6710 Astrobite 4

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Title: Bolometric detection of neutrinos
Authors: Cabrera, B. Krauss, L. M., Wilczek, F.
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Astrophysics is often thought of as a study of light interactions. In recent decades, astrophysics has evolved into the "multi-messenger" age, taking information about the universe not only from light, but neutrino and gravitational wave detections as well. Neutrinos, Fermi's "little neutral ones", are just that: small, neutral, and extremely weakly interacting.

Neutrinos offer valuable insight into the inner machinations of stellar processes, tracing weak nuclear reactions which happen within. A majority of solar neutrinos come from the p-p chain, where hydrogen is fused into helium, which cannot be directly traced by light. Since the energies of these neutrinos are determined by the weak interactions in which they are created, detection of these neutrinos directly traces the sub-processes of stellar fusion. These particles are made in ridiculously large numbers: there are tens of billions of them from the Sun passing through your eyes every second.

So what is the issue? If there are such large numbers of neutrinos being produced, why is it so hard to find them? The 1980s pushed the horizons of neutrino detection to find the neutrino spectrum of the Sun. Cabrera, Krauss, and Wilczek offer a solution to the problem of bolometric neutrino detection in 1985 in a foundational approach still in practice today.

The answer lies in the interaction of neutrinos with other matter. Neutrinos interact weakly, meaning that the scattering rates are very low compared to the fluxes by many orders of magnitude. There are several scattering processes, but the most informative is neutrino-nucleus scattering, where, as the name suggests, a neutrino scatters off of a nucleus. This scattering event produces a shower of particles which can interact with detectors to produce a signal.

Cabrera, Krauss, and Wilczek propose a detector of order 100 kg of Si to measure these neutrino-nucleus interactions. The neutrino will scatter off of the Si nucleus, releasing this radiation of other particles to be read by the surrounding detectors. By today's standards, this 100kg proposed detector is minuscule, but modern neutrino detectors work in the same fashion.

The number of neutrino detections scales with the size of the detector, so "bigger is better" when it comes to neutrino detector experiments. Current world-class neutrino detectors like Super-Kamiokande in Japan are orders of magnitude larger than the Cabrera, Krauss, and Wilczek detector, with Super-K containing a massive 40000 tons of ultrapure water.

Detectors operating on these principles give invaluable insight into the mechanisms of stars invisible to regular telescopes. Neutrino detectors like these have also become the basis for dark matter particle searches, offering even more insight into the workings of the universe invisible traditional telescopes. This work by Cabrera, Krauss, and Wilczek is critical to the formation of the age of multi-messenger astrophysics in studies of stellar interiors and beyond.