Study on Output Current Behavior of Electrochemical Apparatus Sensitive to Antielectron Neutrinos

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論　文　内　容　の　要　旨

As one of leptons, neutrinos commonly fill the whole universe. After postulation of the existence of neutrino in 1930, neutrinos have attracted considerable interests of scientists. Especially, in the past decade, some neutrino oscillation experiments have revealed that neutrinos should own a quite small mass in relation to the oscillation phenomena, which are inconsistent with the standard model for weak interaction. The output current was observed from electrochemical apparatus by irradiation of nuclear reactor neutrinos. The apparatus was also understood to be sensitive to natural neutrinos on the earth. The experimental current was understood to be ascribed to formation of considerably large mass in neutrino system. Although the signal generation scenario was proposed, quantitative analysis was not performed for the output current of the apparatus. In addition, a poor reproduction of current peak at initial period of a few days was not understood.

In this study, a half-cell model with assistance of weak interaction is proposed to numerically calculate the output current of the apparatus, and the reason is experimentally studied for the poor reproduction of initial peak.

Chapter 1 explains the discovery of neutrinos, neutrino sources, weak-interaction theory and several experiments for low-energy solar neutrinos. Following these, the objective in this study is stated.

Chapter 2 describes the electrochemical detector. Some physical and chemical properties of water, the selection criteria of working electrodes, and electrode treatment procedure are summarized. The proposed basic scenario of output current generation is described: A neutrino consists of boson and fermion particles as $v_b v_f$. When neutrinos are incident into auxiliary field generated from a biological material, they will obtain mass and tend to separate into boson v_b and fermion v_f particles. The particles may break water molecule into hydrogen and hydroxide ions. The boson combines with hydrogen ion as $H^+ v_b$ and fermion will react with hydroxide one as $OH^- v_f$. The repulsive properties of v_b and v_f at rest do not allow $H^+ v_b$ and $OH^- v_f$ to be recombined. The hydroxide ions with

fermion ($OH^- v_f$) may diffuse to a gold plate, and hydrogen ions with boson ($H^+ v_b$) may diffuse to a carbon one. The output current is obtained in the experiment.

Chapter 3 presents the electrochemical analysis of output current by using a half-cell model with assistance of weak interaction. The time evolution of output current is solved with the half-cell model under the consideration of weak interaction effect. The reduction current density j_{H^+} of hydrogen ions is given by the Butler-Volmer equation. The reaction of hydroxide ions is endothermic one; the reaction is assumed to be promoted with assistance of weak interaction between the fermion particle and the auxiliary field. The activation energy is obtained from experimental data at different temperatures as Δ= 0.65 eV. The hydrogen ions are treated to disappear in the rate of *I/F* as the current *I* flows where *F* is the Faraday constant. The oxygen concentration was taken to be consistent to experimental data. For reproduction of experimental current, however, time parameters t_d and t_r were required for expressing the delay and rising times, respectively, for initiation of weak interaction assistance. The values of t_d and t_r of few days were treated as adjustable parameters. The comparison between the experiments and calculations suggested that the half-cell model works well for the environmental experiment. The same electrochemical parameters were applied to reactor-neutrino irradiation experiment. By the use of estimated antielectron neutrino flux, the output current was twice as large as the experiment. The larger signal is successfully suppressed by setting limited value of hydrogen ion concentration of 9.27 x 10^{-7} mol cm^{-3}. Thus, the use of basically the same electrochemical parameter leads to reproduction of the experimental data.

Chapter 4 describes the experiments on the poor-reproductive initial peak at a few days. The output current of electrochemical detector under environmental condition gives an initial peak around 2 days and an equilibrium value in 2-3 weeks under environmental conditions. At early stage of our experimental study, a tendency of positive correlation was observed between the initial peak and solar activity, namely, solar wind velocity. To make clear the situation, further experiments were carried out during the period for one year. For the later experiments, no clear correlation was found. It was concluded that the former positive correlation in the early stage was the accidental result.

Finally in Chapter 5, the conclusion of whole study is given.

論 文 審 査 の 結 果 の 要 旨

本研究は、電気化学装置による反電子ニュートリノへの出力応答電流について、弱い相互作用による効果を取り入れた半電池模型を提案し定量的なシミュレーションを行ったものであり、電気化学反応における弱い相互作用の効果の解明および将来的な利用につながる可能性があり、価値ある業績であると認める。