TIME VARIATIONS IN SOLAR NEUTRINO FLUX

Probhas Raychaudhuri
Department of Applied Mathematics,Calcutta University,Calcutta-700009,INDIA
e-mail:probhasprc@rediffmail.com

Abstract

We have studied solar neutrino flux data from Super-Kamiokande(SK), SAGE, GALLEX-GNO detectors statistically and have shown that solar neutrino flux data varies with the solar activity cycle.We have also studied the solar neutrino flux data during the period from 31May 1996 to 31December 2001 from SAGE,GNO and Superkamiokande detectors we find 5 and 10 months in the solar neutrino flux data with more than 99% C.L. and 5 months period have already been observed in solar neutrino flux data from Homestake detector,sunspot data,solar proton events data etc.which indicates that solar activity cycle is due to the pulsating character of nuclear energy generation inside the sun.For the strength of our suggestion we have studied the fractal nature of solar interior along with solar flares,sunspot data and we find that both the solar neutrino flux data and solar surface data (i.e.,sunspot data,solar flares data etc.) are fractal in nature. All the observed fact and short time variation indicate that the standard solar model must be modified to include the variable nature of solar interior.

1. INTRODUCTION

The detection of neutrino flux from the sun is very important towards the understanding of stellar evolution characteristics from the nuclear energy generation either pp or CNO cycle.Before the SNO detector[1] all of the solar neutrino experiment indicated that the solar neutrino flux is less than that predicted by the Standard solar model(SSM)[3] and that the solar neutrino flux data are varying with the solar activity cycle [7,11].Recently SNO group reported their findings suggesting that there is no discrepancy between SSM and observational neutrino flux if MSW matter oscillation is taken into account. Although SNO group observed solar neutrino flux from 2 November 1999 for 301 live days but they have not yet present their time dependence of data. In this paper we will analyse the solar neutrino flux data from SK [4,12], SAGE [5], GALLEX-GNO [2,6] detectors statistically to see whether neutrino flux data varies with the measurement period or not.At the same time we will study whether solar neutrino flux data exhibits periodicity or not.

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2. ANALYSIS OF SUPER-KAMIOKANDE, SAGE, GALLEX-GNO SOLAR NEUTRINO FLUX DATA

(a)SUPER-KAMIOKANDE detector: (i)Time variation:solar neutrino flux data for 1496 days from 31May 1996 to 15 July 2001. Fig.1 shows the time dependence of solar neutrino flux data from SK.We use t-statistic for the variation of solar neutrino flux data.We take two groups:one group comprises the data from 31 May 1996 to 15 July 1998 and another group comprises the data from 16 July 1998 to 15 July 2001. We find that the solar neutrino flux data are varying with the measurement period with more than 98% C.L. Earlier Raychaudhuri [10,11] showed that solar neutrino flux data from Kamiokande and SK during the period from 31 May 1986 to 3 June 1997 are varying the solar activity cycle. (ii)Correlation: We do not see any statistically significant correlation between solar neutrino flux data and sunspot numbers data. (iii)Periodicity: We find that solar neutrino flux data exhibit periods around 5 and 10 months with a very high statistical significance about 99% C.L. b)SAGE detector: (i)Time variation: SAGE group reported 126 individual runs from January 1990 to December 2000(Fig.2)whose average is 77 SNU and covers almost one solar cycle.We use t-statistic for the variation and two groups: one group comprises the data from January 1990 to July 1993 and May 1999 to Decemember 2000 and another group comprises the rest of the data.We find that the solar neutrino flux data are varying with the solar activity cycle with more than 99% C.L. (ii)Correlation: we do not see any statisticaly significant correlation between solar neutrino flux data and sunspot numbers data. (iii)Periodicity:We have considered the solar neutrino flux data during the period from April 1998 to December 2001 (Fig.3) and these data are only the combined analysis of K and L events. However,We find that solar neutrino flux data exhibit periods around 5 and 10 months with more than 99% C.L. (c)GALLEX-GNO detector: (i)Time variation: GALLEX-GNO group reported 100 individual runs from May 1991 to May 2001(Fig.4).The data are continuous and as the data provides seven different time observations (Gallex-I, II,III,IV, GNO-I,II,III) it is better to use analysis of variance test.Our analysis shows that all the different time observations have different average values and the solar neutrino flux data are varying within the solar activity cycle with more than 99% C.L. (ii)Correlation:We do not see any statistically significant correlation between solar neutrino flux data and sunspot number data. (iii)Periodicity: We have considered GNO-I,II,III,IV solar neutrino flux data from 20 May 1998 to 31 December 2001(Fig.5).We find that GNO solar neutrino flux data exhibit periods around 5 and 10 months with more than 99.5% C.L.It may be noted that we have also found 5 months period in the solar neutrino flux data from Homestake [8].

3. FRACTAL NATURE OF SOLAR NEUTRINO FLUX DATA

The knowledge of the fractal dimension of an attractor enable us to conclude whether the behaviour of a dynamical system is chaotic or not.We have studied the dimension of the solar attractor for the solar neutrino flux data (e.g.,SAGE and GALLEX-GNO)and solar surface data (e.g.,sunspot numbers and solar flares data)and we have obtained the dimension of the attractor of the dynamical system responsible for the solar activity cycle which according to our estimation is fractal. By analysing the solar neutrino flux data from Homestake detector Raychaudhuri[9] showed also that the solar core is fractal in nature.

4. DISCUSSION

It is shown from our analysis that solar core is not rigid as SSM suggests.We emphasized again that solar neutrino flux data from SK,SAGE,GALLEX-GNO are varying with the solar activity cycle. From our analysis it appears that the solar core is fractal in nature and thus SSM must be modified to include the variable nature of the solar core.

5. References

1.Ahmad Q R et al. 2002, Phys.Rev.Lett.**87**,071301.
2.Altmann M et al. 2000, Phys.Lett.**B490**,16.
3.Bahcall J N.,Basu S.,Pinsonneault M H. 1998 Phys.Lett**B343**,1.
4.Fukuda Y et al. 2001, Phys.Rev.Lett.**86**5651.
5.Gavrin V N et al. 2001, Nucl.Phys.(Proc.Suppl.)**B91**,36.
6.Kirsten T. 2002, in NEUTRINO 2002 held on 25-30 May, Munchen, Germany.
7.Raychaudhuri P. 1984, Solar Phys.**93**,397.
8.Raychaudhuri P. 1986, Solar Phys.**104**,421.
9.Raychaudhuri P. 1992, in STATPHYS.**18** 2-8 August, Berlin, Germany.
10.Raychaudhuri P. 1998, Mod.Phys.Lett.**A13**,1109.
11.Raychaudhuri P. 1999, Int.J.Mod.Phys.**A14**,1205(1999).
12 Smy M. 2002, in NEUTRINO 2002 held on 25-30 May, Munchen, Germany.

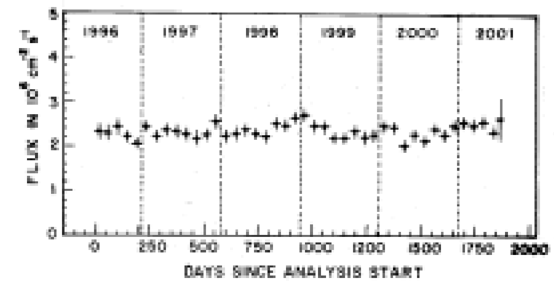

Fig. 1. Solar neutrino flux data from 31 May 1996 to 15 July 2001 for SK detector.

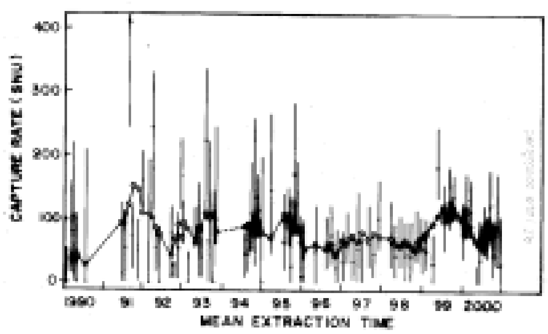

Fig. 2. Solar neutrino flux data from January 1990 to December 2001 for SAGE detector.

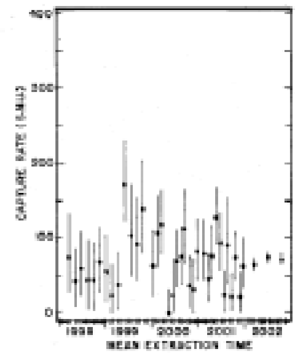

Fig. 3. Combined analysis of K and L peaks for runs from April 1998 to December 2001 for SAGE detector.

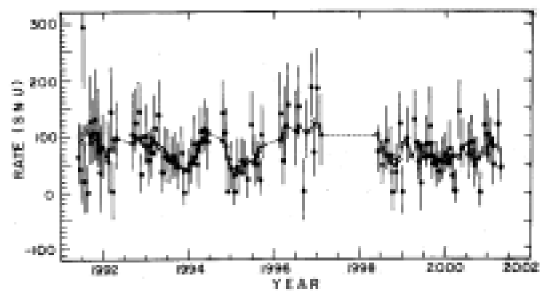

Fig. 4. Solar neutrino flux data from May 1991 to May 2001 for GALLEX-GNO detector.

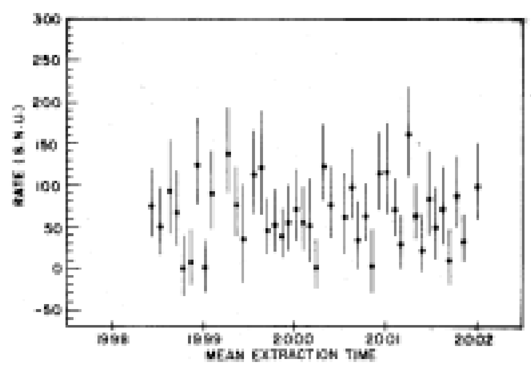

Fig. 5. Solar neutrino flux data from 20 May 1998 to 31 December 2001 for GNO detector.