title: Zachary First Reading Notes
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1 | How to Deal with Large and Small

- Scientific notation is required to deal with large and small quantities
  - This is required in much of particle physics since particles tend to be very small and fast
- People also tend to create more fitting units for a specific application

1.1 | Units

Fentometers are used as a unit of measurement in the atomic world. They're $10^{15}m$.

For **speed** we use fractions of the speed of light c ~$3 * 10^8 m/s$

Volts are used for charge.

Particle Masses can also be expressed in eV units. Particle masses are actually pretty large with the eV unit.

Planck Size is about $10^{-35}m$

Angular Momentum can be measured in h-bars which are Planck's constant divided by 2π

1.2 | Relative Scales Distance

- The nucleus takes up a very small amount of a particle
  - Comparison drawn here is a basketball in an airport for a large nucleus and a golf ball for smaller ones
- Electrons occupy in a probability distribution the rest of the space more or less
- The only viable way to measure distances that small are through scattering experiments involving shooting electrons at say a proton and observing the scatter pattern
  - The diameter of 1 proton is approximately 1 fermi
- We live in a relative distance average
- Short Wavelengths can also be observed to estimate the size of such small particles
- The Planck size is the smallest meaningful distance before spacetime breaks down into quantum foam

1.3 | Relative Scales Speed

- The fastest anything can go so far as we know is the speed of light
- It's hard to get anything close to the speed of light, but for stuff like particle accelerators and cosmic rays it isn't super uncommon to get close

- Mass being the reluctance to accelerate means that the mass-less photon should be the fastest particle requiring no energy to reach the speed of light. For anything to go faster would be difficult.
  - However, physicists have studied the Tachyon which is theoretically capable of doing so but has not been discovered and also creates strange circumstances

1.4 | Relative Scales Time

- The longest known time is the lifespan of the universe
  - This is currently estimated to be about 13.7 billion years
- The speed of light is the natural link between distance and time measurements

1.5 | Relative Scales Mass

- Mass is a measure of inertia meaning how hard something is to accelerate
- We measure particle's speed by measuring their resistance to acceleration with knowledge of their speed
- With particle masses it becomes more sensical to use MeV instead of kg since the units make more sense

1.6 | Relative Scales Energy

- Energy and its conservation make it perhaps one of the most important things in physics
- Kinetic energy and mass energy are the most important types when it comes to particles
  - Rest mas is different from mass
- Mass represents a highly concentrated form of energy
  - A little mass leads to a lot of energy while a lot of energy can yield a little mass
- In the subatomic world mass and energy are typically both measured using the electron volt

1.7 | Relative Scales Charge

- Electric charge is that thing that makes a particle attractive to another type of particle
- If the Gluons are overcome by the repulsion of the protons a nucleus will break apart
  - This is why there is a cap for how large an atom can be realistically since it would require too much energy to keep together than the gluons can offer
- Negative and positive is entirely arbitrary they are just opposites

1.8 | Relative Scales Spin

- Spin occurs with anything from the largest galaxies down to the smallest particles
- Angular momentum is used to measure both orbital motion and rotation on one's own axis
  - Fundemental particles have measurable angular momentum, but a rate of rotation cannot be specified
    * Planck's constant divided by 2π is the fundamental quantum unit of rotation
- Difference in spin is drastic enough for us to call particles with different spin new particles
- All electrons have the same spin
  - Spin is quantized and things such as electrons are either ”up” or ”down”