Muons, Swiss and the wages of SIN

Only Switzerland, which was the scene of the activities of John Calvin, Ulrich Zwingli and—our all-time favorite among reformers—Oecolampadius, would name a particle accelerator SIN. The letters actually stand for Swiss Institute of Nuclear Research (in its German form), but their concatenation seemed appropriate to some Swiss taxpayers, who complained it was not only a sin but a crime to spend so much on a piece of equipment for physicists to play with.

Franc-counting taxpayers notwithstanding, the thing is now operative. It is a very modern cyclotron of 590 million electron-volts energy designed to produce and study in detail some of the most puzzling particles, the mesons.

According to a report in the September CERN COURIER, the first experiments are concentrating on the properties of one of the strangest of particles, the muon, and with the precision for which the Swiss have long been noted in other fields, they are measuring those properties to accuracies around one part in a million. One experiment by physicists from the Eidgenössische Technische Hochschule (Federal Institute of Technology) and the Universities of Zurich and Mainz has measured the magnetic moment (intrinsic magnetic field) of the muon to an accuracy of 3.5 parts per million. (The number is quoted as the ratio of muon magnetic moment to proton magnetic moment and is 3.1833545 ± 0.0000112.) The result agrees with a previous measurement done at Berkeley, but disagrees significantly with the most precise determination yet, which was done at Yale University in 1975. The present figure is regarded as a preliminary result and the ETH-Mainz-Zurich group are hoping that they will shortly achieve a precision of less than one part per million.

Another experiment, by a group from SIN itself, is measuring the momentum of muons produced in the radioactive decay of pions that have been stopped in flight, and a third, by a group from ETH and the University of Fribourg in Switzerland, is studying the X-rays given off by atoms in which muons have replaced electrons.

The problems may seem a little picky but they bear on important natural philosophical questions about the nature and significance of the muon and particles like it. Is the muon, for example, a body with a spatial extent that can be defined? We are so used to seeing particles depicted, even in advanced textbooks, as little spinning balls that we forget that the image can be seriously misleading. One sort of theory wants the muon and particles like it to be geometric points, that is, dimensionless. But this raises paradoxes: All parts of an electrically charged muon bear the same charge. If they are squeezed to zero dimensions their mutual repulsion becomes infinite, and the thing should explode because of this infinite self-energy. Historically this is known as the self-energy crisis, and it has been with us for a long time. In classical physics, magnetic fields are produced by electric charges moving in currents or circuits. It's easy to see how a spinning charged ball produces a magnetic field, but how can a point be a current or circuit?

On the other extreme, a particle may not be a localizable entity at all. There is a kind of theory that sees it primarily as an aspect of a particular quantum mechanical wave. A wave is not in one place or another, but in many at once; it has a potentially infinite extent. The conundrums are enough to increase physicists' bills for aspirin or Valium, so it is not surprising that even the most philosophical of them, when they sit down to do a textbook, start drawing little spinning balls. But, *caveat lector*, the question is not so simple. □

Sizing up the universe by radio

One of the most important things that cosmologists want to know—it is crucial to deciding among their various theories —is how far away objects of cosmological interest are. To build up a scale from the nearest to the farthest objects, observers use a variety of means of measurement. The more different means of cross-checking they have, the happier they are.

Up to now all of the techniques used information gained through visible light. Now the first one using nonvisible radiation has been demonstrated by radio astronomers R. B. Tulley and J. R. Fisher. They will publish the description in ASTRONOMY AND ASTROPHYSICS.

The method uses the famous and long-studied 21-centimeter radio waves emitted by hydrogen to measure the distance to spiral galaxies. A peculiarity of spiral galaxies is that the more massive the galaxy, the faster the spiral arms rotate around its center. The 21-centimeter emitting hydrogen pervades the interstellar space of the spiral arms and rotates with them. The speed of the rotation can be found from a Doppler shift in the 21-centimeter wavelength.

From the speed, the mass of the galaxy is known. The more massive the galaxy, the more stars it has. The more stars it has, the brighter it is. By this chain of reasoning the observer comes to the intrinsic brightness of the galaxy. Comparing that with the apparent brightness can get the distance by well-known laws of optics.

The method has been tested by comparing its determinations with the distances of spiral galaxies that can be determined by other means. The correspondence is excellent—almost too excellent in fact. Spiral galaxies of the same class are not exact twins of one another, and small differences in shape and motion should introduce more errors than appear. This circumstance, as the NEW SCIENTIST puts it, "is just a thin cloud of doubt over what may become a very useful yardstick." □

Survey of binaries in Magellanic Cloud

The majority of the stars in our galaxy appear to be members of binary or multiple systems, and if one galaxy is more or less similar to another in its physics, large numbers of binary and multiple systems should also occur in other galaxies. Until now, accurate study of binary systems has been confined to those in our own galaxy. Now, for the first time according to an announcement from the University of Pennsylvania, a systematic survey of binaries in another galaxy, the Large Magellanic Cloud, is about to be undertaken by a group of astronomers led by Robert H. Koch.

The ultimate purpose of the survey is to see whether the chemical composition of the Large Magellanic Cloud's binaries is different from those in our galaxy and in the Andromeda galaxy. The Large Magellanic Cloud is the nearest galaxy that is easy to study, being only 200,000 light years away. Beyond it and its companion, the Small Magellanic Cloud, the Andromeda galaxy is the nearest to our own. A similar survey of binaries in the Andromeda galaxy is not in the near future, but Koch expects it to take place within his lifetime.

Chemical elements heavier than hydrogen and helium are formed by nucleosynthetic processes in stars. Young stars start out making the lighter elements; heavier elements are made as the stars age. Finally, when old stars explode as supernovas, come the heaviest elements.

The stars of the Magellanic Clouds are believed to be generally younger than those of our galaxy and the Andromeda galaxy, and this should show up in their chemical composition. Detailed studies of accurate graphs of brightness variation of eclipsing binaries can determine the size of the stars, and that leads to an estimate of their age.

Since the Magellanic Clouds are near the southern pole of the sky, the observations will be done at the Mt. John University Observatory near Christchurch, New Zealand. Plates will be sent to Pennsylvania for analysis. The work is expected to go on for many years. □