7.3.8 Measurement of Flavor or Mass? (Added in June 2022 revision)

Note that a typical neutrino detection device is composed of normal matter, i.e., electrons and nuclei. From Fig. 7-3, pg. 231, we see that only electron neutrinos could interact with such a device, not muon or tau neutrinos. The latter two types would be undetectable.

I recall, as a student studying the material of this chapter, wondering that if mass eigenstates and flavor eigenstates are different, which do we actually measure in experiment? From the prior paragraph, we can understand that neutrino measurement devices generally detect a given flavor, and commonly in the early days of neutrino research, this was the electron neutrino flavor.

Neutrino experiments detect flavor eigenstates, not mass eigenstates (The two are different for neutrinos)

So, each detection could have one of three different masses. Any number we would assign as mass of an electron neutrino is then a statistical average, over many mass measurements, of those three mass values. Such measurements are extremely difficult, however, so neutrino masses are not known to high precision. (More on this in Chap. 10.)

Quarks are different, since we use Basis IIq, visualized in Fig. 7-5, pg. 337, as opposed to Basis I, visualized in Fig. 7-3. While we can't measure quarks directly, we can think in terms of a measurement with a normal matter detector of first-generation particles, but, unlike neutrinos, these detectors can interact with any of the three generations. Charge measurements can't discern between flavors, but mass measurements do. Different hadrons with the same charge, like the proton (*uud*) and the Σ^+ (*uus*) are distinguished between from their mass differences. Unlike neutrinos, quark flavor eigenstates are the same as quark mass eigenstates. So, quark flavor discernment in experiment is done via their respective masses.

Quarks discerned in experiments via mass eigenstates (which for quarks are the same as flavor eigenstates)