Current status of the Ga-Cr neutrino project

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Abstract

The Russian-American experiment SAGE [1] is situated in a specially built underground laboratory at the Baksan Neutrino Observatory of INR RAS in the northern Caucasus Mountains. The main chamber of the laboratory is 60 m long, 10 m wide and 12 m high. It is located 3.5 km from the entrance of a horizontal adit excavated into the side of Mount Andyrchi and has an overhead shielding of 4700 meters of water equivalent. The combined analysis of 214 extractions from December 1989 through December 2011 gives a capture rate of solar neutrinos with energy more than 233 keV of $65.4^{+3.1}_{-3.0}(stat)^{+2.6}_{-2.8}(syst)$ SNU. The weighted average of the results of all three Ga solar neutrino experiments, SAGE, Gallex, and GNO, is now 66.1±3.1 SNU, where statistical and systematic uncertainties have been combined in quadrature.

The experimental procedures of the SAGE and Gallex experiments have been checked by exposing the gallium target to reactor-produced neutrino sources whose activity was close to 1 MCi. The weighted average value of the ratio R of the measured ^{71}Ge production rate to that expected for the four experiments is R = 0.87 ± 0.05 [2], more than two standard deviations less than unity.

A probable explanation that this low result is overestimation of the cross section for neutrino capture by the two lowest-lying excited states in ^{71}Ge has not been confirmed [3]. Other explanations might be a statistical fluctuation or a real physical effect of unknown origin, such as a transition to sterile neutrinos [2]. Possibilities of SAGE for investigation of transitions from active to sterile neutrinos with $\Delta m^2 > 0.5$ eV^2 with a sensitivity to disappearance of electron neutrinos of a few percent are discussed. The interpretation of the Ga source experiments in terms of oscillations to a sterile neutrino with $\Delta m^2 \approx 1$ eV^{2}is considered in detail in Ref. [4].

To further investigate the sterile neutrino explanation for the Ga source experiments, we intend to pursue an improved version of these measurements which is described here. Our plan is to place a ^{51}Cr source with initial activity of 3 MCi at the center of a 50-tonne target of liquid Ga metal that is divided into two zones, an inner 8-tonne zone and an outer 42-tonne zone. If there is either a significant difference between the capture rates in the two zones, or the average rate in both zones is considerably below the expected rate, then there is evidence of nonstandard neutrino properties [5, 6]. The region in $\Delta m^2 - \sin^2(2\theta)$ space to which the new 3 MCi ^{51}Cr experiment will be sensitive is presented. Several possible outcomes on how our new 2-zone experiment may shed light on transitions to sterile neutrinos are considered. Preliminary time schedule and cost estimate are presented.

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