CHAPTER 1: Introduction

Section 1.1: Neutrinoless Double-beta Decay

Fundamental symmetries provide a mechanism for understanding the world. There are three discrete fundamental symmteries. Their respective operators are C, which stands for “Charge”, P, which stands for “Parity”, and T, which stands for “Time”. For a long time it was assumed that these symmetries were absolutely conserved. Indeed, they are quite intuitive. This worldview was disrupted when partiy violation was first discovered by CS Wu. Paritry symmetry went unquestioned until 1956 when T.D. Lee and C.N. Yang postulated its possibility and noticed evidence for its existence was gravely lacking. C.S. Wu demonstrated the existence of partiy violation with her famous cobalt-60 experiment, in which electrons from beta decay were emitted in a preferential direction relative to the spin orientation of the cobalt nuclei. Parity was violated an violated maximally. The effect was substantial. Nevertheless, deep-seated assumptions about symmetries, perhaps based on instinct, were hard to displace. The belief that combinations of symmetry operators must be valid symmetries persisted. The union of charge and partity, or CP symmetry was the next tenet to be challenged when in 1964, Cronin and Fitch discovered CP violation in the decay of kaons. The discovery of CP violation has since prompted physicists to search for other symmtery violating effects, resulting in the discovery of CP violation in both D and B meson oscillations. Discoveries of symmetry violations actually provide an explanation for other cosmological phenomena. In 1967, Andrei Sakharov pointed ou that CP violation is necessary to explain the existing baryon asymmetry in the universe. These are the so-called Sakharov conditions and they must have manifested themselves in the early universe in order to produce the matter-antimatter asymmetry. Though numerous examples of symmetry violations have been found, the combination of all three symmetry operators, CPT, is generally believed to be a conserved symmetry. It is dided CPT is conserved. CP-violation has only been observed in the weak interactions of the quark sector. Its existence in the lepton sector has not been conrmed experimentally. Notably, long-baseline neutrino experiments are being constructed at great cost to look for CP-violation in the neutrinos. Experiments such as DUNE (Deep Underground Neutrino Experiment) require a baseline which runs from Illinois to South Dakota and a collaboration of more than 525 scientists and engineers [7]. Other groups have been searching for CPviolation in the charged lepton sector as well [8]. For example, if the electron has an electric dipole moment, this would be a sign of T violation, which is equivalent to CP-violation, provided CPT is conserved.

Physicists have observed the flavor oscillation of neutrinos from a variety of sources blah blah blah [**?**].

Section 1.2: Another Section

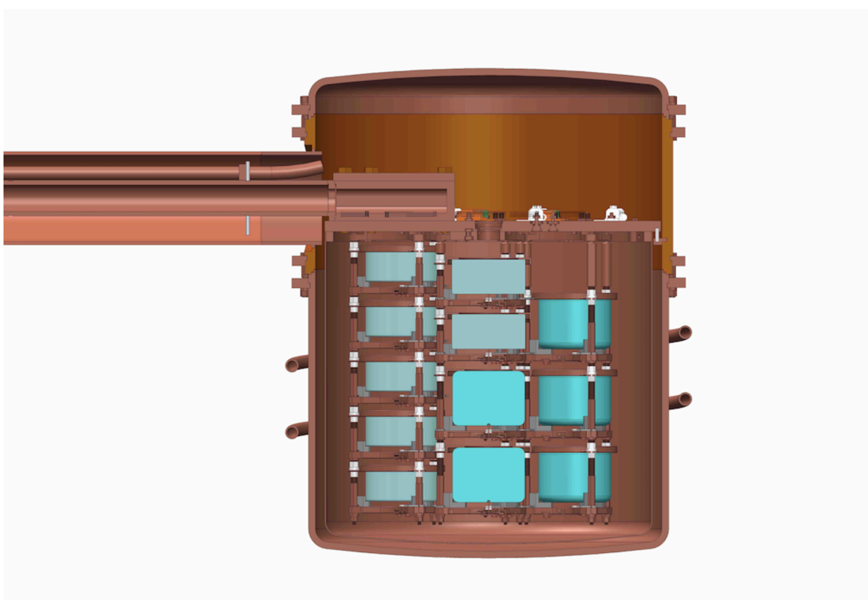

Figure 1.1: Drawing of a Majorana Demonstrator cryostat. Strings of germanium crystals (turquoise) hang from the cryostat cold plate.