UNDERGROUND TELESCOPES

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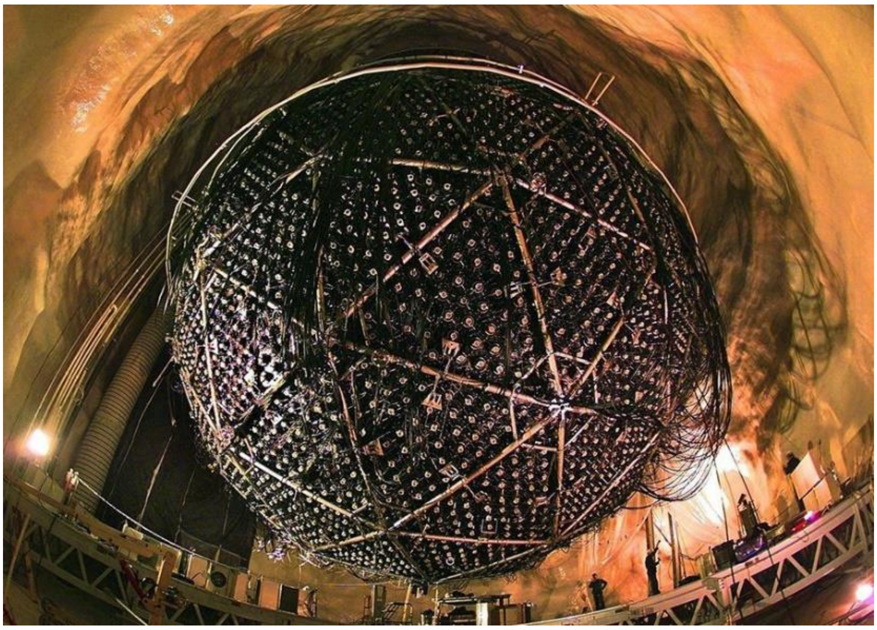
Ken Tapping, 1st October, 2024

We put optical observatories on tops of high mountains to get them above the clouds and away from our light pollution. On the other hand, radio observatories are usually put in bowls in the mountains or other locations screened from the cacophony of manmade radio interference. However, around the world are telescopes installed deep underground. Some use big tanks of dry-cleaning fluid, others water and in one case a cubic kilometre of arctic ice. These instruments are key in understanding some of the fundamental questions about the universe, and, in their own way, they are located where they are to reduce the levels of interference they have to live with.

We have one of the more important instruments of this kind buried 2.1 kilometres below Sudbury, Ontario. Known as the Sudbury Neutrino Observatory (SNO), its "telescope" consists of a 12-metre diameter vessel containing 1,000 tonnes of heavy water. The hydrogen atoms in molecules of ordinary water consist of a single proton, orbited by an electron. To get heavy water, we add a neutron to the atom. Water using these "heavy" hydrogen atoms is referred to as "heavy water" and is used in radiation screening and radiation detectors because it is very good at catching high-energy particles. This big vessel of heavy water is surrounded by around 9,600 photomultiplier tubes. These are highly sensitive detectors of the faint pulses of light produced when high-energy particles pass through the heavy water.



The SNO and the other underground "telescopes" are mainly used to detect neutrinos. These ghostly particles come from the Sun and other bodies in space and arrive here in huge quantities. About 100 trillion neutrinos pass through our bodies every second, and only on extremely rare occasions do they actually interact with anything. We use huge volumes of heavy water, ice or other materials to increase the chance that somewhere inside the vessel, a neutrino will interact with a molecule, producing a pulse of light that will be detected. Why would we go to the trouble of putting the detector deep underground?

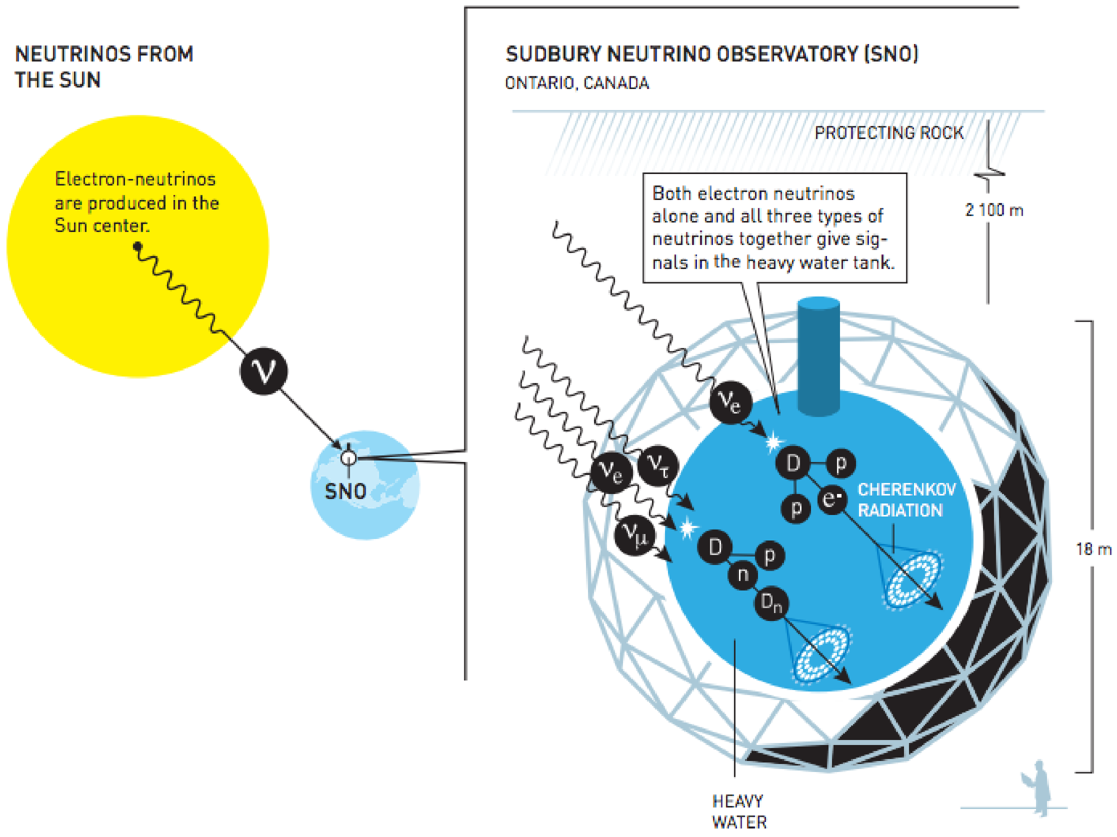


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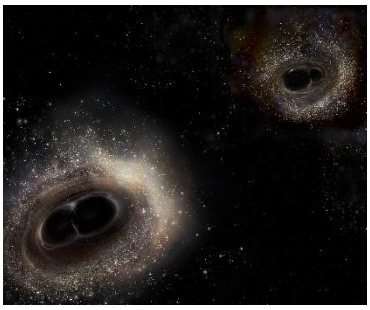
Image – University of Washington

The problem is that there are many high-energy particles coming from space. Most of these are cosmic rays, particles accelerated to almost the speed of light in the remains of exploded stars or in the magnetic fields of the Milky Way. Maybe there are some crossing inter-galactic space, reaching us after journeys of millions or billions of years. These would swamp our detectors. However, whereas neutrinos pass freely through almost anything, cosmic rays can be blocked by a nice, thick layer of rock. That is why we put these telescopes deep underground. We now know that the galaxies and some of the huge structures we see in the universe are moulded by a totally invisible something we have come to call "dark matter". We have no idea what this material is, other than it supplies the additional gravity needed to explain what we are seeing. To make this happen, there must be about six times as much dark matter in the universe than ordinary matter, which is what we, the planets, stars and everything we can see are made of. Ordinary matter is made up of particles; maybe dark matter is too.



If so, these particles don't interact much with ordinary matter, otherwise we would have detected them by now. Maybe they interact sometimes. In this case, we might be able to detect them using the detectors we use for neutrinos, which very rarely interact with anything else. Of course it might be something else entirely. Not knowing what is moulding the major structures of the universe is downright embarrassing. We would really like to know the answer to such a fundamental issue.