^{6}Li Neutron Poison for SNO

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There are two independent possible signatures of neutrino oscillations in SNO: i) a NC/CC (neutral current/charged current) ratio greater than unity, and ii) a distortion of the ^{8}B CC spectrum. If oscillations are occurring, it is most probable that both of these signatures will manifest themselves. However, there are some scenarios where only one of these signatures is present, e.g. in the case of oscillations into "sterile" neutrinos, the NC/CC ratio will be unity, whereas the CC distortions should still occur. In any case, it is always preferable to investigate a new phenomenon through as many channels as possible.

The motivation for introducing ^{6}Li into the heavy water of SNO is to enhance the detector's ability to measure CC distortions. For the experimentally favored "non-adiabatic" MSW solution[1] these distortions correspond to a suppression in the 5-7 MeV part of the spectrum, where complications arise from neutron capture on deuterium (Q = 6.25 MeV). To remove this complication and measure a clean CC spectrum, it is proposed to introduce 300 kg of $LiNO_3$ salt (enriched to 95% ^{6}Li) into the D_2O. The ^{6}Li will absorb neutrons without emitting γ rays and reduce the deuterium neutron capture efficiency down to 1% as compared to 27% in pure D_2O.

It has previously been shown[2] that the complication arising from the deuterium neutron-capture gamma peak in pure D_2O reduces the significance of the non-adiabatic MSW CC distortion to a negligible level (a 1 σ effect in one year's data). In contrast, by adding a poison such as ^{6}Li, the statistical significance of the CC distortion is greatly enhanced and one can exclude the null hypothesis (no distortion) at the 99.9% confidence level (one year's data).

Enriched lithium nitrate or sulfate (0. 3 tonnes) have been chosen as the most suitable chemical forms for introducing a neutron poison into the heavy water because they are very similar to the magnesium chloride salt (2 tonnes), which has already been developed as a neutral current additive. Thus, the reverse osmosis technology already installed by SNO for removing the magnesium chloride from the D_2O can be used for the lithium nitrate or sulfate. This has been demonstrated, in small scale laboratory tests, by A. Kumar and K. Lamb[3] of NRC Canada at our request. In addition, small scale tests carried out at LBNL have shown that the technique of seeded ultrafiltration for purifying magnesium chloride worked equally well for lithium nitrate solutions[4].

The ^{6}Li , in the chemical form of $LiOH{\cdot}H_2O$, is supplied by Oak Ridge National laboratory and a 1 kg sample was purchased and analyzed for chemical and radioactive contamination. A chemical procedure has been established for converting the $LiOH{\cdot}H_2O$ into $LiNO_3$ and, at the same time, removing the Th and U chain contaminants. This procedure has been successfully carried out at the 1 kg scale using the material from Oak Ridge. Our objective is to produce the 300 kilograms of purified $LiNO_3$ or Li_2SO_4 by the end of 1997 so that it is ready soon after the detector is filled with D_2O.

Footnotes and References

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