is likely to be complex, but one hypothesis says the particle streams produce changes in the upper atmosphere.

Finally, scientists in several fields are taking another look at the old theory that sunspots may somehow be involved in weather changes on a scale of decades. Climatologist Mitchell told SCIENCE NEWS that research he is conducting with Charles W. Stockton of the University of Arizona indicates that droughts in the western United States may indeed be related to the cycle of sunspots.

Roughly every 11 years the sun's surface reaches a state of maximum activity, which can be measured by observing the number and extent of sunspots—dark areas caused by cooling of matter thrown up from the active sites. By examining the growth rings of trees from 40 sites in the West, Stockton has constructed a climatic picture of the region, going back to 1700. When he looked at the periods of drought, he found that they coincided fairly closely with *alternate* periods of minimum sunspot activity.

Mitchell has now analyzed this data and hopes to publish a joint paper with Stockton within a couple of months. Mitchell says their conclusions will support the idea that droughts in the western United States do indeed seem to follow a 22-year cycle—coinciding with every other minimum in the sunspot cycle. According to this scheme, the scheduled time for the next drought would come sometime in the remaining part of this decade. While Mitchell stops short of actually predicting one, he says the theory at least "justifies an extra degree of caution that we are in a drought-prone situation right now."

So far no physical mechanism has been discovered to connect droughts and other phenomena to the sunspot cycle. Slightly less radiation falls on the earth during a sunspot minimum, and changes in the direction of the sun's magnetic field give every other minimum some distinguishing features. But links to weather would be complex and they remain a mystery.

Over a longer period, the average radiation of the sun may itself change, and a decrease of this so-called "solar constant" by even one or two percent might cause the earth to cool one or two degrees—enough perhaps to trigger an ice age. During the 17th century an unusually long period of low sunspot activity, and thus lower radiation, coincided with a "little ice age" in the Northern Hemisphere (SN: 3/6/76, p. 154).

At least the memorable "Winter of '77" may stimulate new research into what climate changes may occur in the future and what nations can do to minimize their effects. Discussion is now going on in government circles over what funding increases should be given to weather research. Many professionals believe that a doubling or even tripling of effort over the next decade could be handled and would now be justified. ☐

An elegant inquiry into the electron

The electron is the lightest particle known to physics that possesses mass and electric charge. It is also the lightest to play an important role in the structure of atoms and molecules. The question of its structure—if any—has been one of the most compelling in the physics of the 20th century and has driven both theorists and experimenters to fantastic refinements of calculations and measurement. At the meeting of the American Physical Society in Chicago this week, Hans G. Dehmelt of the University of Washington reported on an experiment done by himself and several collaborators that measures the magnetic properties of the electron to the accuracy of 2 parts in 10 billion. This is not only an experimental "work of art" in Dehmelt's words; it happens also to be potentially more accurate than the best theoretical calculation and so challenges theorists to match its accuracy.

The theory in question is quantum electrodynamics, the theory of electric and magnetic behavior on the subatomic world, and its history is bound up with questions about the properties and structure of the electron and successive attempts to measure them, especially the magnetic ones. Because an electron has an electric charge, it can produce a magnetic field, and, as a matter of physical observation, it turns out that the electron can do so in two ways. First, the electron orbiting in an atom produces a magnetic field, because in its motion it constitutes an electric current. Second, it produces a magnetic field because it possesses spin. That an electron should produce spin magnetic field is not so immediately obvious to a physicist as the orbital case. A spinning electron will be an electric current only if it has some structure. If the electron is a geometric point without spatial extension—as some theorists would have liked to believe—it could not make an electric current as it spins. So there has to be some kind of charge distribution over space associated with the electron, but what it is remains mysterious. The models and mental pictures that people use are very crude. Physicists hate to try to describe what the structure of the electron may look like, but they use mathematical assumptions about it in putting together their theories.

The first theory, due to P.A.M. Dirac, postulated that the electron's spin magnetic field and that of its smallest possible orbit were exactly the same.

In 1947 experiment showed Dirac's postulate to be wrong: The ratio of the two magnetic fields differs from the unity by about one part in a thousand. This difference was one of the bases of modern theory of quantum electrodynamics which won for Richard P. Feynman, Julian S. Schwinger and Shinichiro Tomonaga the Nobel Prize for physics in 1965. The modern theory allows the difference to be calculated, and there has been something of a dialectic between experiment and calculation in recent years. The best experimental data previous to that of Dehmelt and collaborators was accurate to 3 parts in a billion. The latest theoretical calculation was 10 times more accurate. Now, Dehmelt's result, accurate to 2 parts in 10 billion, matches that of the theory. The experiment has the potential of doing 100 times as well as the current theory, and so it presents theorists with a challenge to recalculate.

Whether this new theoretical challenge, if and when it is taken up, will lead to revisions in theoretical concepts, as some of the previous experiments did, Dehmelt declines to speculate. What he stresses is that here is a very precise way of measuring the properties of an isolated electron, one of the tiniest bits of matter known. (Previous experiments were done on electrons in atoms.) A single electron is trapped in a very high vacuum and is levitated by electric and magnetic fields that hold it in an energy "well," a region of space where its energy will be lowest and to which it will naturally gravitate. The electron is allowed to oscillate in the well, and the proper exposure to microwave radio signals can drive it and cause changes in its orbital frequency or reverse its spin. The changes caused by this driving can be measured and compared by magnetic sensors and so the lowest possible amounts of spin and orbital magnetism can be compared.

Dehmelt says the method can be used on a positron, and he and his colleagues will do it as soon as they can figure out how to catch a positron in a vacuum. Thus, they will be able to check whether matter and antimatter are exact mirror images of each other to the highest accuracy yet. Furthermore, the technique will work on singly charged atoms, and promises to bring about "a vast improvement in optical spectral resolution and laser atomic clocks of unprecedented stability," Dehmelt points out.

He also stresses the wider philosophical context: "The reductionist approach so successful in the hard sciences and so dangerously seductive in the soft ones has been driven to an extreme in our work: a very small part of the world—a single atomic particle—has been isolated in ultrahigh vacuum, brought to rest nearly as completely as possible, and the same identical particle has been subjected to precise studies for hours, as never realized before." The reason for the effort is given in the quotation from Goethe's *Faust* that heads Dehmelt's paper: "*Dass ich erkenne, was die Welt im innersten zusammenhält.*" "That I may know what holds the world together in its innermost parts." ☐