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CRAB: Calibration by Recoils for Accurate Bolometry at the 100 eV scale using neutron capture – on the shore of particle, nuclear and solid state physics

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The detection of the coherent elastic neutrino-nucleus scattering (CEνNS) at reactors or of an hypothetical light dark matter (DM) particles will allow to test new physics beyond the standard model. In both cases their direct detection will lead to sub-keV nuclear recoils. This requires low energy thresholds of few 10 eV along with energy resolutions of few eV, which can be achieved by cryogenic detector operated at mK temperatures. Understanding the response of these detectors at a sub-keV energy scale is therefore crucial but remains a challenge. Up to now the calibrations have been only performed with X-rays sources leading to electronic recoils above keV energies. Recently the CRAB collaboration has proposed [1], based on the nuclear de-excitation FIFRELIN code predictions [2], to calibrate the cryo-detectors with pure nuclear recoils induced by thermal neutron radiative captures, mimicking the CEνNS or DM signals. In fact single-gamma cascades of several MeV produce nuclear recoil calibration peaks between 100 eV – 1 keV in a mm/cm-scale cryo-detector.
We discuss the first measurement performed with a CaWO4 cryogenic detector of the NUCLEUS experiment [3] and with thermal neutrons produced with a 252Cf source showing a nuclear recoil peak at around 112 eV (182W(n,γ)183W) with a 3σ significance and evidence at the 6σ level of the nuclear recoil spectrum, in very good agreement with FIFRELIN-GEANT4 simulations [4]. This has been recently confirmed by the DM experiment CRESST [5], demonstrating the feasibility of this method as an in-situ non-intrusive calibration of cryogenic detectors.
Then we present the interplay between the nuclear de-excitation timing and atom recoil in matter timing which has recently been investigated in coupling the FIFRELIN and IRADINA [6] (binary collisation approximation) codes. It shows that the nuclear recoil spectrum shape can be significantly impacted, especially for germanium and silicone detectors [7], and so the calibration.
An up-coming high precision measurement will be performed at the TRIGA Mark-II reactor in Vienna where the gammas escaping the cryo-detector will be tagged in addition to the nuclear recoil. This will allow to get more calibration peaks to test the detector linearity response, to determine quenching factors and could also set constraints on nuclear models and solid state physics.

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