TOWARDS THE DETECTION OF COSMOLOGICAL RELIC NEUTRINOS WITH NEUTRINO CAPTURE ON BETA DECAYING NUCLEI

A. G. Cocco, G. Mangano and M.Messina* JCAP 0706:015,2007 and Phys. Rev. D 79, 053009 (2009)

The content of the poster is based on the papers quoted above where it was shown that neutrino interactions on beta-unstable nuclei have the key feature requiring no energy threshold for the neutrino interaction to occur. This peculiarity offers an unprecedented opportunity for the Cosmological Relic Neutrinos (CRN) detection and, more in general, for the neutrinos' detection of vanishing energy. Another interesting feature was underlined, namely σ·v keeps a constant value only depending on the specific target nucleus. Furthermore, a detailed calculation of the cross section of neutrino interaction on instable nuclei was shown for the first time and, a value of the cross section sizably different from zero was calculated. It is worth saying that the detection of the CRN has been downgraded from a principle problem to a technological challenge.

State of Art

The Cosmological relic Neutrinos decoupled 1 sec after Big Bang

$$\bar{n}_{\nu_i 0} = \bar{n}_{\bar{\nu}_i 0} = \frac{3}{22}\bar{n}_{\gamma 0} = 53\,cm^{-3}$$

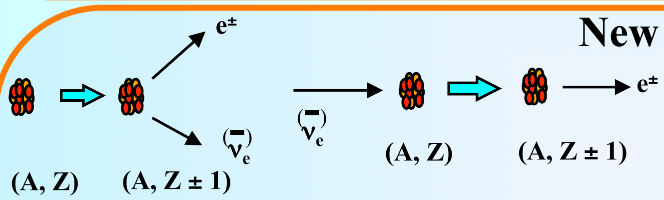
$$p_\nu \approx 10^{-3}\, eV/c$$

Every thing we know today about our Universe is obtained from the measurements of CMB decoupled 10^5 y after the Big Bang. CRN detection can provide a closer look to the origin of the Universe.

The methods proposed so far for the CRN detection:

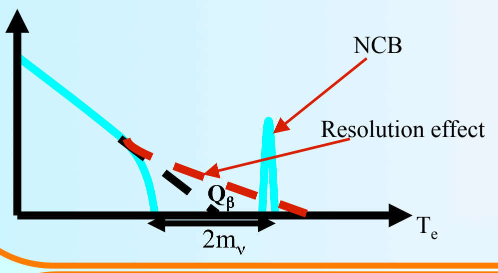
- annihilation of EECν off relic neutrinos. In this case a neutrino source of E=10^{22} eV was required.
- An accelerator as large as the earth circumference to increase the energy in the c.m.r and subsequently interaction rate.
- Coherent neutrino scattering off a torsion balance: more than 15 o. of m. were missing in sensitivity.

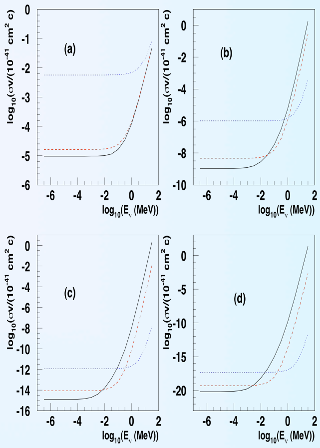
New prospects



$$A = \int_{m_e}^{W_o} \frac{C(E'_e, p'_\nu)_\beta}{C(E_e, p_\nu)_\nu} \frac{p'_e}{p_e} \frac{E'_e}{E_e} \frac{F(E'_e, Z)}{F(E_e, Z)} E'_\nu p'_\nu dE'_e \;\rightarrow\; \sigma_{NCB} v_\nu = \frac{2\pi^2 \ln 2}{A\, t_{1/2}}$$

Any beta instable nuclei is a possible target for CRN, provided that the cross-section times the life time of the target nucleus does not conflict with any technological problem. The main experimental issue is the energy resolution < 1eV. In fact, the energy spectrum of the CRN is expected to be a sharp line with mean value $2m_\nu$ larger than the end point of the beta spectrum.





In the case of ^3H target and neutrinos with momentum around 10^{-3} eV/c the cross section times the velocity has a value of 7.7x10^{-45} cm^2c. Also the ^{187}Re offers a sizable cross-section even if smaller (~10^{-52} cm^2c) than in the case of Tritium.

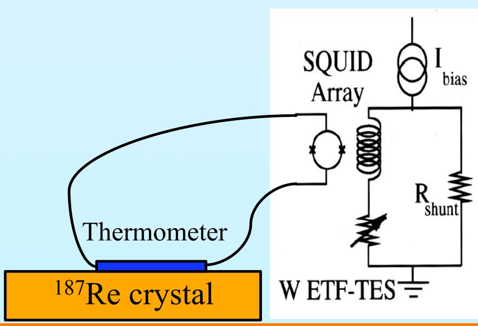
Possible experimental solutions

One chance is the electrostatic measurement technique used by the KATRIN experiment. Then if we make the following assumptions:

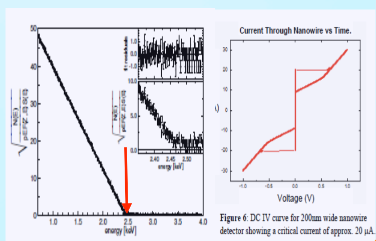
- 0.2 eV energy resolution (KATRIN second phase)
- 0.1 mHz background rate
- the typical neutrino density plus gravitational clustering effect: ~100/cm^3
- the cross-section of 7.7 10^{-45} cm^2c
- 16 g of ^3H as target

we get 15 events of CRN signal and 12 of background in 1 year data taking with 16 g of ^3H. This would result in a clear evidence of CRN signal, but such an amount of ^3H would completely spoil the energy resolution.

The ^{187}R suites well with the bolometers technology. Nevertheless, the small cross section requires to many channels (10^9-10^{12}) to be able to run a detector with enough mass and getting, consequently, the desired CRN signal. Bolometers with larger absorber mass per channel are not feasible given their the long time (10^{-3} s) response, that, would result in an overlapping of the beta decay events.



A threshold effect like in KATRIN experiment would allow to select only interesting events. The technology of temperature nano-sensor seems promising if applied to the bolometers. The nano-sensor allows to define a threshold above which the signal can be measured. In this case also high rate can be tolerated.



*University of Bern and LHEP