A Possible Correlative Time Variation in the Production Rates of the Neutrinos from the p-p Reactions and the Boron-8 Decay Processes in the solar Core

Kunitomo Sakurai
Institute of Physics, Kanagawa University Yokohama 221-8686, Japan

Abstract

Both of the observational results from the Homestake and the Gallex, now GNO experiments have been made in use to find some possible time variation in the neutrino fluxes from the p-p reactions and the Boron-8 decay processes. It is suggested out that the production rates of the neutrinos from these two processes have a tendency to vary quasi-biennially. Since it seems that this tendency is further correlated with the distribution of the magnetic fields inside the convective layer of the sun, the emission of the neutrinos generated from the proton-proton chain reactions in the solar core may be modified by the growth and decay of these magnetic fields.

1. Introduction

Up to now, many technical papers have been written about the possibility on the periodic time variation in the fluxes of the neutrinos from the sun [1,2]. A paper, which suggests that these fluxes might vary quasi-biennially was written by myself in 1979 by using the observational records obtained at Homestake [3]. In this paper, a possible causal relation was suggested between this periodic variation in the fluxes of the solar neutrinos and the time variation of the sunspot activity, though the latter was always delayed from the former by about half a year.

Recently, Haubold [4] and Haubold and Gerth [5] have confirmed that there surely exists the quasi-biennial periodic variation in the fluxes of the neutrinos from the sun by making in use of the observed results on these neutrinos obtained from the Homestake experiments. According to Sturrock's group, there also exists the quasi-biennial variation in the fluxes of the solar neutrinos, though the amplitude of this variation is so small, because of the shuffling effect to the observed data from the Homestake and the Gallex, later GNO, experiments [6,7].

It thus seems necessary to reconsider on whether the fluxes of neutrinos from the sun vary quasi-biennially by using the observed data on these fluxes obtained from the Homestake and the Gallex experiments [8]. It may be noted that this quasi-biennial periodicity was named "Sakurai's periodicity" by [4], since this periodic variation was first suggested in the paper written in [3,9].

pp. 1247–1250

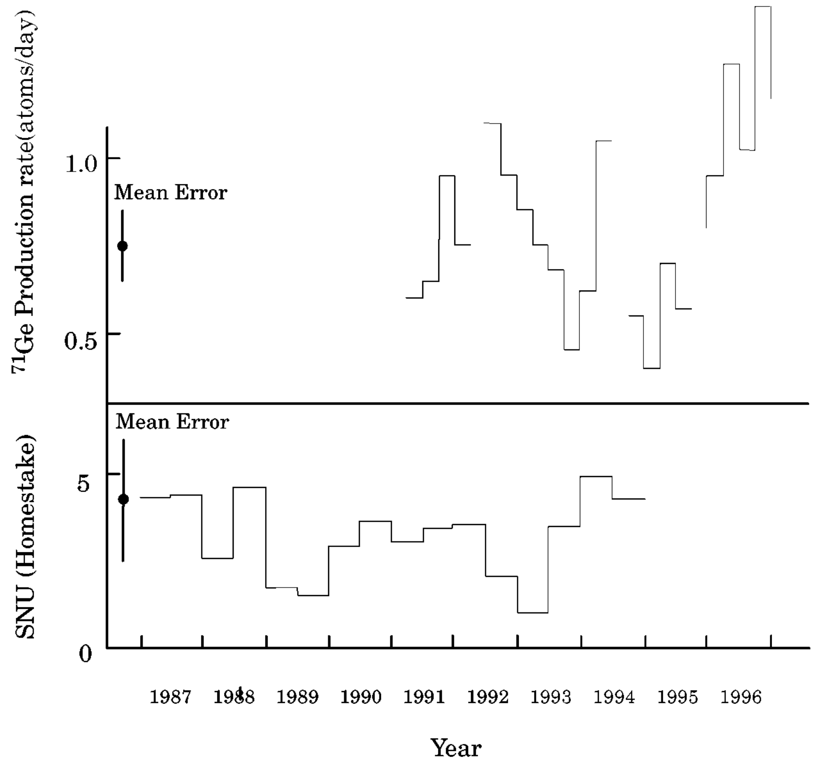

Fig. 1. The time variations of the fluxes of the neutrinos produced from the p-p reactions and the Boron-8 decay processes in the solar core. The observed results obtained from the Gallex and later the GNO experiment (top) and Homestake experiment (down).

In order to look for whether this quasi-biennial variation detected in the time variation in the fluxes of the neutrinos from the sun, both of the magnetic activity on the sun being causally connected with the sunspot activity and the interplanetary magnetic fields will be taken into account to search for some causal relation between the time variation in the fluxes of the solar neutrinos and the magnetic configuration inside the sun.

2. Energy Production Reactions Inside the Solar Core and Their Relation to the Neutrino Emission

Since it is known, however, that the most important processes of the proton-proton chain reactions are the p-p reactions, it seemed necessary to measure the flux of the neutrinos from these reactions in order to examine whether or not these processes are working in accordance with the theoretical prediction for the proton-proton chain reactions. So, the two research groups, SAGE and Gallex, have begun to detect those neutrinos radio-chemically by establishing the

Gallium detecting devices.

The research group called Gallex and later GNO has published the observed data on the fluxes of the neutrinos from the p-p reactions for several years [8,10]. Although these data on these neutrino fluxes are not available for so many years as compared with those from the Boron-8 decay processes in the PPIII processes, which were obtained from the Homestake experiment, it is still possible to search for how the fluxes of the neutrinos generated from the p-p reactions vary with time and to compare the time variation of these neutrino fluxes with both of the magnetic fields over the solar photosphere and the interplanetary magnetic fields.

3. Possible Short-Term Variation in the Production Rates of Neutrinos in the Solar Core

The observed results on the fluxes of the neutrinos from the sun recorded in the Homestake and the Gallex experiments highly suggest as shown in Fig. 1 that both of the fluxes of the neutrinos being generated from the p-p reactions and the Boron-8 decay processes vary quasi-biennially throughout the observing period, though the former is only available several years.

At the present moment, it seems difficult to conclude from Fig. 1 that such a short-term variation as quasi-biennial one is clearly seen in the production rates of the neutrinos from the p-p reactions and the Boron-8 decay processes, because the observed data prom the Homestake and the Gallex experiments are not enough to reach any of the deterministic statement about this short-term variation. Since the initial step of the proton-proton chain reactions is the p-p reactions, the so-called quasi-biennial periodicity as seen on the fluxes of the neutrinos from the Boron-8 decay processes could be causally related to that of the p-p reactions.

4. Concluding Remarks

Based on their work on the short-term variation of the magnetic fields on the sun and its relation to the magnetic fields in the interplanetary space, Wang et al. [11] have shown that, though being dependent on the phase of the solar activity cycle, the magnetic fields over the solar photosphere have a tendency to vary quasi-biennially with time. So, the magnetic fields in the interplanetary space being transported from the sun also vary quasi-biennially.

Although the existence of the magnetic moment for neutrinos has not been found experimentally as yet, it seems possible to say that the quasi-biennial variation in the fluxes of the neutrinos from the sun may have been caused by the action of the strong magnetic fields generated deep inside the convective zone and their transport up to the photosphere of the sun.

5. References

1. Bahcall, J. N. 1989, Neutrino Astrophysics 1989, (Cambridge Univ., Cambridge)
2. Davis, R., Jr. 1994, Prog. Part. Nuc. Phys. 32, 13
3. Sakurai, K. 1979, Nature 278, 146
4. Halubold, H. J. 1998, Astrophys. Space Sci. 258, 201
5. Halubold, H. J. and Gerth, E. 1990, Solar Phys. 127, 347
6. Sturrock, P. A., Walther, G. and Whether, G. and Wheatland, M. S. 1997, Ap. J. 491, 409
7. Sturrock, P. A., Scargle, J. D., Walther, G. and Whether, G. and Wheatland, M. S. 1999, Ap. J. 523, L77
8. Kirsten, T. A. 2000, Physica Scripta T85, 71
9. Sakurai, K. 1981, Solar Phys. 74, 35
10. Bahcall, J. N. 2000, Physica Scripta T85, 63
11. Wang, Y. M., Sheely, M. R., Jr. and Lean, J. 2002, Ap. J. 580, 1188