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Scintillating bolometers based on ZnMoO₄ and Zn¹⁰⁰MoO₄ crystals to search for 0ν2β decay of ¹⁰⁰Mo (LUMINEU project): first tests at the Modane Underground Laboratory

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Neutrinoless double beta (0ν2β) decay is a powerful tool to investigate neutrino properties, weak interaction, and effects beyond the Standard Model of particle physics. The main aim of the LUMINEU project (Luminescent Underground Molybdenum Investigation for NEUtrino mass and nature) is to realize a pilot experiment to search for 0ν2β decay of ¹⁰⁰Mo with the help of zinc molybdate (ZnMoO₄) crystals operated as scintillating bolometers and to demonstrate prospects of this technique for a next large scale 0ν2β experiment to probe the inverted neutrino mass hierarchy. First results of measurements with a 313 g ZnMoO₄ crystal installed in the low-background EDELWEISS set-up at the Modane Underground Laboratory (LSM, France) show high energy resolution (FWHM = 9 keV at 2615 keV) and excellent rejection efficiency from alpha particles in the region of interest (above 2.6 MeV) by using the light and the heat signals. The radiopurity of the ZnMoO₄ sample, derived from the 851 h data of the low background test, satisfies the LUMINEU goals: trace internal contamination is related with ²¹⁰Po at the level of 0.62(3) mBq/kg, ²²⁶Ra (0.026(5) mBq/kg), and ²²⁸Th (0.010(3) mBq/kg), while only limits on the activity of other naturally occurring alpha radionuclides (from U/Th families, ¹⁴⁷Sm and ¹⁹⁰Pt) were set in the range of 0.003–0.014 mBq/kg.

In December 2013 improved ZnMoO₄ cylindrical crystals, with size D50 x 40 mm and mass 334 and 336 g, have been produced by recrystallization using the low-thermal-gradient Czochralski technique from molybdenum purified by double recrystallization from aqueous solutions. Moreover, a zinc molybdate crystal from enriched ¹⁰⁰Mo (Zn¹⁰⁰MoO₄) was successfully grown for the first time. Two samples cut from the Zn¹⁰⁰MoO₄ boule (with mass 59 and 63 g) were tested as scintillating bolometers at the Centre de Sciences Nucléaires et de Sciences de la Matière (Orsay) with satisfactory results, and then installed in the EDELWEISS set-up at the LSM. First results of the low background measurements with the new LUMINEU detectors, as well as prospects of scintillating bolometers array based on 48 Zn¹⁰⁰MoO₄ crystals (which contain ~ 10 kg of enriched ¹⁰⁰Mo) and located in the EDELWEISS set-up will be presented.

Summary

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