What follows from a comparison of Cl–Ar and Ga–Ge solar neutrino experiments?

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The distributions of the individual runs of radiochemical solar neutrino experiments with respect to the mean value over all runs of each experiment are compared. The difference between the data of the distributions for the Cl–Ar and Ga–Ge experiments is evidence of a possible error.

Four solar-neutrino detectors are presently operating, three of which are radiochemical—Homestake (Cl–Ar), SAGE (Ga–Ge), and Gallex (Ga–Ge)—and one electronic—Kamiokande. The information obtained from these detectors is basically in contradiction of the predictions of the Standard Solar Model (SSM). This comment applies mainly to the Cl–Ar experiment, which has been going on for more than 20 years now. The situation which has developed has come to be called the "solar neutrino problem." The rate at which the ^{37}Ar product nucleus forms from the ^{37}Cl target nucleus is 2.3 ± 0.3 SNU, while the theory[1] leads us to expect 8.0 ± 3.0 SNU [$1\ \mathrm{SNU}=10^{-36}$ capture/(atom·s)]. A prediction for the Ga–Ge experiment is[1] 131.5^{+21}_{-17} SNU, while the experimental data are $82\pm17\pm8$ for Gallex[2] and $58^{+17}_{-24}\pm14$ for SAGE.[3] So far, we have not run into a problem, since the minimum rate of ^{71}Ge production in the gallium target should correspond to 79 SNU if it is the $4p\rightarrow{}^4He$ process that accounts for the sun's luminosity. This conclusion does not contradict Gallex and it is not far from the SAGE results, as we see.

However, when we compare the experimental data of these three experiments, which are very similar in terms of methodology, we run into some serious problems. In order to compare the data of these three experiments, we construct a distribution of the amplitudes of the individual runs (a "run" is one cycle of extraction and subsequent counting of the ^{37}Ar and ^{71}Ge decays), divided by the mean SNU figure over the entire observation period. These distributions are shown in Fig. 1. We see that in the Cl–Ar case the distribution is fairly regular, approximately bell-shaped. In the Ga–Ge case, the distributions have a different shape. The two are similar to each other, and each has significant deviations from the mean value which are clearly larger than in the Cl–Ar experiment. The latter has no runs exceeding three times the mean. It can thus be asserted that the Cl–Ar and Ga–Ge experiments have quite different distributions. Why? The counting system and even the design of the counters in these experiments are identical. Furthermore, the requirements of a low background for the counter are more critical in the Cl–Ar case, because of the relation $T_{1/2}(^{37}Ar)>T_{1/2}(^{71}Ge)$. The extraction procedures are also approximately the same, especially in the Gallex case. The additional chemical procedure for converting $GeCl_4$ into GeH_4 should affect the final result in the form of a systematic error. As we can see from the value reported for it, it amounts to less than 10% of the mean value

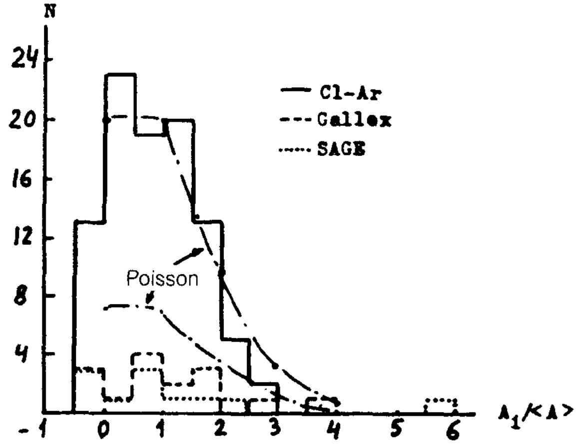

FIG. 1. Distribution of individual runs in three radiochemical experiments, expressed as the deviation of the amplitude of an individual run, A_i, from the mean value $\langle A\rangle$. The Poisson distribution for the Ga–Ge data has been normalized to the sum of the SAGE and Gallex runs.

in the Gallex case. These arguments show that these distributions should be identical. The fact that they are different implies that either the Cl–Ar data or the Ga–Ge data are incorrect. The conclusions which follow from this assertion may be extremely significant.

1. If we assume that the Cl–Ar distribution is correct, then the "large" SAGE and Gallex runs are a consequence of systematic errors which have been overlooked, and the exclusion of these runs from the total data set reduces the Gallex result to 50–60 and the SAGE result to 30–40. This leads us to a fundamental contradiction with the SSM and strengthens the role of the MSW effect in the interpretation of these experiments.

2. If the SAGE and Gallex distributions are correct, then Cl–Ar runs with large SNU values have been discarded over all these 20 years. Extrapolating from the Ga–Ge experiments, we conclude that there should have been at least ten such runs, each with a mean of 10 SNU. In other words, the mean Cl–Ar value should be no less than 3.2 SNU. With respect to the SSM, this figure is not greatly different from the Kamiokande data, and it apparently improves the outlook for explaining the results on the basis of purely astrophysical factors.

However, the resolution of the question probably lies between these extreme cases. Specifically, certain events with large SNU values are being discarded from the Cl–Ar data for reasons of some sort. However, the contribution of these events to the mean value does not go beyond the Poisson distribution shown in Fig. 1, so it would not greatly increase the mean multiyear value of 2.3 ± 0.3. On the other hand, events with anomalously large SNU values in the Ga–Ge data can apparently be linked with the high background of the proportional counters used in those runs. As the sensitivity of the Ga–Ge experiments increases, the relative number of such runs should become insignificant, but there may be a simultaneous decrease in the number of null runs, which would have the effect of canceling the decrease in the mean over all runs. Precisely this tendency was noted in the last report by the Gallex collaboration.[2] In any case, the distributions of the Cl–Ar and Ga–Ge experiments should be identical in the representation in Fig. 1.

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[1] M.Pinsonneault, in *Progress in Atomic Physics, Neutrinos and Gravitation* (XII Moriond Workshop, 1992) (Editions Frontieres), p. 17.

[2] Th. Stolyarchik, in *Perspectives in Neutrinos, Atomic Physics and Gravitation* (XIII Moriond Workshop, 1993) (Editions Frontieres, in press).

[3] T. Bowles, in *Perspectives in Neutrinos, Atomic Physics and Gravitation* (XIII Moriond Workshop, 1993) (Editions Frontieres), in press.

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