Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Detection of solar neutrinos with a torsion balance with sapphire crystal

To cite this article: M Cruceru and G Nicolescu 2018 *J. Phys.: Conf. Ser.* **940** 012036

IOP Conf. Series: Journal of Physics: Conf. Series **940** (2017) 012036 doi:10.1088/1742-6596/940/1/012036

Detection of solar neutrinos with a torsion balance with sapphire crystal

M Cruceru and G Nicolescu

Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering, Magurele, Jud.Ilfov, RO-077125, ROMANIA

E-mail: madalina.cruceru@nipne.ro

Abstract: The solar neutrinos (antineutrinos) are detected with a dedicated torsion balance in the case when they interact coherently on stiff crystals (sapphire with high Debye temperature ~1000K and lead with ~100K Debye temperature). The balance consists in two equal masses of lead and sapphire, of 25g. An autocollimator coupled to this balance measures small rotation angles of the balance. The force with which neutrino flux interacts with these crystals is between 10^{-5}dyn and 10^{-8} dyn, comparable with that reported in Weber's experiments [1]. A diurnal effect is observed for solar neutrinos due to the rotation of the Earth around its own axes. The solar neutrino flux obtained at the site of our experiment is ~$3.8*10^{10}$neutrinos/cm^2*s [2]. Experimental data for neutrinos signals from this high sensitivity torsion balance are presented and commented [3].

1. Introduction

The solar neutrinos flux may produce a transfer of momentum to the two crystals of sapphire and lead. These two crystals are the two weights of a torsion balance. They have different Debye temperature: 1000K for sapphire and 100K for lead.

In our case a torsion balance is involved to check the Eötvös experiment. Two equal masses with different concentrates, of sapphire and lead are positioned on a plate which is hanged on a wolfram wire of 1meter, in a vacuum room. Neutrinos will interact with sapphire crystal and torsion will appear in the balance. Gravitational and inertial forces will not give any torque. The vacuum inside the balance body has a value of 10^{-5} torr. This value of vacuum will assure no disturbance to any torque. Our balance has a sensitivity of $2.6x10^{-7}$dyn.

2. Experimental device

The kinematical scheme of our torsion balance is presented in Figure 1 and it consists from a wolfram wire, a sapphire crystal and an optical port. An autocollimator will measure the deviations of the balance.

In Figure 2 we can see the inside view of the torsion balance body. It is evidenced a plate with sapphire and lead weights. A mirror is in the middle to reflect the light from the autocollimator.

IOP Conf. Series: Journal of Physics: Conf. Series **940** (2017) 012036 doi:10.1088/1742-6596/940/1/012036

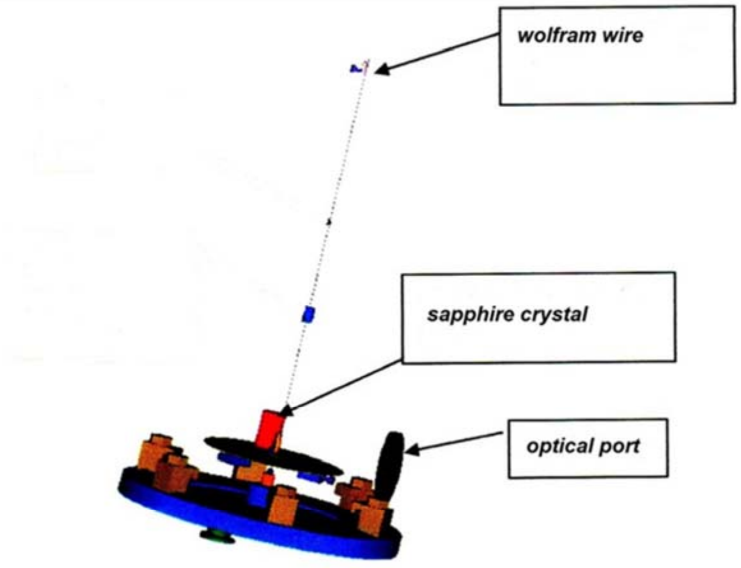

Figure 1. Kinematical scheme of the torsion balance.

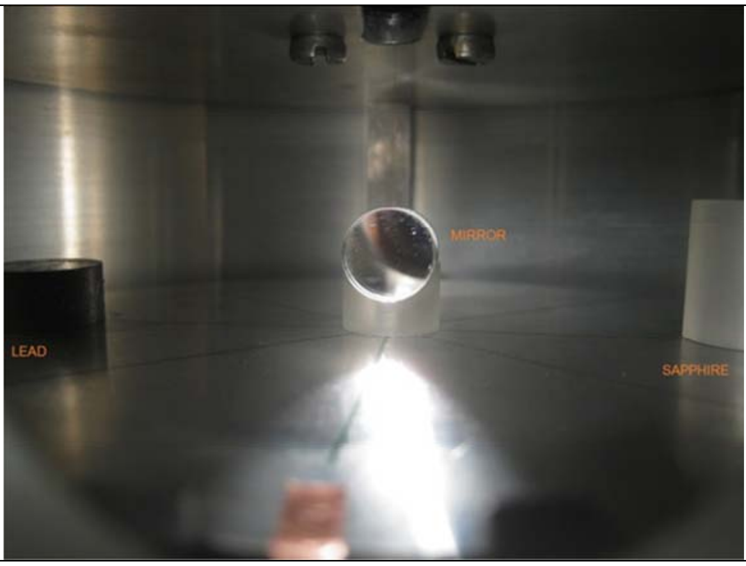

Figure 2. Inside view of the torsion balance: two weights of lead and sapphire placed on an aluminum tray.

A coherent inelastic scattering is happening between a neutrino and the infinitely stiff crystals and this means that a large cross section is emphasized. Weber, in his experiments, calculated a total cross section which is proportional with N^2:

$$\sigma = \frac{4E_\upsilon^2 G_W^2}{\pi \hbar^4 c^4} N^2 \quad (1)$$

where E_υ is neutrino energy, G_W is the weak-interaction coupling constant, N- is the number of neutrons.

A diurnal effect is presumed to appear. The neutrinos produced in the Sun will touch the Earth without passing any matter. If we measure solar neutrinos in the night, we have to account the fact that neutrinos will pass through the Earth.

The υ_e survival probability during the day is given by formula:

$$P_{ee}^D = cos^4\theta_{13}\left(\frac{1}{2} + \frac{1}{2}cos2\theta_S \bullet cos2\theta_{12}\right) + sin^4\theta_{13}. \quad (2)$$

where θ_S is the mixing angle at the production point inside the Sun[4], θ_{12} and θ_{13} are the mixing angles between the first neutrino mass eigenstate and the two other active mass eigenstates.

The υ_e survival probability at night [4] when solar neutrinos pass through the Earth:

$$P_{ee}^N = P_{ee}^D - cos2\theta_s cos^2\theta_{13} < f_{reg} >_{zenith}, \quad (3)$$

where f_{reg} means the regeneration effect in the Earth.

A maximum has to appear in the diurnal effect when the Sun is at zenith[3].

3. References

[1] Weber J 1988 *Phys. Rev.* D 38 32

[2] Nicolescu G 2013 *J. Phys*. G: *Nucl.Part.Phys.* 40 055201

[3] Cruceru M, Nicolescu G, Duliu O G and Cruceru I 2011 *Int.J.of Mod. Phys*.A 26 2773

[4] Antonelli V, Miramonti L,Pena Garay C and Serenelli A 2012, *Adv. in High En. Phys*. 2013 351926, Hindawi Publishing Corporation