GIACOMINI, Flaminia (ETH Zürich)

**Session Classification:** Gravity and Quantum Mechanics

Contribution ID: 7

Type: **not specified**

## Atomic fountain

*Monday, 10 February 2025 17:40 (40 minutes)*

**Presenter:** POLI, Nicola (Istituto Nazionale di Fisica Nucleare)

**Session Classification:** Gravity and Quantum Mechanics



Contribution ID: 8

Type: **not specified**

## Discussion

*Monday, 10 February 2025 18:20 (20 minutes)*

**Session Classification:** Gravity and Quantum Mechanics

Contribution ID: 9

Type: **not specified**

## VIP Experiment

*Tuesday, 11 February 2025 09:30 (40 minutes)*

**Presenter:** NAPOLITANO, Fabrizio (Istituto Nazionale di Fisica Nucleare)

**Session Classification:** Symmetry Violation

Contribution ID: **10**Type: **not specified**

## Probing the electron's EDM using cold and slow molecules

*Tuesday, 11 February 2025 10:10 (40 minutes)*

Precision measurements on molecular quantum systems have developed into a powerful way to explore new physics. Such measurements are currently the most sensitive way to probe an effective asymmetry in the charge distribution of the electron - its electric dipole moment. Through a measurement of this property, limits can be set on possible extensions of the Standard model of particle physics. In this talk we will present the context, methods and latest developments in this field where the precision techniques of atomic and molecular physics are used to probe the frontiers of particle physics. A particular focus is put on our work to produce slow beams and trapped samples of suitable molecules.

**Presenter:** HOEKSTRA, Steven

**Session Classification:** Symmetry Violation

Contribution ID: **11**

Type: **not specified**

## **Theory Talk 1**

*Tuesday, 11 February 2025 11:30 (40 minutes)*

**Presenter:** JAECKEL, Joerg

**Session Classification:** Symmetry Violation

Contribution ID: 12

Type: **not specified**

## Theory Talk 2

*Tuesday, 11 February 2025 12:10 (40 minutes)*

**Session Classification:** Symmetry Violation

Contribution ID: 13

Type: **not specified**

## **Discussion on Symmetry Violations**

*Tuesday, 11 February 2025 12:50 (40 minutes)*

**Session Classification:** Symmetry Violation

Contribution ID: 14

Type: **not specified**

## Fundamental physics with levitated micromagnets

*Tuesday, 11 February 2025 14:30 (40 minutes)*

Macroscopic and mesoscopic ferromagnets levitated by Meissner effect in vacuum behave as multimode mechanical systems with ultrahigh quality factor and high sensitivity to external magnetic fields. Furthermore, they can be easily coupled to superconducting quantum devices. This suggests the possibility of using this experimental platform for a variety of measurements in the context of fundamental and quantum physics. In this talk I will review our recent experimental work on levitated micromagnets with SQUID-based detection. Among various results, we have recently demonstrated magnetic field resolution beyond the energy resolution limit, atomic-like gyroscopic effects, and ultrafast spinning at MHz frequencies. I will discuss potential applications to fundamental physics, including the search for ultralight dark matter, fifth force measurements, and more speculative investigations on the macroscopic limits of quantum mechanics.

**Presenter:** VINANTE, Andrea (Istituto Nazionale di Fisica Nucleare)

**Session Classification:** Light Dark Matter

Contribution ID: 15

Type: **not specified**

## **New Detection of Dark Matter**

*Tuesday, 11 February 2025 15:10 (40 minutes)*

**Session Classification:** Light Dark Matter



Contribution ID: **16**

Type: **not specified**

## **ANDROMeDa**

*Tuesday, 11 February 2025 15:50 (40 minutes)*

**Presenter:** PANDOLFI, Francesco (INFN Rome)

**Session Classification:** Light Dark Matter

Contribution ID: 17

Type: **not specified**

## DELIGHT: The Direct Search Experiment for Light Dark Matter

*Tuesday, 11 February 2025 17:00 (40 minutes)*

There is vast parameter space to explore for dark matter masses below a few GeV, and the field of direct dark matter detection is constantly expanding to new frontiers. In particular, low mass dark matter candidates necessitate novel detector designs with lower thresholds and alternative target materials compared to e.g. the xenon-based experiments currently providing the strongest overall constraints on many dark matter models. The Direct search Experiment for Light dark matter (DELIGHT) will deploy a target of superfluid  $^4\text{He}$  instrumented with large area microcalorimeters (LAMCALs) based on magnetic microcalorimeter (MMC) technology in a setup optimized for low mass dark matter searches. In this talk the motivation, setup, and current status of this novel upcoming experiment will be presented.

**Presenter:** FASCIONE, Eleanor Katherine

**Session Classification:** Light Dark Matter

Contribution ID: **18**

Type: **not specified**

## **New Frontiers**

*Tuesday, 11 February 2025 17:40 (40 minutes)*

**Presenter:** ESPOSITO, Angelo (Istituto Nazionale di Fisica Nucleare)

**Session Classification:** Light Dark Matter

Contribution ID: **19**

Type: **not specified**

## **Axion Experiments**

*Tuesday, 11 February 2025 18:20 (40 minutes)*

**Session Classification:** Light Dark Matter

Contribution ID: 20

Type: **not specified**

## Discussion on Light Dark Matter

*Tuesday, 11 February 2025 19:00 (20 minutes)*

**Session Classification:** Light Dark Matter

Contribution ID: 21

Type: **not specified**

## Overview of $^{229\text{m}}\text{Th}$ based nuclear clock

*Wednesday, 12 February 2025 09:30 (40 minutes)*

Nuclear transitions have energy scale a few orders of magnitude larger than atomic ones. This mismatch of energy scales prevented to use laser sources for excitation of nuclear levels. In the 70th it was deduced that  $^{229}\text{Th}$  isotope might have an isomeric state at the energy of a few eVs. Recently, with development of the optical frequency combs, this state stimulated a broad interest, in particular regarding a possible nuclear clock application, allowing to enhance the atomic clock precision and test correlations between fundamental forces. In the last decade many experiments on the  $^{229\text{m}}\text{Th}$  isomer were performed, including TORIO-229 experiment of INFN, confirming the past expectations. In this presentation an overview of the current knowledge on the lowest nuclear isomer  $^{229\text{m}}\text{Th}$  will be presented as well as its possible future applications.

**Presenter:** Dr OSIPENKO, Mikhail (GE)

**Session Classification:** Fifth Force and Variation of Fundamental Constants

Contribution ID: 22

Type: **not specified**

## Frequency metrology of buffer-gas-cooled molecular spectra for fundamental Physics research

*Wednesday, 12 February 2025 10:10 (40 minutes)*

Based on the production of molecular samples at cryogenic temperatures by the buffer-gas-cooling technique and their combination with cavity-enhanced spectroscopy in the Lamb-dip regime, we present a new generation of high-accuracy physics tests beyond the Standard Model at the eV energy scale. Examples include searching for putative fifth-force interactions and assessing the space-time stability of the proton-to-electron mass ratio.

**Presenter:** MADDALONI, Pasquale (Istituto Nazionale di Fisica Nucleare)

**Session Classification:** Fifth Force and Variation of Fundamental Constants

Contribution ID: 23

Type: **not specified**

## Long range forces: A theory review

*Wednesday, 12 February 2025 11:30 (40 minutes)*

Various types of BSM physics, in particular new light particles, can lead to long-range forces. We can search for such “fifth force” interactions by sensitivity measuring gravity on various scales. In this talk, I will review how such long-range forces can be generated and how they lead to apparent violations of the inverse-square law and the equivalence principle of gravity. I will also discuss the of different types of long-range forces and give an overview of which kinds of BSM physics that long-range forces can be used to test.

**Presenter:** SOERENSEN, Philip (Istituto Nazionale di Fisica Nucleare)

**Session Classification:** Fifth Force and Variation of Fundamental Constants



Contribution ID: 24

Type: **not specified**

## **Discussion on 5th force and variation of fundamental constants**

*Wednesday, 12 February 2025 12:10 (50 minutes)*

**Session Classification:** Fifth Force and Variation of Fundamental Constants