RECOIL ELECTRON ENERGY SPECTRUM IN SUPER-KAMIOKANDE AND SNO DETECTORS

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Abstract

Super-Kamiokande(SK) and SNO detectors detected recoil electron energy spectrum from $\nu_e + e^- \rightarrow \nu_e + e^-$.Analysing statistically recoil electron energy spectrum from SK and SNO detectors we find that recoil energy spectrum from $>$ 10 MeV is higher than the recoil electron energy spectrum from 5 MeV to 10 MeV with $>$ 95% C.L. This finding indicates that recoil energy spectrum is distorted which is due to disturbed nature of the solar core.We suggest that both SK and SNO detectors detected neutrino flux from ^3He+p neutrinos apart from ^8B neutrinos.We have calculated the neutrino flux from ^3He+p neutrinos and is found to be$(1 \sim 1.5) \times 10^5 cm^{-2} sec^{-1}$ which is higher than the observed upper limit reported by SK's 1496 day data. We suggest that the contribution of ^3He+p and ^8B neutrino flux from 5 to 20 MeV is reflected in both the detectors due to distortion of neutrino flux.The recoil electron energy spectrum is fitted with the sum of several Gaussian curves indicating the stochastic nature of the solar core.

1. INTRODUCTION

The detection of neutrinos from the sun will provide us very important information on the nuclear energy generation inside the sun and also properties of neutrino propagation in the dense matter like sun.There were major problems arisen from Homestake [5],Kamiokande and SK [6,8],SAGE [7]and GALLEX-GNO [2] detectors with a different threshold and all detectors observed neutrino fluxes less than that predicted by standard solar model (SSM)[3].Recently SNO groups [1] observation of neutrino fluxes from the sun with energy threshold $E_\nu \geq 5MeV$ by using the process $\nu_e +^2 D \rightarrow p + p + e^-$ (CC), $\nu_x + e^- \rightarrow \nu_x + e^-$ (ES), $\nu_x +^2 D \rightarrow \nu_x + n + p$ (NC) suggest that neutrino conversion takes place in the core of the sun and thus solved the long standing solar neutrino problems. Variations of solar neutrino flux has been observed in Homestake, Kamiokande and SK, SAGE and GALLEX-GNO detectors [9,10,11].Many scientist's already reconfirmed the variation of solar neutrino flux within the solar activity cycle but controversy exists only on the correlation/anticorrelation between solar neutrino flux data and sunspot numbers data.Again one of the principal goal also of the

pp. 1217–1220

SK and SNO detectors for solar neutrinos is to determine the shape of the solar neutrino spectrum between 5 MeV and 20 MeV.We know in the energy range between 5 and 14 MeV,(only the energy of ^3He+p neutrinos is up to 18.8 MeV or may be around 20 MeV)neutrinos from ^8B decay are expected to dominate the solar neutrino experiment according to standard solar model(SSM).It has been suggested by Bahcall [4] that if electroweak theory is correct, then the shape of ^8B and ^3He+p neutrinos energy spectrum is independent of the solar influences and shape of the neutrinos determine the shape of the recoil energy spectrum produced by the neutrino-electron scattering in the detector.Therefore any departure of the observed recoil electron energy spectrum from the shape produced by using the electroweak theory indicates a possibility of new physics beyond electroweak theory. In this paper, we will study the recoil electron energy spectrum in SK and SNO detectors and will find what will be the ^3He+p neutrino fluxes after studying the recoil energy spectrum.

2. RECOIL ELECTRON ENERGY SPECTRUM IN SUPER-KAMIOKANDE AND SNO DETECTORS

a) SUPER-KAMIOKANDE:The recoil electron energy spectrum from elastic scattering of electrons with neutrinos($\nu_x + e^- \rightarrow \nu_x + e^-$)are reported by SK group for 1496 days of data and set an upper limit of $7.3 \times 10^4 cm^{-2} sec^{-1}$ for the neutrino flux from ^3He+p neutrinos.They have displayed R = DATA/SSM of the measured number of electrons to the number of electrons expected from SSM in Fig.1. To do statistical analysis of the recoil electron energy spectrum and to see whether is any distortion in the recoil electron energy spectrum.We use t-test to find the variation of recoil electron energy spectrum from the energy > 5 MeV. We will take the data into two groups: one group comprises the recoil electron energy spectrum(i.e.,DATA/SSM) from 5.5 MeV to 12.0 MeV and another group comprises recoil electron energy spectrum(i.e.,DATA/SSM)from 12.5 MeV to 20 MeV.We find that the average recoil electron energy spectrum from 5.5 MeV to 12 MeV and >12.5 MeV are not the same and we find that after 12.5 MeV the recoil electron energy spectrum are sufficiently higher with $> 98.5\% C.L.$.This observation indicates that there is a distortion or the excess of DATA/SSM in the recoil electron energy spectrum from 12.0 to 20 MeV. We have also fitted the DATA/SSM of the observation by the equation

DATA/SSM $= 0.440 + 0.043 exp[-(E-7.5)^2/1.5 MeV^2] + 0.035 exp[-(E-9.75)^2/0.4 MeV^2] + 0.045 exp[-(E-11.5)^2/1.2 MeV^2] + 0.280 exp[-(E-15.5)^2/3.7 MeV^2]$ (1)

The very nature of the curve shows Gaussian in nature indicating the stochastic nature of the solar core which may be due to temperature and density fluctuation of the interior of the sun where the nuclear burning occurs.From Fig.1, we see that DATA/SSM=0.45 from 5 MeV to 12.0 MeV, then the excess of DATA/SSM =0.45 must come from ^8B+^3He+p neutrino flux from 12.5 to 20 MeV which is about 0.48 i.e.,0.03 must come from ^3He+p neutrino flux i.e.,0.03 of ^8B neutrino flux i.e.,$(1.2to1.5) \times 10^5 cm^{-2}sec^{-1}$ which is about (1.5 to 2) times higher than the observed upper limit reported by Smy[12]. b) SNO detector: Like SK analysis we will analyse the recoil electron energy spectrum to find the variation of recoil electron energy spectrum(i.e.,DATA/SSM) from 6.5 MeV to 20 MeV (Fig.2).We have again used t-test and we have found that the average recoil energy spectrum from 6.75 MeV to 10 MeV(DATA/SSM) is less than the average recoil electron energy spectrum from 10.5 to 20 MeV(DATA/SSM)with a very high statistical significant level $> 95\%$ C.L..This observation indicated also that there is a distortion or excess of DATA/SSM in the recoil electron energy spectrum after 10.5 to 20 MeV. We have also fitted the DATA/SSM by the equation

DATA/SSM=$0.250 + 0.16exp[-(E-7.5)^2/0.16MeV^2] + 0.10 \times exp[-(E-8.5)^2/0.4MeV^2] + 0.10exp[-(E-9.5)^2/1MeV^2] + 0.17exp[-(E-11)^2/0.5MeV^2] + 0.16exp[-(E-15)^2/4MeV^2]$ (2)

The very nature of the curve also shows Gaussian in nature indicating the stochastic nature of the solar core which may be due to temperature and density fluctuation in the core of the sun.From Fig.2 we see that DATA/SSM=0.35 from 5 MeV to 10 MeV,then excess of DATA/SSM=0.35 must come from ^8B+^3He+p neutrino flux from 10.5 to 20 MeV which is about 0.38 i.e.,of 0.03 of ^8B neutrino flux must come from ^3He+p neutrino flux i.e.,$1.5 \times 10^5 cm^{-2}sec^{-1}$ which is also around 2 times the observed upper limit reported by Smy[12]. The excess of electrons observed at high energies suggest that the contribution of both ^8B and ^3He+p neutrino fluxes from 10 to 20 MeV.The oscillatory nature of recoil electron energy spectrum is more important after 10.5 MeV energy of electron and the distortion of recoil electron energy spectrum above 10.5 MeV is due to the spiky nature of solar neutrino fluxes arises from temperature and density fluctuation in the solar core.The exponential (Gaussian form)in R=DATA/SSM indicating a pulsating character of nuclear energy generation due to temperature and density fluctuation of the solar core.This may also indicate the stochastic nature of the solar core.

3. DISCUSSION

It appears that recoil electron energy spectrum is also an important for the evaluation of ^3He+p neutrino flux and may provide the very important characteristics of the solar core.It is to be pointed out that the calculation of ^3He +p neutrino flux is very difficult for SSM .It must be noted that if ν which is the decay product of β-decay is a mixture of ν_e and ν_μ in the low energy region(i.e.,0.233 MeV to 20 MeV)then the flux of ν can be written as $\phi(\nu) = \phi(\nu_e) + \phi(\nu_\mu)$ If we consider the cross section is the same for electroweak theory then if $\phi(\nu_\mu)/\phi(\nu_e)$

= 5/2 for $E_\nu\rangle$ 5 MeV and $\phi(\nu_\mu)/\phi(\nu_e)$ =1/3 for $E_\nu\langle$ 0.5 MeV, then the observed solar neutrino flux from Homestake, SK, SAGE,GALLEX-GNO and SNO can be explained without the MSW neutrino oscillation mechanism.

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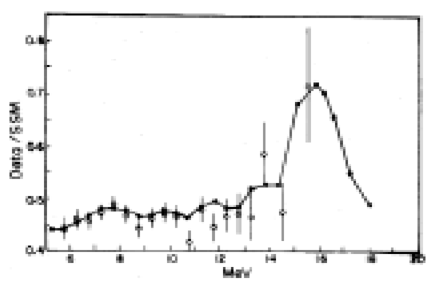

Fig. 1. Recoil electron energy spectrum (i.e., R =DATA/SSM) from 5 MeV to 20 MeV in the SK detector. The coninuous curve here represent our estimate of ^{8}B+^{3}He+p recoil electron energy spectrum from equation(1).

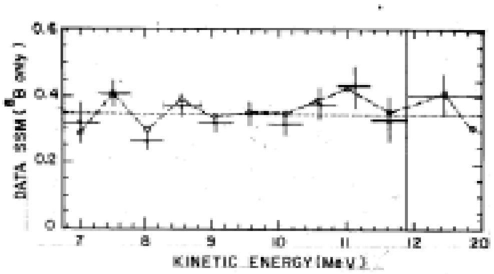

Fig. 2. Recoil electron energy spectrum R =DATA/SSM from 5 MeV to 20 MeV in the SNO detector. The continuous curve here represent our estimate of ^{8}B+^{3}He+p recoil electron energy spectrum from equation(2).