HONORS 135 - Ideas in Honors - Week 8

Theory and Future Experiments

Demo: Homopolar motor

Overview: Introduce Lagrangian with simple example. Then go over SM Lagrangian. Talk about symmetry and breaking symmetry. Super symmetry, dark mater search, dark energy, and possible new particles. Talk about ILC, FCC, the current plan for LHC (HL-LHC). Mysteries in neutrinos, as a promising alternative to higher energy.

Class plan:

- 10min. Review material about DAQ quickly.
- 20min. Homopolar motor. Build and experiment with.
- 10min. Discussion:
  - What makes the motor spin? What forces are involved?
  - How does the motor pick a direction? Something has to break the symmetry.
- 30min Slides to cover Lagrangian, Symmetry, Super Symmetry, what we don't know: dark matter, dark energy. Future colliders and experiments.
  - Lagrangian: mathematical way to predict behavior or an object. T-U
  - Lagrangian example: ball roll down plank. Use both newtonian and Lagrangian mechanics, side by side comparison.
  - The motivation behind Lagrangian is symmetry: spacial symmetry in the case of the ball. In fact, if you wanted to *derrive* the Lagrangian above, you could do it by looking for the most generic equation with spacial symmetry.
  - Lagrangian of the Standard Model - explain the terms. The symmetries that it is based on: gauge and reference-frame invariant are the two top symmetries. Gauge symmetry requires non-differentiable fields to produce same effects. Explicit symmetries: U(1)SU(2)SU(3) - gauge, translational symmetry, rotational symmetry. These are all very reasonable assumptions, and out falls Lagrangian - which does a very good job of predicting particles.

- Super Symmetry (SUSY): an additional symmetry that can be added. Suggests all particles have supersymmetric, heavy partners. One goal of the LHC is to search for these. Fixes bad predictions of SM.
- Future of the LHC - show LHC upgrade timeline, run 2, HL-LHC
- Next generation accelerator: ILC, Japan interested in building. Construction will begin soon and end in 2026. e+e- collider. Hadron colliders are better for discovery, since they probe range of energies due to parton distribution. Linear colliders more clean, more precise, can be tuned for Higgs production.
- FCC - distant plans for 100km collider.
- Neutrino science. US is investing heavily. Many problems to study in neutrino physics. Mass, oscillation.

References:

- Yuval Grossman: http://indico.cern.ch/event/318367/material/slides/0.pdf
- Beyond SM G.F. Giudice: http://indico.cern.ch/event/318520/material/slides/0.pdf