Physics 100: The First-Year Seminar in Physics

Accelerator-Based Materials Analysis to the Quark Structure of Matter

The course is divided into five two-week parts, with five different professors presenting background material in their fields of expertise. We hope to make some connections between the material across these different topics and the professors will be coordinating the grading and logistics of the course. Here's an outline of the course:

1. **Accelerator-Based Materials Analysis:** PIXE, or Proton Induced X-ray Emission spectroscopy, is a powerful analytical tool used to determine the trace elemental composition of a solid sample. The PIXE technique provides a relatively inexpensive and non-destructive means of materials analysis that is used routinely in research and industry. A beam of 2.2 MeV protons will be created using a Pelletron particle accelerator and this beam will interact with the atoms that make-up the unknown sample. X rays characteristic of the elements in that sample will be produced from the interactions between the protons and the inner shell electrons in the atoms. A characteristic x-ray energy spectrum will be recorded and analyzed to identify the elemental composition of the sample. (Scott LaBrake)

2. **Lasers:** Lasers are found in lots of everyday technology today, from the supermarket check-out to your CD player. We'll first learn a bit about the physical properties of light, in general, and laser light, in particular. After learning about how lasers work, we'll see some of their applications in industry, medicine, and science, as well as their use as a tool in the study of the structure and dynamics of biomolecules. (Jay Newman)

3. **New Worlds to Discover:** The age-old dream of finding planets beyond the solar system was realized in the mid 1990s, and the search for Earth-like, habitable, or inhabited worlds continues as one of the most active fields of astronomy. We will learn about the methods for discovering these exoplanets, and their surprising properties, such as the well-known "Hot Jupiters" and "Hot Neptunes". We will use data from the Union College Observatory to get a deeper understanding of planet transits, and perform CCD imaging at the observatory. (Francis Wilkin)

4. **Dark Matter and the Distribution of Galaxies in the Universe:** Astronomers have concluded that most of the matter in the Universe does not emit light! We will discuss the observations leading to this conclusion and possible candidates for the unseen or 'dark' matter. While dark matter is still mysterious in composition, its discovery has helped us to understand the structure and evolution of the Universe. It has also led to predictions about the numbers and types of galaxies that should exist and how they should be distributed. For example, the galaxy distribution in the local universe shows a filamentary pattern with high density regions containing lots of galaxies separated from other high density regions by nearly empty ones, the voids. Numerical simulations of the distribution of dark matter explain the presence of voids but also indicate that they should not be as empty of galaxies as observations have shown. We will help search for galaxies in one of the most prominent voids in the local Universe by carrying out a remote (internet) observing run at the Arecibo Radio Telescope in Puerto Rico. (Becky Koopmann)

5. **Quark Structure of Matter:** Lying at the core of every atom and comprising over 99% of its mass, the atomic nucleus is made up of protons and neutrons. The protons and neutrons, collectively referred to as nucleons, are in turn made up of what we now believe are the fundamental constituents of matter, called quarks. In this module we'll discuss our current understanding of nuclear structure and the experiments that led to this understanding. We will also talk about the very active research going on today to try to understand how the quark model accounts for the observed properties of nuclei. This module will include a Rutherford basckscattering (RBS) experiment using the 1.1-MV Pelletron accelerator in the Union College Ion-Beam Analysis Laboratory. (Mike Vineyard)

Reading material will be supplied for each modular topic as will homework assignments. The nature of the homework may vary with the module, but there will be some graded work for each two-week portion of the course. Students are *encouraged to work on the assignments together with others in the course.* It is expected, however, that the *work you hand in to be graded will be written up independently by you* after discussions with other students. **Please indicate on the homework who you worked with in preparing the assignment.**

Each module will also have an associated quiz, lab, or project.

Your grade in each module will be based on your performance on the quiz/project and/or homework, and your final grade for the course will be the average of your grades in the five modules.

Union College recognizes the need to create an environment of mutual trust as part of its educational mission. Responsible participation in an academic community requires respect for and acknowledgment of the thoughts and work of others, whether expressed in the present or in some distant time and place.

Matriculation at the College is taken to signify implicit agreement with the Academic Honor Code, available at honorcode.union.edu. It is each student's responsibility to ensure that submitted work is his or her own and does not involve any form of academic misconduct. Students are expected to ask their course instructors for clarification regarding, but not limited to, collaboration, citations, and plagiarism. Ignorance is not an excuse for breaching academic integrity.

Students are also required to affix the full Honor Code Affirmation, or the following shortened version, on each item of coursework submitted for grading: "I affirm that I have carried out my academic endeavors with full academic honesty." [Signed, Jane Doe]