# VARIATIONS IN THE SOLAR NEUTRINO FLUX

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Abstract

Observations are reported from the chlorine solar neutrino detector in the Homestake Gold Mine, South Dakota, USA. They extend from 1970 to 1985 and yield an average neutrino capture rate of 2.1±0.3 SNU. The results from 1977-1985 show an anti-correlation with the solar activity cycle, and an apparent increased rate during large solar flares.

1. Introduction. A solar neutrino detector based on the neutrino capture reaction on chlorine, $^{37}Cl(\nu,e^-)^{37}Ar$, has been in operation since 1967. In 1970 the sensitivity of the detector was increased by employing pulse rise-time measurements to improve the discrimination of the $^{37}Ar$-like pulses from those produced by background beta and gamma radiations. The experimental procedures and various tests of the detector efficiency have been described in earlier reports [1]. We report here results obtained between October 1970 and May 1985. Observations were terminated in May 1985 by the failure of the liquid circulation pumps. One pump has been replaced, and observations were resumed in October 1986. We plan to continue monitoring the solar flux in the future. The observed $^{37}Ar$ production rates for the period October 1970-January 1984 are listed in reference 2). Additional data are now available through May 1985.

We will discuss this set of data (Runs 18-88) in relation to solar model calculations, neutrino oscillation phenomena, and solar activity.

2. Averaged Results, Solar Models, and Neutrino Physics. The average $^{37}Ar$ production rate for the set of 68 individual experimental runs is 0.472±0.036 $^{37}Ar$ atoms per day in 615 m-tons of $C_2Cl_4$ ($2.19\times10^{30}$ atoms $^{37}Cl$). From this we subtract an estimated production of $^{37}Ar$ from background processes, in particular those from cosmic ray muons, equal to 0.08±0.03 $^{37}Ar$ atoms/day [3]. A new measurement of the muon background effect is in progress, using the radiochemical method of Fireman [4], based on the photonuclear interactions of muons with $^{39}K$ to yield $^{37}Ar$. Subtracting this background rate leaves a net rate of 0.392±0.047 $^{37}Ar$ atoms/day that could be ascribed to the solar neutrino flux. The rate corresponds to 2.07±0.25 SNU where SNU stands for a solar neutrino unit, defined as $10^{-36}$ captures/target atom/second.

The results of the chlorine experiment can be compared to results predicted using theoretical models of the sun. (See references 5) & 7) for discussion.) The predicted neutrino capture rate in $^{37}Cl$ is 6 to 8 SNU [7].

According to the standard model, approximately 75% of the calculated rate would be attributed to the low flux of neutrinos from $^{8}B$ decay in the Sun. Only these neutrinos (E=0-15 Mev) have sufficient energy to feed the analog state in $^{37}Ar$, a super-allowed transition with a neutrino capture cross section 3 to 4 orders of magnitude greater than that for other neutrino sources in the Sun (PeP, $^{7}Be$, $^{13}N$ and $^{15}O$) [6]. The production of $^{8}B$ in the Sun is very sensitive to the internal temperatures. A number of solar models have been devised to accommodate the low rate observed by the $^{37}Cl$ experiment. These models invoke conditions that would lower internal temperatures, i.e., mixing, diffusion, reduced heavy element abundances, magnetic fields, and internal roation [8]. They predict neutrino capture rates in $^{37}Cl$ from 1.5 to 2.5 SNU, in good agreement with experimental results.

It was suggested very recently, by Mikheyev and Smirnov [9] that electron-type neutrinos could be converted to muon or tauon type neutrinos in their passage through the dense interior of the Sun. The conversion, $\nu_e \rightarrow \nu_\mu$, is a resonance phenomenon ($\nu_\mu = \nu_\mu$ or $\nu_\tau$) resulting from a difference in the respective scattering cross sections with electrons. The process

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