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The Chlorine and Bromine Solar Neutrino Experiments

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The solar neutrino experiment based upon the neutrino capture reaction $^{37}Cl\ (\nu, e^-)\ ^{37}Ar$ has been in operation in the Homestake Gold Mine at Lead, South Dakota since 1967. The results of this experiment are well known, and have been reported most recently to the solar neutrino conference at Lead in 1984.[1] We report here the latest results from this experiment. A radiochemical neutrino detector based upon the neutrino capture reaction $^{81}Br\ (\nu,e^-)\ ^{81}Kr^* \rightarrow {}^{81}Kr$ has recently been shown to be feasible.[2] Our plans for performing a full scale test of the method using the Homestake chlorine detector are discussed briefly.

The Chlorine Experiment

The average ^{37}Ar production rate in the detector from a series of 64 individual experimental runs conducted during the period 1970 through 1984 was 0.470 ± 0.038 (1σ) ^{37}Ar atoms/day. The cosmic ray production of ^{37}Ar in the detector by muons was estimated to be 0.08 ± 0.03 ^{37}Ar atoms/day. By subtracting the cosmic ray production from the average value, one

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obtains a rate of 0.39 ± 0.05 ^{37}Ar atoms/day that could be ascribed to neutrinos. This rate corresponds to 2.1 ± 0.3 SNU (Solar Neutrino Units ≡ 10^{-36} captures sec^{-1} $atom^{-1}$). These results can be compared to the standard theoretical model for the sun that predicts the neutrino capture rate for ^{37}Cl is in the range of 6 to [illegible] SNU.[3] Solar models invoking diffusion, mixing, and lower heavy element composition for the sun predict neutrino capture rates in ^{37}Cl in the range of 1.5 to 2.5 SNU in agreement with our observations.[4]

The yearly average ^{37}Ar production rates exhibit an anti-correlation with the solar activity cycle as measured by sunspot occurrences. These rates also correlate directly with the galactic cosmic ray intensity,[5] and measurements of the coronal hole area. Power spectrum analyses of the data (1970-1982) by Haubold and Gerth,[6] indicate a fundamental period of 8.33 years and a set of nearly equidistant frequencies that can be treated as a series of harmonic waves that could be connected to the eleven year solar activity cycle. Specific experimental runs are high and each one corresponds to an intense solar flare.[1,5] The dates of the solar events, and the ^{37}Ar production rates are as follows: Aug. 4-7, 1972, 1.23; Oct. 7-12, 1981, 1.21; and Aug. 8, 1984, 1.26 ^{37}Ar atoms/day. It is important to recognize that if these correlations with solar activity, and solar flares indeed valid, these phenomena must be taken into consideration when interpreting the chlorine experiment.[7]

The chlorine neutrino detector is no longer operating because the two liquid circulating pumps have failed after about 20 years of operation.

We plan to install new pumps and resume operation in mid-1986. The University of Pennsylvania has accepted responsibility for the facilities in the Homestake mine, and will operate the chlorine neutrino detector.

The Bromine Experiment

Recently it has been proposed that a solar neutrino detector based upon the neutrino capture reaction $^{81}Br\ (\nu, e^-)\ ^{81}Kr^* \rightarrow {}^{81}Kr$ is feasible. This detector would be primarily sensitive to the flux of ^7Be-decay neutrinos. The solar neutrino spectrum can be determined using three radiochemical detectors, those based upon gallium, bromine and chlorine as target elements. We suggest that these three radiochemical detectors are needed to understand the solar energy producing processes and determine whether or not neutrino oscillations or conversion of neutrino types by resonance effects[8] in their passage through solar matter take place.

A laser mass-spectrometer technique was developed by G. S. Hurst and his associates to count individual atoms of ^{81}Kr ($t_{1/2} = 2.5 \times 10^5$ y). We plan to test the full-scale feasibility of the bromine experiment by carrying out tests of the recovery of krypton using the chlorine detector followed by ^{81}Kr atom counting measurements. Measurements of the background effect will be carried out with methylene bromide, a suitable liquid to use for a bromine experiment.

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