Detecting low energy neutrinos through CEvNS

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The Problem

Neutrinos are notorious for being the most elusive particles in the Standard Model. Low-Energy neutrinos, mainly coming from the fusion reactions in the Sun or from the centre of an exploding Supernova, are even harder to detect compared to high energy neutrinos.

The Idea

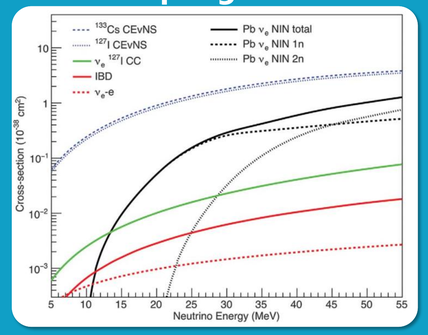
In the 1970s, D Freedman proposed the idea for a Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) but he too admitted that observing this experimentally is quite an impossible feat.

The Mechanism

- When a low energy neutrino has its de Broglie wavelength of the order of the size of the target nucleus then the whole nucleus vibrates through the exchange of a Z^0 Boson and then this recoil energy is our signal.
- The nucleus stays in ground state post-interaction.

Success of CEvNS

CEvNS has the largest low energy neutrino coupling cross-section



Total cross sections of CEvNS and some known neutrino couplings [Source - Akimov et al., Science 357, 1123–1126 (2017)]

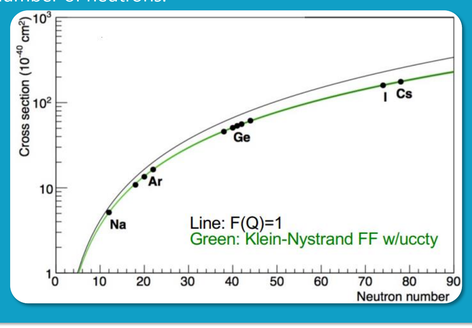
All over the world there are various efforts of CEvNS

Experiment	Technology	Place
COHERENT	CsI, NaI, Ge, Ar	USA
CONNIE	Si CCDs	Brazil
CONUS	HPGe	Germany
TEXONO	p-PCGe	Taiwan
CCM	Ar	USA
NuCLEUS	Cryogenic $CaWO_4$, Al_2O_3 calorimeter array	Europe

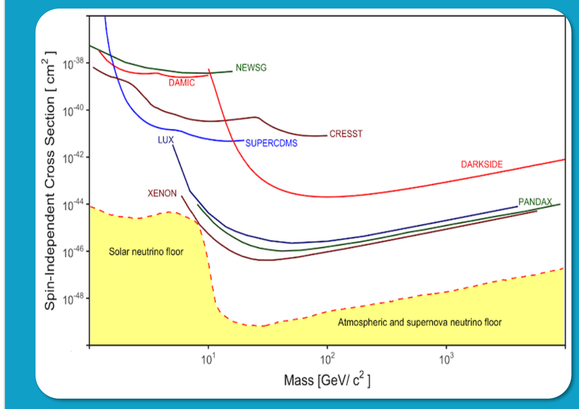
CEvNS is very well predicted in the Standard Model.

$$\frac{\mathrm{d}\sigma}{\mathrm{d}T} = \frac{G_F^2 M}{2\pi}\frac{Q_w^2}{4}F^2(Q)\left(2 - \frac{MT}{E_\nu^2}\right)$$

As the weak neutral charge of proton is close to zero, the scattering cross section is roughly proportional to the square of number of neutrons.



CEvNS is helpful for studying the neutrino floor for various Dark Matter Experiments.



The neutrino floor shown here in red dashed line in comparison with the sensitivity limits of various dark matter experiments [Source - L. Strigari/Texas A&M University]

Applications

1) A new avenue to search for sterile neutrinos.
2) Shrinks the detector size to a few kg scale.
3) Can be incredibly helpful in studying solar and supernovae neutrinos.
4) Background for multiple Dark Matter experiments.

Further info

Coherent Elastic Neutrino-Nucleus Scattering: An outlook on the mechanism, success and applications of the phenomenon.
Sahil Arora, DoPPS, NIT Hamirpur
Kuldeep Kumar Sharma, DoPPS, NIT Hamirpur

1. D. Akimov et al. (COHERENT Collaboration), Observation of coherent elastic neutrino-nucleus scattering (2017)
2. D. Z. Freedman, Phys. Rev. D 9, 1389–1392 (1974)

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