Status of the geochemical determination of the solar pp-neutrino flux by LOREX

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Abstract

Allchar is a Sb-As-Tl-Au deposit located in FYR Macedonia at the northwestern margins of the Kožuf Mountains, close to the border between FYR Macedonia and Greece. The mine contains the world's largest known concentrations of thallium-bearing minerals and, in particular, the mineral lorandite (TlAsS2). LOREX, the acronym for LORandite EXperiment, is the only geochemical solar neutrino experiment still actively pursued. It addresses the determination of the long-time average of the solar neutrino flux using the lorandite from Allchar via the neutrino-capture reaction $^{205}Tl + \nu_e ?^{205}Pb + e^-$. The final step of LOREX would be extraction of lorandite and quantitative determination of the ratio of $^{205}Pb/^{205}Tl$ atoms, thus providing the product of solar neutrino flux and neutrino-capture cross section, integrated over the age of the lorandite of 4.31 My. In contrast to the production of ^{205}Pb by solar neutrinos, which is independent of depth, cosmogenic ^{205}Pb produced from fast muons of the secondary cosmic-ray cascade is strongly depth-dependent and very sensitive to the long-term erosion history of the field area. To determine the erosion rate, we applied three different methods: geomorphologic analysis, accelerator mass spectrometry of long-lived radioactive cosmogenic nuclides (^{10}Be and ^{26}Al) and finally noble gas mass spectrometry of the stable cosmogenic nuclides ^{3}He and ^{21}Ne. For the two important Allchar locations with ore bodies containing lorandite, we thus propose erosion rates of 70 m/My at Crven Dol and 130 m/My at Centralni Deo. With these erosion rates the paleo-depths of lorandite bearing ore-bodies at the time of mineralization range from 450 to 1070 [mwe] what, contrary to some earlier discouraging estimates, leads to satisfactory signal/background ratios. Finally, it is discussed how to obtain the still unknown capture probability of solar pp-neutrinos from ^{205}Tl into ^{205}Pb via the measurement of the lifetime for the bound beta decay of the completely ionised ^{205}Tl, as well as how to count by Schottky mass spectrometry the extremely small number of ^{205}Pb atoms i.e. it is estimated that, depending on paleo-depth, 10kg of lorandite contains about (3.5 - 11.6) $\times 10^5$ atoms of ^{205}Pb, what is needed to attain the accuracy of the final result of the order of about 30%. Both crucial measurements are planned to be carried out at the GSI.

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