The variations in counting rates of Cl-Ar and Ga-Ge solar neutrino detectors.

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The results of search of solar neutrino counting rate variations by means of joint analyses of independent data of Cl-Ar (R. Davis's experiment) and Ga-Ge (SAGE experiment) detectors are presented. The data of this two detectors span the time interval from 1970 to 2005. During the time interval from 1990 to 1994 both detectors had been operating.

The purpose of the investigation the search of possible correlations between counting rates of two different detectors, which are sensitive to different parts of solar neutrino energy spectrum.

The quasi-biennial periods in independent sets of data being equal 2,1 years for Cl-Ar and 2,01 years for Ga-Ge detectors accordingly has been found. The results of spectral analysis showed that the variations in counting rates of two independent detectors are not occasional. The search of possible powerful solar flare signals in the neutrino detectors data was carried out also.

I. INTRODUCTION

One of the important task of solar neutrino physics is the proof of presence or absence of time variations of solar neutrinos flux. There are many papers concerning this question [1, 2], but the final result is absent till now. In the present work we have constructed the set of data the period from 1970 to 2005, using two sets of data of Cl-Ar and Ga-Ge detectors. It has appeared possible because the both of detectors were in operating simultaneously in 1990 - 1994. The spectral analysis of each set of data and combined one was made.

As in data Cl-Ar detector and Ga-Ge there are several runs with abnormal high counting rate. Search of possible connection between such runs and flares of cosmic rays on the Sun has been made.

II. SPECTRAL ANALYSIS OF EXPERIMENTAL DATA OF NEUTRINO DETECTORS

The data from Cl-Ar detector are available from 1970 till 1994, and data Ga-Ge detector - from 1990 till present time

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[3, 4]. In the period of January 1990 - May 1994 the both of neutrino detectors were in operation simultaneously. If we

assume that the processes inside of the Sun do not depend on time or if the same time variations exist in the all parts of solar neutrino energy spectrum, then the independent data sets of two neutrino detectors can be normalized. In this case for the period of 1990-1994 we can write:

$$Q(\text{Ga-Ge}) = k \cdot Q(\text{Cl-Ar}),$$

where the values $Q(\text{Ga-Ge})$ and $Q(\text{Cl-Ar})$ are given in

SNU, accordingly, and $k = 147.5$. The joined normalized set of data is shown in Fig. 1.

Fig. 1. The joined normalized set of data.

The data sets of Ga-Ge and Cl-Ar detectors and joined normalized data set has been subjected to the spectral analysis. To do it we need to have the equidistant time intervals between experimental points. It was made with using of the linear interpolation method (the special program was used).

In Fig. 2 the fragment of experimental data for the period since January 1990 till May 1994 and the same fragment after application of linear interpolation are presented. It is seen a good coincidence of the experimental points and interpolated ones.

The spectral analysis performed for data set of each detector and for joint normalized set shows the presence of significant peak with the period of $T \sim 2$ years in all sets. Other significant periodicities in the interval $0.5 < T < 20$ years appeared in all sets of data simultaneously were not revealed. Fig. 3 illustrates this conclusion. The same periodicity near 2 years in solar neutrino flux has been found

in [4, 5]. Autocorrelation functions of data sets of the both detectors also have shown the existence of quasi-biennial period.

Fig. 2. The piece of experimental data from CI-Ar detector and the same data after interpolation.

The nature of the 2-year periodicity is not known. Also, it is necessary to note especially, that the 11-years periodicity was not revealed in any of sets of data.

III. COUNTING RATE INCREASE OF SOAR NEUTRINO DETECTORS AND POWERFUL FLARES OF SOLAR COSMIC RAYS (SCR)

The experimental data about solar neutrino flux presented in Fig. 1 show that some runs give high counting rate. During some of such runs powerful solar flares with the generation of charged particles were observed [1]. For example, in the period from 1971 till 1990 the increased counting rate in CI-Ar experiment was observed in runs № 19, 27, 71, 117. The Ga-Ge detector recorded the increased counting rate in the run of January, 2005.

Table 1.

№	№ of session	Date started of session	Date of the end of a session	Counting rate, SNU	Average counting rate for 4 session	Increasing of counting rate of neutron monitors, %	Date of flash in SCR (days)
Events in CI-Ar detector							
1	19	15.11.70	6.03.71	53.3	34.8	26	24.01.71
2	27	8.07.72	6.11.72	165.1	49.4	15, 8	4, 7.08.72
3	71	3.09.81	28.10.81	183.7	45.1	11.5	12.10.81
4	86	21.07.84	2.09.84	171.3	50.3		5.08.84
5	106	13.06.89	24.08.89	144.7	40.9	11.1	16.08.89
6	117	1.06.91	7.06.91	178.3	104	20.9	15.06.91
Events in Ga-Ge detector							
7	12.04	5.12.04	31.12.04	305.5	28.3	180	20.01.05

In Table 1 the runs with high counting rates of neutrino detectors are presented. The start and the end of each run and the date of SCR flare, possible delay time (in days) between increase of the counting rate of neutrino detector and

occurrence of flare in SCR are given. The average counting rate obtained from the joint normalized data set (see Fig. 1) is equal to $\langle N \rangle = (81.4 + 43.0)$ SNU. If we choose runs with the counting rates equals to $\langle N \rangle + 2\sigma$ and $\langle N \rangle + 1.5\sigma$, we will have 10 runs, and 28 runs accordingly. If powerful solar flares occur with the same probability on visible and invisible sides of the Sun, some increases of counting rates of neutrino detectors could not be compared with SCR flares because solar particles from flares on opposite side of our Sun are not detected.

Fig. 3. Results of the spectral analysis of data sets from CI-Ar (upper panel) and Ga-Ge (middle panel) detectors, and joint normalized set (bottom panel). The reliability level of 0.99 is given also.

IV. CONCLUSION

The analysis of Cl-Ar and Ga-Ge sets of data on solar neutrino flux shows, that there are variations of neutrino flux in the data of Cl-Ar and Ga-Ge detectors. These variations are not occasional ones. The presence of quasi-biennial periodicity in two independent sets of data and in the joint normalized set of data testifies that this variation really exists though the reason of its origin is unknown.

Correlation between SCR powerful flares and increase of the counting rate of neutrino detectors is found.

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