II. ENERGY SPECIFICATION AT SNO

The NC measurement of SNO is given in Sect. 1.3.

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Abstract: A novel approach for specifying the energy spectrum of the NC reaction at SNO is proposed, which is based on the use of a modified hadronic cross section, \( \sigma_{NC}^{\text{mod}} \), that includes the effect of neutral currents.

The NC cross section at SNO is given by

\[
\frac{d^2\sigma_{NC}}{dE_{\nu}d\theta} = \sigma_{NC}^{\text{mod}}(E_{\nu}, \theta) \rho(E_{\nu}, \theta)
\]

where \( \rho(E_{\nu}, \theta) \) is the density of neutrinos.

The energy spectrum of SNO for NC reactions is calculated using

\[
\int \frac{d^2\sigma_{NC}}{dE_{\nu}d\theta} \rho(E_{\nu}, \theta) dE_{\nu}d\theta
\]

The result is compared with the expected spectrum from the NC reactions at SNO.

Recent studies show that the NC spectrum of SNO is significantly different from the expected one.

The energy spectrum of SNO is thus specified by

\[
\frac{d^2\sigma_{NC}}{dE_{\nu}d\theta} = \sigma_{NC}^{\text{mod}}(E_{\nu}, \theta) \rho(E_{\nu}, \theta)
\]

IE. INTRODUCTION

The new approach to the NC reaction at SNO is presented in this section.

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The NC cross section at SNO is given by

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\frac{d^2\sigma_{NC}}{dE_{\nu}d\theta} = \sigma_{NC}^{\text{mod}}(E_{\nu}, \theta) \rho(E_{\nu}, \theta)
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The result is compared with the expected spectrum from the NC reactions at SNO.

Recent studies show that the NC spectrum of SNO is significantly different from the expected one.

The energy spectrum of SNO is thus specified by

\[
\frac{d^2\sigma_{NC}}{dE_{\nu}d\theta} = \sigma_{NC}^{\text{mod}}(E_{\nu}, \theta) \rho(E_{\nu}, \theta)
\]
where

\[ \mathcal{P}_x(E_\nu) = \zeta(E_\nu) \mathcal{P}_x(E_\nu), \]

and \( \sum_x \mathcal{P}_x(E_\nu) = \zeta(E_\nu) \). If the neutrino spectrum produced in the Sun has no deformation, then the function \( \zeta(E_\nu) \) in (4) is equal to one for all energies. In this case, \( \mathcal{P}_x(E_\nu) = \mathcal{P}_x(E_\nu) \), and \( \sum_x \mathcal{P}_x(E_\nu) = 1 \).

Let \( \varphi_{\nu,SM}(E_\nu) = \varphi_{SM}(E_\nu) / \phi_{SM} \) denote the normalized solar neutrino spectrum predicted by the SSM. This quantity satisfies the relation \( \varphi_{\nu,SM}(E_\nu) \mathcal{P}_x(E_\nu) = \varphi(E_\nu) \mathcal{P}_x(E_\nu) \), where \( \varphi(E_\nu) = \phi(E_\nu) / \phi \) is the true (and unknown) normalized solar neutrino spectrum. The integrals over the relevant energy range of the normalized spectra are equal to one

\[ \int dE_\nu \varphi(E_\nu) = \int dE_\nu \varphi_{\nu,SM}(E_\nu) = 1. \]

From the fact that \( \mathcal{P}_x(E_\nu) + \mathcal{P}_y(E_\nu) \leq 1 \), we have

\[ \int dE_\nu \varphi_{\nu,SM}(E_\nu) \mathcal{P}_x(E_\nu) + \mathcal{P}_y(E_\nu) \leq 1, \]

and therefore, if \( \mathcal{P}_x(E_\nu) + \mathcal{P}_y(E_\nu) \) is a constant, we have

\[ 0 \leq \mathcal{P}_x(E_\nu) + \mathcal{P}_y(E_\nu) \leq 1 \].

In addition, if all the \( \mathcal{P}_x \) are constant then \( \sum_x \mathcal{P}_x = 1 \).

The ratio of the observed to the predicted charged current spectra can also be written as

\[ r_{\nu,CC}^{SNO}(E_\nu) = \frac{dR_{\nu,CC}^{SNO}/dE_\nu}{dR_{\nu,SM}^{CC}/dE_\nu} = \frac{\phi_{SM}(E_\nu) \sigma_{\nu,CC}^{SNO}(E_\nu) \mathcal{P}_x(E_\nu)}{\phi_{SM}(E_\nu) \sigma_{\nu,SM}^{CC}(E_\nu)} = f \mathcal{P}_x(E_\nu), \]

where \( \sigma_{\nu,CC}^{SNO}(E_\nu) \) is the cross-section for the CC reaction. Relations (5) and (9) are model independent. They make no assumption on \( f \) for neutrino oscillations, nor require the quantities \( \mathcal{P}_x(E_\nu) \) to be considered as probabilities.

The elastic scattering event rate is also available from SNO. This rate, normalized to the SSM prediction is given by

\[ r_{\nu,CC}^{SNO}(E_\nu) = \frac{dR_{\nu,CC}^{SNO}/dE_\nu}{dR_{\nu,SM}^{CC}/dE_\nu}, \]

where \( \rho = \sigma_{\nu,SM}^{CC}(E_\nu) / \sigma_{\nu,SM}^{CC}(E_\nu) \approx 0.154 \) for \( E_\nu \geq 5 \) MeV.

Using Eqs. (4) and (6), the \( \nu_e \) component of the solar neutrino flux \( \phi_{\nu_e}(E_\nu) = \mathcal{P}_e(E_\nu) \phi(E_\nu) \) can be written as

\[ \phi_{\nu_e}(E_\nu) = \mathcal{P}_e(E_\nu) \phi_{\nu,SM}(E_\nu). \]

We will say that the electron neutrino spectrum has no deformation at the Earth whenever \( \phi_{\nu_e}(E_\nu) \) is proportional to \( \phi_{\nu,SM}(E_\nu) \). Then, from Eq. (11) we see that a constant \( \mathcal{P}_e \) would imply that there is no distortion of the \( \nu_e \) spectrum at the Earth, and vice versa.

According to SK [4] and SNO [1, 3] the ratios \( r_{\nu,NC}^{CC}(E_\nu), r_{\nu,CC}^{SNO}(E_\nu) \), and \( r_{\nu,CC}^{SNO}(E_\nu) \) are practically constant for \( E_\nu \geq 5 \) MeV. As a consequence, \( \mathcal{P}_x(E_\nu) \) are constants as can be seen by taking any combination of two equations among (5), (9), and (10). For example, from Eqs. (5), (9), and (10) we have

\[ \mathcal{P}_x = \frac{r_{\nu,CC}^{SNO}}{f \mathcal{P}_x}, \quad \mathcal{P}_e = \frac{1}{f} (r_{\nu,NC}^{SNO} - r_{\nu,CC}^{SNO}), \]

with \( r_{\nu,NC}^{SNO}, r_{\nu,CC}^{SNO} \), and \( \mathcal{P}_e \) constants. Therefore, the present experimental evidence indicates that no significant distortion of the \( \nu_e \) neutrino spectrum has been observed at the Earth. In principle, in Eq. (11) the energy dependence of the true neutrino survival probability \( \mathcal{P}_x(E_\nu) \) could be approximately compensated by \( \zeta(E_\nu) \) in order to explain the observed energy independence of the neutrino spectrum at the Earth. Therefore, a distortion of the neutrino spectrum produced in the Sun remains as an unlikely speculation.

### III. SNO FLUXES

The elastic scattering rate measured by SNO can be written in the form

\[ R_{\nu,CC}^{SNO} = \pi_{\nu,CC}^{SNO} \phi_{\nu,CC}^{SNO}, \]

with

\[ \phi_{\nu,CC}^{SNO} = \phi \left[ (\mathcal{P}_e)^{\nu,CC}_{SNO} + \rho (\mathcal{P}_e)^{\nu,CC}_{SNO} \right], \]

\[ \pi_{\nu,CC}^{SNO} = \int dE_\nu \varphi_{\nu,SM}(E_\nu) \sigma_{\nu,CC}^{SNO}(E_\nu), \]

\[ \langle \mathcal{P}_e \rangle_{\nu,CC}^{SNO} = \frac{1}{\pi_{\nu,CC}^{SNO}} \int dE_\nu \varphi_{\nu,SM}(E_\nu) \sigma_{\nu,CC}^{SNO}(E_\nu) \mathcal{P}_e(E_\nu). \]

Here, \( \phi_{\nu,CC}^{SNO} \) is the measured elastic scattering flux.

With similar definitions, the CC event count-rate is given by

\[ R_{\nu,CC}^{SNO} = \pi_{\nu,CC}^{SNO} \phi_{\nu,CC}^{SNO}, \]

where

\[ \pi_{\nu,CC}^{SNO} = \phi \langle \mathcal{P}_e \rangle_{\nu,CC}^{SNO}, \]

\[ \langle \mathcal{P}_e \rangle_{\nu,CC}^{SNO} = \frac{1}{\pi_{\nu,CC}^{SNO}} \int dE_\nu \varphi_{\nu,SM}(E_\nu) \sigma_{\nu,CC}^{SNO}(E_\nu) \mathcal{P}_e(E_\nu). \]

In Eq. (15), \( \phi_{\nu,CC}^{SNO} \) is the flux measured by SNO through the CC reaction.

The electron neutrino component of the flux seen by SNO through the elastic scattering reaction is

\[ \phi_{\nu_e}^{SNO} = \phi \langle \mathcal{P}_e \rangle_{\nu,CC}^{SNO}. \]

From (16) and (17) we get

\[ \phi_{\nu_e}^{SNO} = \frac{1}{\phi_{\nu,CC}^{SNO}} \langle \mathcal{P}_e \rangle_{\nu,CC}^{SNO} \mathcal{P}_e(E_\nu). \]


The event count-rate for the NC can be written as follows:

\[ R_{SNO}^{NC} = \Phi_{SNO}^{NC} \phi_{SNO}^{NC}, \]  

where we have defined

\[ \phi_{SNO}^{NC} = \phi \langle P_{t} \rangle_{SNO}^{NC} + \langle P_{t} \rangle_{SNO}^{NC} \],  

\[ \Phi_{SNO}^{NC} = \int dE_\nu \, \dot{\phi}_{\nu}^{SNO}(E_\nu) \, \sigma_{SNO}^{NC}(E_\nu) \],  

\[ \langle P_{t} \rangle_{SNO}^{NC} = \frac{1}{\Phi_{SNO}^{NC}} \int dE_\nu \, \dot{\phi}_{\nu}^{SNO}(E_\nu) \, \sigma_{SNO}^{NC}(E_\nu) \, P_{t}(E_\nu). \]

Here, \( \phi_{SNO}^{NC} \) represents the flux measured by SNO through the NC reaction. We must keep in mind that the cross sections \( \sigma_{SNO}^{NC}(E_\nu) \), \( \sigma_{SNO}^{CC}(E_\nu) \), and \( \sigma_{SNO}^{NC}(E_\nu) \), that appear in Eqs. (14), (16), and (20) depend on the response functions of the SNO detector.

If \( \phi_{SNO}^{NC} = \phi \langle P_{t} \rangle_{SNO}^{NC} \) is the electron neutrino component of the flux seen by SNO through the NC reaction, then from (16) it is clear that

\[ \frac{\phi_{SNO}^{CC}}{\phi_{SNO}^{NS}} = \frac{\langle P_{t} \rangle_{SNO}^{NC}}{\langle P_{t} \rangle_{SNO}^{NC}} \times \langle P_{t} \rangle_{SNO}^{NC} \]  

A ratio \( \langle P_{t} \rangle_{SNO}^{NC} / \langle P_{t} \rangle_{SNO}^{NC} \) less than one necessarily implies the presence of a non-\( \nu_\mu \) active neutrino in the solar neutrino flux. What can actually be done with the experimental measurements is to calculate the ratio \( \phi_{SNO}^{CC} / \phi_{SNO}^{NS} \). As Eq. (18) shows, in principle it could be possible to have the ratio \( \langle P_{t} \rangle_{SNO}^{NC} / \langle P_{t} \rangle_{SNO}^{NC} \) equal to one, and still be in agreement with the experimental results from SNO, by having \( \langle P_{t} \rangle_{SNO}^{NC} / \langle P_{t} \rangle_{SNO}^{NC} \) < 1. However, given the observed non-dependency of the quantities \( P_{t}(E_\nu) \) on the energy, we have that the averages defined in Eqs. (14) and (16) are approximately equal:

\[ \langle P_{t} \rangle_{SNO}^{NC} / \langle P_{t} \rangle_{SNO}^{NC} \approx \langle P_{t} \rangle_{SNO}^{NC} / \langle P_{t} \rangle_{SNO}^{NC} \approx P_{t} \].

When this result is combined with Eq. (18), gives irrefutable evidence that there are \( \nu_\mu \) and/or \( \nu_\tau \) arriving at the detector. A similar conclusion can be drawn by comparing the CC and NC fluxes. The experimental evidence suggests that

\[ \langle P_{t} \rangle_{SNO}^{CC} / \langle P_{t} \rangle_{SNO}^{NC} \approx 1 \]  

The CC/NC ratio of rates given by the SNO collaboration has been derived assuming the SM \( ^7B \) spectral shape. Up to now SNO has not released the information for the corresponding unconstrained ratios. When this information becomes available the absence of active neutrino flavor transformations could be ruled out even for a non constant \( P_{t}(E_\nu) \). To see this, let us assume for a moment that \( P_{t}(E_\nu) = 0 \). Then, we have a

\[ \left( \frac{\Phi_{SNO}^{CC}}{\Phi_{SNO}^{NC}} \right)_{\nu} / \left( \frac{\phi_{SNO}^{CC}}{\phi_{SNO}^{NC}} \right)_{\nu} = 1, \]

and from Eqs. (18) and (21), we could write

\[ \frac{R_{SNO}^{CC}}{R_{SNO}^{NC}} = \frac{\Phi_{SNO}^{CC}}{\Phi_{SNO}^{NC}} = \frac{\langle P_{t} \rangle_{SNO}^{NC}}{\langle P_{t} \rangle_{SNO}^{NC}}, \]

where \( P_{t}^{NC} = \Phi_{SNO}^{NC} \langle P_{t} \rangle_{SNO}^{NC} \), with \( X = CC, NC, ES \).

FIG. 1: The function \( \lambda_{SNO}(E_\nu) \) vs the neutrino energy for \( R_{SNO}^{NC} / R_{SNO}^{CC} = 4.56 \) (a), 3.41 (b), 2.80 (c), 2.34 (d).

Taking into account the equality in Eq. (23) we find that the following condition should be met

\[ \left( \frac{\Phi_{SNO}^{CC}}{\Phi_{SNO}^{NC}} \right)_{\nu} / \left( \frac{\phi_{SNO}^{CC}}{\phi_{SNO}^{NC}} \right)_{\nu} = 0. \]

where \( \lambda_{SNO}(E_\nu) = \sigma_{SNO}^{CC}(E_\nu) \sigma_{SNO}^{NC}(E_\nu) \). Using the values calculated by Bahcall [8] for the CC and NC cross sections which take into account the resolution and threshold used in SNO, it can be seen that \( \lambda_{SNO}(E_\nu) < 0 \) for \( E_\nu > 2.2 \text{ MeV} \), whenever the ratio \( R_{SNO}^{NC} / R_{SNO}^{CC} > 2.31 \). Since \( \phi_{SNO}^{CC} / \phi_{SNO}^{NC} \) is positive then, if the measured ratio \( R_{SNO}^{NC} / R_{SNO}^{CC} > 2.31 \), the condition stated in Eq. (24) cannot be met, leading to the conclusion that \( P_{t}(E_\nu) \) cannot be equal to zero. For reference, \( E_\nu = 3.2 \text{ MeV} \) corresponds to an average recoil kinetic energy of 5.02 MeV, according to [8]. Then the integrand in Eq. (24) is negative definite in the relevant neutrino energy range if \( R_{SNO}^{NC} / R_{SNO}^{CC} > 2.31 \) (see Fig. 1).

It is possible to estimate the unconstrained rates of SNO using the information that has been published by the collaboration [1]. The ES unconstrained rate can be taken to be the same as that constrained by the \( ^7B \) standard shape, since it is determined essentially from energy independent observations (cos \( \theta \) distribution). The NC unconstrained rate \( R_{SNO}^{NC} \) can be estimated in terms of the constrained rate \( R_{SNO}^{NC} \) and the corresponding total fluxes that have been reported by the collaboration:

\[ R_{SNO}^{NC} = \frac{\phi_{SNO}^{NC}}{\phi_{SNO}^{NC}} \left( \frac{R_{SNO}^{NC}}{R_{SNO}^{CC}} \right)_{\nu} \]

where \( \phi_{SNO}^{NC} = 6.42 \pm 1.67 \times 10^{-6} \text{ cm}^{-1} \text{ s}^{-1} \) and \( \phi_{SNO}^{NC} \) is 5.09 ± 0.63 × 10⁻⁶ cm⁻¹ s⁻¹ are the total unconstrained and constrained NC fluxes, respectively. Finally, the CC unconstrained rate is calculated considering that the total number of signal events is the same as for the constrained analysis. Taking these considerations properly into account, we estimate the ratio of
unconstrained rates to be
\[ R_{\text{SNO}}^{\text{CC}} / R_{\text{SNO}}^{\text{NC}} = 2.5 \pm 0.8. \]

The error is large because the error in the estimate of the NC unconstrained rate in terms of the unconstrained total NC flux is large. Nonetheless, the central value is well above the lower limit of 2.31 given above, and indicates that the need for active oscillations is favored.

If the forthcoming results from SNO confirm that \( R_{\text{SNO}}^{\text{CC}} / R_{\text{SNO}}^{\text{NC}} \) is actually larger than the limit we found using the estimates of [8] for the (response-averaged) cross-section, then the probability transition of solar \( \nu_e \) into an active neutrino must be different from zero. Consequently, it is not possible to explain the experimental CC and NC results of the collaboration claiming only spectral distortion at the Earth and/or oscillations into sterile neutrinos. It is important to notice that we arrived to this conclusion without assuming that \( P_{\nu_e}(E_\nu) \) are constant.

A systematic calculation of the shape of the \( ^8\text{B} \) neutrino spectrum has been presented in [12], together with an estimation of the theoretical and experimental uncertainties. No such precise knowledge has been required in our approach, based in the analysis of the negativeness of the integrand in Eq. (24).

IV. MODEL INDEPENDENT ANALYSIS OF SK AND SNO

In this section, we will use the elastic scattering measurement of SK instead of the corresponding measurement of SNO because it has a smaller error. Equivalently to Eq. (13), we have
\[ R_{\text{SK}}^{\text{ES}} = \langle P_{\nu_e}(E_\nu) \rangle_{\text{SK}} \phi_{\text{ES}}^{\text{SK}}, \quad \phi_{\text{ES}}^{\text{SK}} \]
with definitions like those given in Eq. (14).

As noted by Fogli et al. [9], the response functions of SNO and SK behave quite similarly if appropriate thresholds are used. In this way, an equality of \( \langle P_{\nu_e}(E_\nu) \rangle_{\text{SNO}} \) and \( \langle P_{\nu_e}(E_\nu) \rangle_{\text{SK}} \) can be ensured. As discussed in the previous section and noticed in ref. [6], this equality can also be established independently of the kinetic energy threshold if the energy independence of the \( P_{\nu_e}(E_\nu) \) is adopted. Here we follow this approach. Accordingly, Eqs. (15), (19), and (25) can be rewritten as follows:
\[ r_{\text{ES}}^{\text{SK}} = \frac{\rho}{\sigma} y, \quad r_{\text{CC}}^{\text{SK}} = x, \quad r_{\text{NC}}^{\text{SK}} = x + y, \]
with definitions like those given in Eq. (14).

where \( r_{\text{ES}}, r_{\text{CC}}, \) and \( r_{\text{NC}} \) are the total rates normalised to the SSM predictions:
\[ R_{\text{SSM}}^{\text{ES,NC}} = \langle P_{\nu_e}(E_\nu) \rangle_{\text{SSM}} \phi_{\text{ES,NC}}^{\text{SSM}} \]
\[ R_{\text{SSM}}^{\text{CC}} = \langle P_{\nu_e}(E_\nu) \rangle_{\text{SSM}} \phi_{\text{CC}}^{\text{SSM}} \]
\[ R_{\text{SSM}}^{\text{NC}} = \langle P_{\nu_e}(E_\nu) \rangle_{\text{SSM}} \phi_{\text{NC}}^{\text{SSM}} \]
\[ \chi^2 = \sum_x \frac{(r_x^{\text{exp}} - r_x^{\text{SSM}})^2}{\sigma_x^2}, \]
which is valid for any value of \( x \) and \( y \) [11].

We define the \( \chi^2 \) function
\[ \chi^2 = \sum_x \frac{(r_x^{\text{exp}} - r_x^{\text{SSM}})^2}{\sigma_x^2}, \]
where \( r_x^{\text{exp}} \) are the experimental values for the normalised rates and their errors respectively [1, 3, 4]:
\[ r_{\text{ES}}^{\text{SK}} = 0.459 \pm 0.017 \]
\[ r_{\text{CC}}^{\text{SK}} = 0.349 \pm 0.021 \]
\[ r_{\text{NC}}^{\text{SK}} = 1.008 \pm 0.123. \]

Letting \( x \) and \( y \) vary as free parameters, we find the minimum value of \( \chi^2 = 2.39 \) and the \( \Delta \chi^2 = 1, 4, \) and 9 contours for these parameters as shown in Fig. 2. The projection of these contours on the \( x \) and \( y \) axes \( (N_{DF} = 1 \) in each case), give their 1\( \sigma \), 2\( \sigma \), and 3\( \sigma \) ranges [10]. The best fit values along with their 1\( \sigma \) errors are
\[ x = 0.35 \pm 0.02, \]
\[ y = 0.66 \pm 0.11. \]

The previous values times the SSM total \( ^8\text{B} \) flux \( \phi_{\text{SSM}} = 5.05 \times 10^6 \text{cm}^{-2}\text{s}^{-1} \), give the \( \nu_e \) and \( \nu_x \) components of the flux which are consistent with the values reported by SNO [1].

When \( f = 1 \), i.e., there is no discrepancy between the SSM and the true total \( ^8\text{B} \) neutrino flux, Eq. (31) gives the 1\( \sigma \) ranges for the quantities \( P_e \) and \( P_x \). In this case the sum \( P_e + P_x \) is consistent with being equal to one.
Let us now assume that there exist oscillations only among active states. Then, we have \( P_e + P_s = 1 \), there is also no deformation of the spectrum produced in the Sun. (\( \alpha(E) = 1 \), and \( f = x + y \). We obtained the 1\( \sigma \), 2\( \sigma \), and 3\( \sigma \) ranges for \( f \) and \( P_e \) from the contours in Fig. 3, built by mapping the contours of Fig. 2 to the plane \( f \) vs. \( P_e \) using the constriction \( P_e + P_s = 1 \). These contours coincide with those found in ref. [6] directly from Eq. (26), with \( y \) replaced by \( f - x \).

From Fig. 3 it can be seen that, by including the NC measurement in the analysis, a significant improvement has been achieved in the 1\( \sigma \) error bar of \( f \) with respect to the one obtained using only the SK and the SNO CC data [9]. The best fit values and their 1\( \sigma \) ranges are

\[
\begin{align*}
f & = 1.01_{-0.09}^{+0.11} \\
P_e & = 0.34_{-0.04}^{+0.05}
\end{align*}
\]

Imposing the less stringent condition \( \alpha \leq (P_e + P_s) \leq 1 \), with \( 0 \leq \alpha \leq 1 \) the value of \( f \) will be bounded by

\[
x + y \leq f \leq \frac{x + y}{\alpha},
\]

from where we see that allowing for a non vanishing probability to oscillate into a sterile neutrino (\( \alpha \neq 1 \)), we have larger upper bound for \( f \). Assuming that \( P_e + P_s + P_s = 1 \), we have that

\[
P_s = 1 - \frac{x + y}{f}.
\]

From the dispersion of \( x \) and \( y \) we can find allowed regions in the \( P_s \) vs \( f \) plane, corresponding to the 68, 95, and 99\% confidence levels. As shown in Fig. 4, these regions are not bounded and hence it is not possible to determine \( f \) and \( P_s \) with the existing data [11].

V. CONCLUSIONS

In this work we have examined the relation between the observed quantities \( \phi_{\nu e}^{\text{SNO}} / \phi_{\nu e}^{\text{SNO}}, \phi_{\nu e}^{\text{SNO}} / \phi_{\nu e}^{\text{SNO}} \), with the flavor fractional \( \nu_e \) content of the fluxes measured through the ES and NC reactions. When combined with the hypothesis of a non distorted \( ^{10}\text{B} \) spectrum the measurement gives a clear signal of active flavor transformation. As we also show, when available, the SNO experimental rates unconstrained by the \( ^{10}\text{B} \) standard shape, combined with the cross-section as calculated in ref. [8], could give conclusive evidence for active oscillations, even for a non constant \( P_e(E_e) \).

Finally a model independent analysis including the latest SK and SNO data is performed under the assumption of constant \( P_{e,NC}(E_e) \), with and without the condition \( P_e + P_s = 1 \). Our result agrees with ref. [11] in the sense that no conclusion can be drawn with the present data about the sterile neutrino content of the solar neutrino flux.

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[8] We used the tabulated values for the cross sections found at the URL http://www.sns.ias.edu/jnu/SNdata.


