PhD Thesis - Dark Matter searches with the KWISP force sensor - Dottorato in Fisica - UniTS

G. Cantatore - 13/6/2022
giovanni.cantatore@ts.infn.it
giovanni.cantatore@cern.ch

KWISP: experimental search for Dark Matter with a network of opto-mechanical force sensors

Abstract

The KWISP force sensor is an opto-mechanical device based on a thin membrane which flexes under a tiny external force, thus displacing itself from its equilibrium position. Membrane displacements are then read out using an interferometric optical layout. KWISP, or "Kinetic detection of Weakly Interacting Slim Particles", thanks to its exceptional force sensitivity in the pico-Newton range, can be used to search for cosmic Dark Matter fluxes depositing momentum on the sensing membrane. Since the KWISP detector has also directional capabilities, a network of KWISP sensors is being setup to intercept possible Dark Matter streaming particles and pinpoint their velocity vector. At the moment two sensors are operational, one in Trieste and one in Rijeka, Croatia, while a third one is being prepared to be installed at the University of Camerino. The network will eventually be integrated with a fourth sensor placed at CERN. Future developments are centered on enhancing the detector sensitivity by achieving operation at sub-Kelvin temperatures.

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 as small as a few pico-Newton. These displacements are readout with a Michelson interferometer equipped with a balanced homodyne readout. 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 setting up and running the KWISP dark matter detector network in collaboration with researchers from the other participating institutions. The PhD candidate, besides acquiring practical skills in an advanced optics laboratory and in data acquisition and analysis, will have the opportunity to actively search for Dark Matter and participate in one of the most exciting quests in contemporary physics.

Main experiment locations
INFN Laboratories, Trieste
University of Rijeka Laboratories, Rijeka, Croatia
University of Camerino Laboratories
CERN

Participating Institutions
UniTS
INFN Sezione di Trieste
University of Rijeka, Rijeka, Croatia
University of Camerino
CERN

People locally involved
G. Cantatore (UniTS and INFN Trieste) - supervisor
M. Karuza (INFN Trieste and UniRijeka (HR)