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Testing Einstein's theory

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Physics students to benefit from magnet donated by MIT

In 1905 Albert Einstein published his Special Theory of Relativity, which changed the world's understanding of space, time, matter and energy.

This theory is based upon the postulate that light, unlike sound, propagates without a medium. Sound travels through air, water or solids but cannot travel through a vacuum. Because there is no medium for light, there is no possible way to determine who is at rest and who is in motion. Only the motion of one observer relative to another is detectable. Hence the use of the term relativity in the name of the theory.

The Special Theory of Relativity predicts that different observers under some circumstances will measure different time intervals and different distances between the same two events. And it is the source of what may be the most well-known equation in all of physics: $E = mc^2$.

This equation, which states that energy is equal to mass, multiplied by the square of the velocity of light, implies that mass and energy are different manifestations of the same thing. It even floats across the screen in the opening of "The Twilight Zone," the popular TV show from the early 1960s. In a voice-over during the opening theme, Rod Serling describes the twilight zone as a journey into a wondrous land whose boundaries are limited only by the imagination. But how do we know that relativity is more than a theory from the twilight zone created by the extraordinary imagination of Einstein?

Students in a physics lab at Furman will soon be able to verify some of the results of this important theory using a special magnet recently donated to the department by the physics department at Massachusetts Institute of Technology. The donation honors Charles Townes, the 1935 Furman graduate who won the Nobel Prize in 1964 for work that led to the development of the maser and laser. The donation was made possible by Jay Kirsch of the MIT faculty. Townes, who is now on the faculty at the University of California, served as provost and professor at MIT from 1961 and 1967.

The unique design of the magnet donated to Furman was developed in 1938. It will be used in the relativistic dynamics lab, where students seek to verify the relationship between energy, momentum and velocity for electrons moving close to the speed of light.

Physics majors Tim Durham (top) and Andy Edwards examine the makeup of the magnet. It will be used in the department's relativistic dynamics lab, where students seek to verify the relationship between energy, momentum and velocity for electrons moving close to the speed of light.

Fast-moving electrons are produced by radioactive decay in a source contained in the vacuum chamber inside the coils of the magnet. When a power supply forces current (a flow of charge) through the coils, a magnetic field is produced which is proportional to the current. (All magnetic fields are in fact produced by motion of electric charge.) For a given current in the magnet, only electrons with a particular momentum will traverse the semi-circular path inside the apparatus. Thus the field and semi-circular path allow one to calculate the momentum of the electrons.

The magnetic field and semi-circular path filter out all electrons except those with a particular momentum. After this process, the electrons enter a region where an additional electric field allows measurement of their velocity. The electrons then strike a detector that measures their energy. Students can measure the momentum, velocity and energy of the electrons and compare their results to theory.

For the exercise to work well, an extremely uniform magnetic field is needed. The MIT magnet will help ensure that Furman students are able to create just such a field and collect more accurate readings, as its precisely manufactured spherical shape produces the uniform field required for this experiment. While the field is not especially strong (only about 100 times that of the Earth), the level of uniformity produced by this design is difficult to achieve.

The testing of theories through precise measurement is the business of experimental physics. The measurements are expected to show that Einstein's theory is correct within the uncertainties in the measurement process.

— David Turner
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