

PhD Thesis - KWISP at CAST - Dottorato in Fisica - UniTS

G. Cantatore - 10/5/2019

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Experimental search for Dark Energy: detection of solar chameleons with an opto-mechanical force sensor at CAST

Abstract

The CAST experiment at CERN (<http://cast.web.cern.ch/CAST/>) is searching for Dark Matter and Dark Energy candidate constituents in the form of Axion and Chameleon particles. Both these exotic species could, for example, be produced in the Sun and stream to Earth. CAST attempts to detect them by tracking the sun with a large superconducting magnet mounted on a special moveable platform. Its magnetic field can cause the conversion of Axions and Chameleons into photons, to be then observed with specific detectors. In addition, the CAST apparatus is equipped with a series of superconducting resonant microwave cavities to detect the presence of non-relativistic Axions left over from the Big Bang. These Axions can either accrete gravitationally around the galactic core or stream through the galaxy subject to gravitational lensing.

Chameleons, due to their specific nature, also possess a type of direct interaction with matter that can be exploited to detect their presence through the momentum deposited on a specially designed opto-mechanical force sensor. This sensor, called KWISP for Kinetic WISP detection, has been originally developed at INFN Trieste and its first two versions have already taken “live” data at CAST. It is now undergoing its third upgrade to a monolithic compact system which will go online at CAST in the coming months, while the next major challenge is to achieve cryogenic operation.

Specific thesis topic

Developing, building and testing advanced versions of the KWISP force sensor. The sensing element of this device is a thin (100 nm) Si_3N_4 membrane which displaces under the influence of an external force. These displacements are readout with a resonant Fabry-Perot interferometry. Membrane displacements as small as 10^{-15} m, the size of an atomic nucleus, can be routinely measured with KWISP. The thesis work will include the design and testing of KWISP upgrades, including cryogenic developments, measurements in an advanced optics laboratory, participation in the measurement runs at the CAST experiment at CERN.

Main experiment location

CERN, Geneva - CAST Experiment

<http://cast.web.cern.ch/CAST/>

Participating Institutions

UniTS

Several international Institutions and Universities (see website)

People locally involved

G. Cantatore (UniTS and INFN Trieste) - supervisor

M. Karuza (INFN Trieste and UniRijeka (HR))