Deccan Herald, Spectrum, Tuesday, April 13, 2010, pp. 03

NASA PROGRAMME
NASA will develop commercial flights of crew and cargo to the International Space Station.

In search of neutrinos

PHYSICS They are omnipresent and travel close to the speed of light. Snaring them is not that easy. Yet, there have been several efforts to study neutrinos by way of the Kamiokande detector in Japan, the IceCube detector in the Antarctic, the Neutrino Mediterranean Observatory et al, notes **C Sivaram**

They are highly elusive particles and can traverse light years without colliding with subatomic particles. We are talking about neutrinos.

Detecting them would need several thousand tons of detector material like water (in case of the Kamiokande detector in Japan) or heavy water (like the Sudbury detector in Canada) or a cubic kilometre of ice like the IceCube detector in the Antarctic. This is to trap even a few of these particles and make them interact.

Solar neutrinos come straight out from the solar core where thermonuclear reactions are taking place and several hundred trillion of them go right through each of our bodies every second. So several kilotons of say, water or dry cleaning fluid, (like the Davis experiment) can hardly detect a few neutrinos per day! Antineutrinos from decay of radioactive isotopes in the earth's interior have also been detected, as also neutrinos from stellar explosions like supernova 1987A.

NEMO's search for neutrinos

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the background noise at depths of two kilometres, Giovanni Pavan of Pavia, a marine biologist who had initiated digital recording of sea-mammal sounds in the early 1980s pointed out that the deep waters were not as silent as the particle hunters would have liked. He was invited to join the ONDE team which had positioned four hydrophones at the NEMO site. Soon data was obtained and apart from the low background uniform noise caused by ship traffic and natural water motions, there were bursts of sounds identified from large ship propellers - sonar impulses.

However it was noticed that sperm whales at that depth produced characteristic sounds consisting of short, periodic sequences of clicks caused by air being compressed in their respiratory apparatus. Whales presumably utilise these sounds (apart from producing them!) to estimate depth, locate prey by echo sounding (like bats do). These whale sounds are very loud and can travel several kilometres of water. The clicks kept being registered in the recording apparatus, month after month, totally contrary to the view that the whales were rare at such depths. The

NEMO's search for neutrinos

The Neutrino Mediterranean Observatory (NEMO) (a collaboration of over 100 scientists from various Italian institutes, mainly Italian National Institute for Nuclear Physics, INFN Catania) experiment tries to study neutrinos in the ocean. The NEMO design calls for thousands of optical detectors spread over two cubic kilometres of water, 3.5 km under the sea at a site off Cape Passero, south of Sicily. An incoming neutrino would very rarely interact with a water molecule producing a pulse of light that photodetectors would capture and amplify.

In theory, high energy neutrinos can also produce detectable sound waves. A pulse of concentrated energy deposited by such a neutrino could cause a shock and the result is occurrence of sound waves. As sound travels much better and farther than light in water, an acoustic detector could increase chances to capture incoming neutrinos. This effect has not yet been tested, but a related, so-called Askarayan effect has been tested in an accelerator experiment.

Hydrophones constitute part of the NEMO design as they are utilised to position the optical detectors. So one could in any case see (or rather hear!) if any such effects are present.

So a feasibility study called Ocean Noise Detection Experiment (ONDE) was mooted and particle physicist G Riccobene was asked to supervise it. It was to be located at a two-km deep test site east of Catania in Sicily.

Earlier experiments in the Mediterranean to detect light pulses from penetrating neutrinos were confused by light flashes from benthic bioluminescent sea creatures (at great depths). Also, it was first assumed that background noise at great depths would be very low. While the neutrino hunters were pondering about

water. The clicks kept being registered in the recording apparatus, month after month, totally contrary to the view that the whales were rare at such depths. The ONDE recordings were from great depths, although after several hundred hours of such deep underwater sound recording, no neutrinos were recorded but lot of information about seasonal social behaviour, sizes, movement and population of whales could be deduced!

Soon the ESONET (European Seas Observatory Network) developing networks of deep sea Mediterranean Sea monitoring agreed to finance ONDE with a new platform called LIDO (Listening Into Deep Ocean) to last for three years, starting March 2010 with four hydrophones. Work will continue also on the NEMO observatory (of course now with the knowledge that there is plenty of background ocean noise to be sorted out before acoustic neutrino detection becomes foolproof) and the sound data would be now shared with biologists, cetologists, seismologists, oceanographers, etc. searching for the tiny neutrino has triggered activity in other disciplines also.

Neutrino detection

There have been many neutrino detection experiments planned including AMANDA, IceCube, NESTOR etc. In India, plans to proceed with the Rs 800-crore Indian Neutrino Observatory (INO) project at Singara in the Nilgiri hills were rejected on environmental grounds.

What started as a quest for messengers from light years away now also involves down to earth and down to the deepest sea floor studies, about which even less is known!

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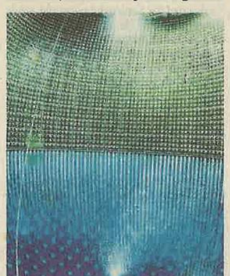

HUNT'S ON **Equipment surrounding a huge tank of extremely pure water from the Super-Kamiokande experiment in Japan. The Sudbury Neutrino Detector has begun to detect nearly invisible particles.** NASA IMAGES