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A POSSIBLE MECHANISM TO CAUSE THE QUASI-BIENNIAL VARIABILITY ON THE SOLAR NEUTRINO FLUX

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ABSTRACT

It is suggested that the quasi-biennial change in the observed flux of the solar neutrinos is causally related to some non-linear process at the central core of the sun, being associated with the change in the central temperature. This process seems to be responsible for the physical adjustment of the internal structure of the sun. Numerical simulation on this process is able to reproduce the quasi-biennial change in the flux of these neutrinos.

1. Introduction In order to see the rate of the energy production at the central core of the sun, Davis and his associates have been measuring the flux of the solar neutrinos which are mainly produced from the PP III process(1). According to their results, the mean observed flux of these neutrinos for more than ten years is by a factor three or more less than the flux theoretcially expected from the standard model of the sun. At present, this discrepancy between observed and theoretical fluxes is thought as a serious problem in the research fields of astrophysics, being known as the "missing solar neutrinos,"because this has seemingly suggested that the proton-proton chain reactions have been prevented from working well effectively in a manner as predicted from the theoretical treatment for the internal structure of the sun on the basis of the standard model(2).

The observed results by Davis et al. certainly indicate that the proton-proton chain reactions are only ineffectively taking place in the interiour of the sun, but it has recently been suggested that these results further indicate that the rate of these reactions has been varying quasi-biennially with a period of about 26 months(3). Although the sun itself should be considered to be a self-regulating feedback system with respect to the energy generation, such periodic variation just mentioned may have been caused by some non-linear process taking place in association with the proton-proton chain reactions.

2. Quasi-Biennial Change in the Observed Flux of the Solar Neutrinos Davis and his associates have been making the measurement of the neutrino flux from the sun for more than ten years(1). Since the results obtained by them are now available to investigate the efficiency of the proton-proton chain reactions at the cnetral core of the sun and its longterm change if any. Using these results, an analysis has

been done to find out possible periodic change in the observed fluxes of these neutrinos during the last ten years or so(3,4,5).

Since the intervals between two successive measurements of these neutrinos are not equally distributed, but scattered at random, the observed fluxes have been averaged over for four monthly intervals without taking the number of the measurements in each interval into account(3). The analysed

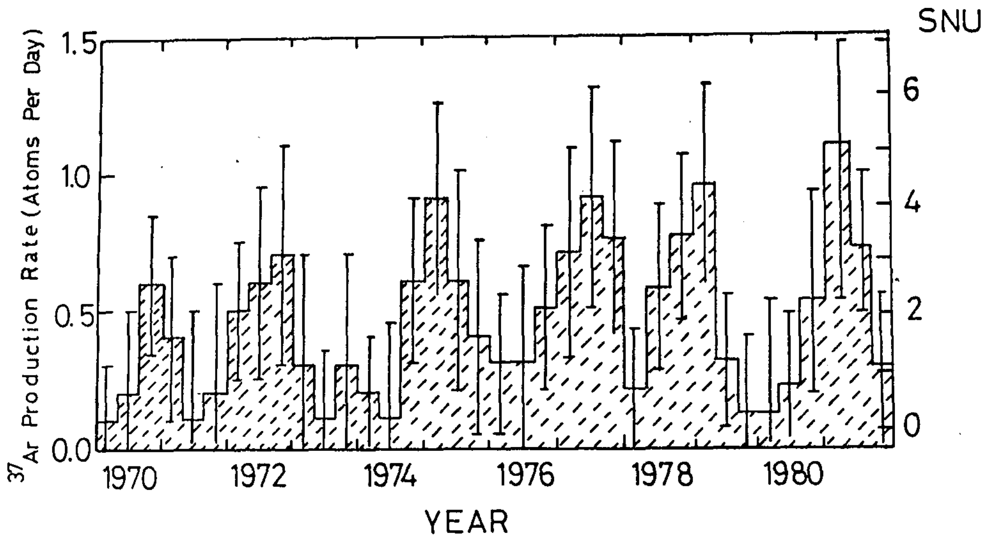

Fig. 1 A "periodic" variation of the four-monthly mean flux of the solar neutrinos produced mainly from the PP III reaction(3).

result is shown in Fig. 1, in which error ranges have been estimated using the error bars appeared in the original data given by Davis and his associates.

The result shown in Fig. 1 clearly indicates that the observed flux of the solar neutrinos had been varying quasi-biennially with a period of about 26 months during the years up to 1981. This seems to mean that the efficiency of the PP III process had been changing quasi-biennially because these neutrinos had been mostly released within three seconds into outer space after produced at the central core of the sun. According to Fig. 1, it seems that the observed background flux of the neutrinos has a tendency to vary throughout the solar activity cycle, since this flux seems to have been highest during the solar maximum. However, this tendency is not so clearly seen when compared with the quasi-biennial change as considered above.

3. Possible Mechanism of the Quasi-Biennial Change In order to explain the quasi-biennial periodicity on the time variation of the neutrino production at the central core of the sun, a non-linear process has been considered as a candidate to control the proton-proton chain reactions, in particular, PP III reaction. Since the efficiency of this reaction is shown to be strongly dependent on the temperature at the central core of the sun, this process seems to be controlled

by this temperature(6). Thus it seems appropriate to assume that this temperature, being denoted by T, is controlled by a non-linear process as following the equation described as

$$\frac{dT(t)}{dt} = [\underline{a} - \underline{b}T(t-\tau)]T(t),$$

where a and b are both constant. Time $T(t-\tau)$ is the one which is earlier than t by τ. The above equation, therefore, expresses that the temperature $T(t)$ is regulated by the time $T(t-\tau)$ as dtermined by the time $(t-\tau)$. This has first been considered to apply to biological population and chemical reactions(7).

From the physical point of view, this process indicates that the temperature varies as being controlled by the time being earlier by τ. By taking some numerical values for a and b, the above equation has been numerically simulated to reproduce the periodic change as shown in Fig. 1. One of these numerical simulations is shown in Fig. 2 as an example and this seems to be applicable to explain the quasi-biennial periodicity in the temperature variation at the central core of the sun. Thus, the quasi-biennial periodicity in the neutrino flux from the sun can be well reproduced

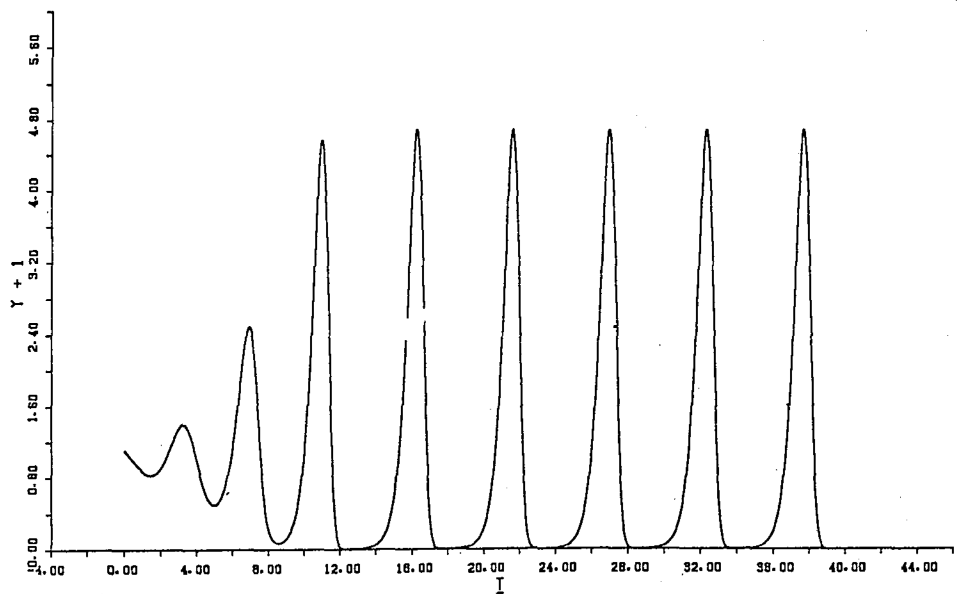

Fig. 2 An example of the numerical simulation for the efficiency of the PP III reaction.

from the non-linear process considered above.

As inferred from from Fig. 2, the occurrence of the periodicity as seen in this figure does not depend seriously on the initial condition which is related to the numerical values of τ, a and b. For this reason, the quasi-biennial change in the efficiency of the PP III reaction as shown in Fig. 1 seems to be almost always excited easily whenever some instability is induced at the central core of the sun, which is associated with the change in the temperature there.

4. Concluding Remarks The quasi-biennial change as seen on the observed flux of the solar neutrinos has been numerically simulated by taking into account the non-linear process as described in this paper, which is associated with the change in the temperature at the central core of the sun. As theoretically deduced earlier, the sun is thought as a self-regulating feedback system with respect to the maintenance of the internal physical processes as related to the proton-proton chain reactions. It should be noted, furthermore, that the temperature and its radial gradient plays the most important role in adjusting the internal structure of the sun(2).

Thus it may be said that, as described in this paper, the non-linear process associated with the change in the central temperature is responsible for the quasi-biennial variation on the efficiency of the PP III reaction.

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