Cosmological Relic Neutrino Detection using Neutrino Capture on Beta Decaying Nuclei

Alfredo G. Cocco
Istituto Nazionale di Fisica Nucleare
(Italy)

AGC, G.Mangano and M.Messina
Journal of Cosmology and Astroparticle Physics 06 (2007) 015

The longstanding question

Is it possible to detect/measure the Cosmological Relic Neutrino background ?

We know that CRN are non-relativistic and weakly-clustered

- UHE cosmic rays scattering (indirect, unknown sources)
- Torsion balance (target polarization, strong ν-$\bar{\nu}$ asymmetry)

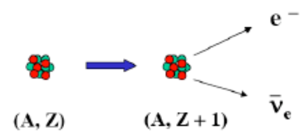
Short answer: NO !!

All the methods proposed so far require either strong theoretical assumptions or experimental apparatus having unrealistic performances

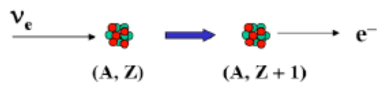
A.Ringwald "Neutrino Telescopes" 2005 – hep-ph/0505024
G.Gelmini hep-ph/0412305

Massive neutrinos and neutrino capture on beta decaying nuclei

Beta decay



Neutrino Capture on a Beta Decaying Nucleus (NCB)



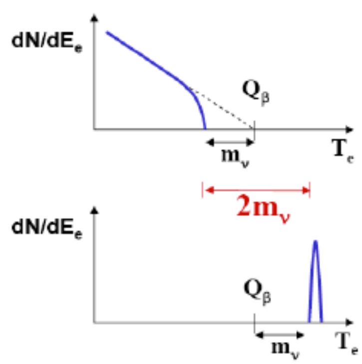
This process has no energy threshold !

Today we know that $m_\nu \neq 0$

Neutrino masses of the order of 1 eV are compatible with the present picture of our Universe

Beta decay

Neutrino Capture on a Beta Decaying Nucleus



The events induced by Neutrino Capture have a unique signature provided by a gap of $2m_\nu$ centered at Q_β

The drawings however are not to scale…..

Relic Neutrino Detection

signal to background ratio

The ratio between capture (λ_ν) and beta decay rate (λ_β) is obtained using the previous expressions

$$\frac{\lambda_\nu}{\lambda_\beta} = \frac{2\pi^2 n_\nu}{\mathcal{A}}$$

In the case of Tritium (and using n_ν=50) we find that

$$\lambda_\nu(^3\mathbf{H}) = 0.66 \cdot 10^{-23} \lambda_\beta(^3\mathrm{H})$$

Taking into account the beta decays occurring in the last bin of width Δ at the β spectum end-point we have that

$$\frac{\lambda_\nu}{\lambda_\beta(\Delta)} = \frac{9}{2}\zeta(3)\left(\frac{T_\nu}{\Delta}\right)^3 \frac{1}{(1+2m_\nu/\Delta)^{3/2}}$$

(about 10^{-10} for $\Delta \sim m_\nu \sim 1$ eV)

Conclusions

The fact that neutrino has a nonzero mass has renewed the interest on Netrino Capture on Beta decaying nuclei as a tool to measure very low energy neutrino

A detailed study of NCB cross section has been performed for a large sample of known beta decays avoiding the uncertainty due to nuclear matrix elements evaluation

The relatively high NCB cross section when considered in a favourable scenario could bring cosmological relic neutrino detection within reach in a few years