"allowed us to make measurements that were never dreamed of."

Dehmelt's group in Washington has now measured the electron *g*-factor to an accuracy of four parts in a trillion. This provides a test of the theoretical predictions of quantum electrodynamics that is more sensitive than any other test of a physical theory.

Ramsey, 74, has done work in several areas. At Harvard in the late 1940s, he developed the technique cited by the Nobel prize committee: the separated oscillating fields method. Until that time, atomic energy spectra were measured by passing a beam of atoms through a magnetic field and exposing them to an electromagnetic field that was tuned to an energy equal to the difference between two energy levels of the atom. The accuracy of this technique was limited by the necessity of keeping the magnetic field constant over a large area.

Ramsey discovered that if the atoms were exposed to two separate electromagnetic fields, once as they entered the magnet and again as they left, the accuracy of the measurement could be greatly improved without the need to make the magnetic field more homogeneous. That idea found application in a number of areas, including today's atomic clocks.

Ramsey also studied the chemical shifts seen in nuclear magnetic resonance experiments. "His work was seminal in the theory of chemical shifts, which underlies the use of the magnetic resonance imaging units in hospitals," say Daniel Kleppner of the Massachusetts Institute of Technology.

Building on Nobel Research

David Pritchard knows what it is like to stand on the shoulders of giants and see farther than anyone else.

In the 16 October issue of *Physical Review Letters*, Pritchard describes a technique for determining the ratio of the mass of CO^+ to the mass of N_2^+ to within an accuracy of 4 parts in 10 billion, or nearly a factor of 10 better than had been reported before for a mass measurement. Speaking to *Science* on the day the 1989 Nobel Prize in Physics was announced, he said his work would not have been possible without the prior accomplishments of physics laureates Wolfgang Paul, Hans Dehmelt, and Norman Ramsey.

Pritchard, a physicist at the Massachusetts Institute of Technology, used a device called a Penning trap to hold single CO^+ and N_2^+ ions in isolation in order to get accurate information on their masses. The Penning trap was invented and developed by Dehmelt and further improved by one of Dehmelt's students, Robert Van Dyck of the University of Washington.

To calculate the masses, Pritchard used the fact that a charged particle in a magnetic field will move in circles with a "cyclotron frequency" that is inversely proportional to its mass. By putting first one type of ion in the magnetic field of the trap and then the other, he compared their cyclotron frequencies and got an extremely accurate measure of the ratio of their masses. The technique for measuring the cyclotron frequencies owes a lot to Ramsey's separated oscillating fields method, Pritchard says.

Pritchard says he hopes to improve the accuracy of measurement by a factor of 10 or more, which could allow some interesting applications, such as calculating the rest mass of the neutrino. Tritium decays into helium-3, an electron, and a neutrino. Since the rest mass of the electron is already well known, an accurate comparison of the masses of tritium and helium-3 should make it possible to calculate the rest mass of the neutrino, long been assumed to be zero. Pritchard's method may reveal whether that assumption is correct. ■ R.P.

And Ramsey has been "a statesman of science," Kleppner adds. He has been president of the American Physical Society and is now chairman of the board of the American Institute of Physics. "He's done so many things that he's a monumental figure in contemporary physics," Kleppner says.

■ Robert Pool

Early Work Rewarded

The Nobel Prize for Economics is a relatively recent innovation—the first one was awarded in 1969—so there seems to be a feeling among economists that there is a lot of catching up to do. That may well be the case with this year's award to Trygve Haavelmo, a professor at the University of Oslo in Norway. Haavelmo is honored for his "fundamental contributions to econometrics," which were mostly made in the 1940s.

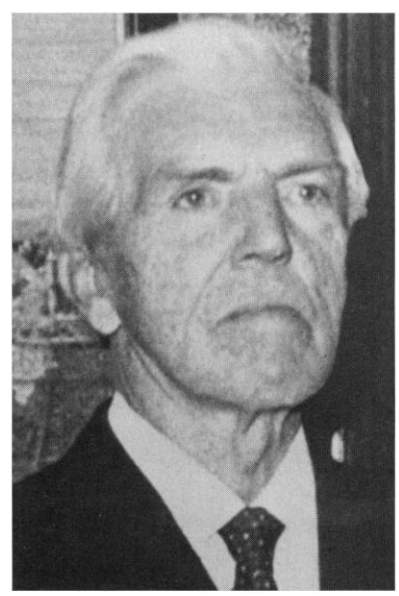
Haavelmo was a pioneer in applying the methods of mathematical statistics to the problems of modeling economies. "His contributions have been path breaking, but unappreciated by many professional economists, let alone the public at large," said Mary Morgan, a lecturer in economic history at the London School of Economics. His central achievement was to develop statistical tools to cope with the fact that an economy is the product of millions of individual decisions bound together in a complex web of interdependencies.

Haavelmo's influence on the subject has been profound. He influenced Lawrence Klein of the Wharton Business School and Arthur Goldberger of the University of Wisconsin at Madison to create the first major model of the U.S. economy, an "algebraic gymnasium," but one that worked quite well. And his methods are still extensively used by econometricians.

The prize comes late in Haavelmo's career. He is almost 78 and has not been very active in the field recently. He is not known as a traveler or conference attendee. Indeed, some economists were surprised to learn that Haavelmo was still alive.

Informed of the news at his home in a suburb of Oslo, Haavelmo was irritated. "I do not like this type of prize," he told reporters in Oslo before unplugging his telephone, getting into his car, and vanishing into the Norwegian countryside. The prize is worth about $470,000.

■ Jeremy Cherfas



Influential econometrician. *Trygve Haavelmo of the University of Oslo in Norway.*