Questions — PS 303 — Fall 2010

7. **What is the one electron universe theory?**

   This theory posits that antiparticles (for example, the positron, or anti-electron) can be viewed as traveling backward in time. Therefore, when an electron and positron interact, that interaction can be thought of as the electron simply changing it's "direction." This would mean that the reason why all electrons have the same charge and same mass (i.e., they are indistinguishable) is because they are all the same electron! And the same goes for the positrons. Of course, this does not seem to be consistent with the fact that there are more electrons than positrons, but there have been (complicated) suggestions to get around this fact.

   A very nice description of this theory can be found in Paul Davies's book *About Time*. In addition, Richard Feynman discusses this in his Nobel lecture here: `http://nobelprize.org/nobel_prizes/physics/laureates/1965/feynman-lecture.html` (search for "same electron"). To learn about the standard model of particle physics, with it's zoo of matter particles and anti-matter particles, a good place to start reading is here: `http://en.wikipedia.org/wiki/Quark`

   — Amy Williams

8. **Why can't two objects occupy the same space at the same time?**

   For example, when you place a water bottle on a table, why doesn't it fall through? Why can't you walk through walls?

   Well, humans, and all other "solid" objects, are mostly empty space. The reason is that atoms, which make up humans, are mostly empty space. The radius of an atom's nucleus is on the order of 1 femtometer (10^{-15} m), compared to the size of the atom (i.e., the electron cloud surrounding the nucleus), which is roughly a half angstrom (0.5×10^{-10} m). This means that the nucleus is 20,000 times smaller than the atom. However, two objects cannot occupy the same space because the electrons in the surfaces of the two objects repel each other due to the Coulomb force.

   An example in which two objects *can* occupy the same space is during galactic collisions. In a galaxy, stars are much smaller than the average distance between them, so two galaxies can pass through each other without any of the stars "colliding." The stars are similar to atomic nuclei, which are also much smaller than the distance between them. However, stars do not have a large electron cloud that would repel the electron cloud surrounding other stars.

   — Sam DeMarco

9. **Why does the rate of fission for Uranium increase when the neutrons move slower?**

   In addition to spontaneously breaking apart (which is rare) a uranium nucleus undergoes fission when free neutrons are fired at it. This in turn breaks apart the nucleus into several pieces (the total mass of the products is less than the mass of the initial particles) and the energy produced from this reaction can be used for many things like propulsion of a submarine. When the free neutrons are shot at the a U-235 nucleus, they are more likely to interact with the nucleus if they are moving slowly. The nucleus needs enough time to interact with the neutron, which means that fast neutrons will pass through the nucleus without breaking it apart. A slow neutron, on the other hand, will interact with the nucleus longer, and the nucleus essentially absorbs the neutron, which sets the nucleus oscillating like a drop of liquid. As the oscillations become more violent, the nucleus is split apart, usually resulting in two approximately equal parts, which of course are the nuclei of atoms.

— Austin Kim

10. **Who won the 2010 Nobel Prize in Physics, and for what?**

    The Nobel Prize in Physics 2010 was awarded jointly to Andre Geim and Konstantin Novoselov "for groundbreaking experiments regarding the two-dimensional material graphene." See `http://nobelprize.org/nobel_prizes/physics/laureates/2010/`

    Graphene is a thin layer of carbon one atom thick. It's a great conductor, it's flexible, transparent, strong (for its size) and light. It is produced by peeling thin sheets off of graphite, the material in pencils. In fact, the reason why pencils write so well, is that it is fairly easy to rub off thin sections. In your pencil scratchings, therefore, there are probably pieces of graphene. Graphite itself is constructed of layers of carbon atoms in hexagonal (honeycomb) pattern, where the layers are only weakly bonded to each other.

    Possible future uses for graphene include touch screens, electronic sensors, and electronic components. However, it has not been produced in quantities large enough for commercial applications.

    — James Kendall

11. **How hard is it to contain plasma?**

    It is essentially impossible to contain a plasma. A plasma is a collection of charged particles, i.e, and ionized gas. Fusion reactors contain plasma and utilize them to create exothermic fusion reactions. The idea behind fusion reactors is if you take two nuclei with relatively light masses and cause them to collide, if they "fuse" into a heavier nucleus there will be a substantial amount of energy released. However, these are charged particles. Before the nuclei can get close enough to become bound and release energy, they must overcome the repulsive Coulomb force. This repulsive Coulomb force makes it extremely hard to get these two particles close enough so that the strong nuclear force will allow them to form a single, heavier, nucleus. To increase the likelihood that the particles will fuse with each other, fusion reactors operate with extremely high densities, pressures, and temperatures. Unfortunately, the high temperature plasma wants to expand, and will ultimately be absorbed by the walls of any container built to confine it. (Even though it is high density for a plasma, it is still close to a vacuum, so usually no damage is inflicted on the walls of the container.)

    In order to confine this extremely volatile substance, physicists have used what is called a "magnetic bottle." Quite literally, a bottle shape is constructed using magnetic field lines. The field lines are the furthest apart at the middle portion of the bottle, and at either end they converge, making the magnetic field much stronger at the ends of this "bottle." The plasma particles (charged particles, of course) spiral around the magnetic field lines, and when they reach the ends of the bottle, the get reflected to the other side and oscillate between the bottle ends. However, these lines do not completely seal off the end. That is to say, the value of B at the ends of the bottle is finite, and as a result, magnetic bottles always leak.

Another confinement method is to bend the magnetic field lines into a torus shape; such a machine is called a "tokamak." However, even though the plasma cannot escape from the ends (there are no ends), other problems are introduced by the torus shape, and ultimately confinement is one of the main obstacles to true plasma confinement (and hence fusion energy).

If you are interested in learning about these methods, consider taking EP 495C — Plasma Physics and Engineering — during the Spring 2011 semester.

— Anthony Bonds