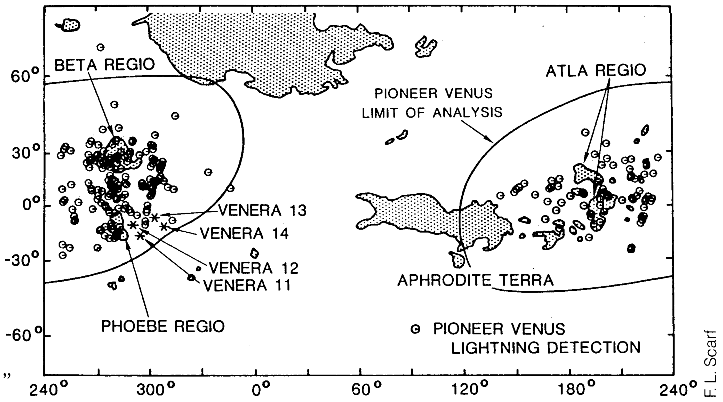
Venus volcanism: The lightning link



Circled dots indicate possible near-surface sources of lightning bolts whose radio "whistlers" were detected from orbit around Venus. Partial analysis suggests dots may be clustered around possible volcanically active regions such as "Beta."

Lightning in the atmosphere of Venus has made its presence known in a variety of ways—optical flashes, radio "whistlers" and other kinds of static. Its signs have been detected by spacecraft in orbit around the planet, on the way down through the clouds and on the surface. Its existence, in fact, was theorized as long ago as the mid-1950s (although the evidence cited at the time, radio signals detected from earth, has since been attributed to the heat of Venus's surface and lower atmosphere). Yet its essential nature remains unclear, from the processes that cause it to its location at or high above the surface.

One of the most intriguing ideas about Venus lightning was raised last year by Frederick L. Scarf of TRW Inc., in charge of an electric-field detector that has been monitoring the planet from the orbiting Pioneer Venus spacecraft. Such an instrument can sense the electromagnetic whistlers typically triggered by terrestrial lightning flashes, and Scarf's, over Venus, had detected a lot of them. Although the tenuous nature of Venus's weak magnetic field makes it difficult to trace the paths of such signals back to their sources, Scarf noted that 336 of 340 whistlers recorded during the orbiter's first 540 days on station seemed to indicate source regions clustered over two particular spots on the planet (SN: 12/5/81, p. 362). The two regions, one encompassing a high surface feature known as Beta and the other around the eastern end of a continent-sized rise called Aphrodite, have been identified by other researchers (from radar studies and gravity data) as possibly the youngest sections of the Venus surface, and thus the likeliest candidates for relatively recent volcanic activity. On earth, explosive volcanic eruptions often eject quantities of dust and ash into the air, which rub together and generate static electricity that produces lightning. The implication of Scarf's tentative hypothesis: Venus is erupting *now.*

Yet there are certainly other causes of lightning, and an important check on such provocative evidence is to find out whether whistlers cannot be traced by the same method to other, less "volcano-prone" parts of the surface. Scarf has so far reported on only one such test, but that region — central Aphrodite — indeed shows, he says, a lack of whistlers.

More of the whistler data remain to be analyzed, but Venus lightning is poorly understood, and there are other factors that must be considered before such a dramatic conclusion as a volcanically active Venus can be reached. Scarf himself has noted, for example, that the only reason his detector can spot whistlers at all is that sometimes the planet's ionosphere develops "holes" — regions depleted in electrons—through which the signals can travel. This suggests a need to confirm (from other data) that the orbiter's failure to detect whistlers over some parts of the surface is not simply due to the lack of a suitably located hole.

In addition, entry-probe data have indicated the lower atmosphere to be virtually free of aerosols and solid particles. Would further study reveal signs of erupted dust whose friction could cause lightning? Its absence would not rule out the possibility of ongoing volcanism, since photos and chemical analyses from the Soviet Venera 13 and 14 landers suggest a surface of tholeitic basalt, a material commonly associated on earth with gradual, oozing eruptions rather than the explosive kind that spew particles into the atmosphere.

Then where does the lightning originate? A likelier source, believes William J. Borucki of the NASA Ames Research Center, is in the clouds, 30 kilometers up and higher, where charge differentials — the stuff of a lightning spark — can build up between the dominant sulfuric acid droplets as the drops are separated by such processes as the vertical motions of the atmosphere. *—J. Eberhart*

Wait till next time for Z particles

The collision of a proton and an antiproton is one of the most elemental actions in physics. Matter meets antimatter, and they annihilate each other, producing a blob of energy. In principle the blob can turn itself into any kind of particle or particles, provided the sum of the masses of those particles and the energies associated with their motion as they come out are less than the total energy in the blob. The only place in the world where such collisions are managed at high energy is at the CERN laboratory near Geneva. Recent experiments in the Super Proton Synchrotron there have brought together protons and antiprotons with energies of 270 billion electron-volts (270 GeV) each, for a total of 540 GeV invested in the collision.

According to first reports of these experiments delivered at last week's meeting of the American Physical Society in Washington, D.C., they have not yet found the particles that physicists all over the world are eagerly waiting for them to find, but they have a good hope of finding at least one during their next running period in the coming autumn. The particles in question are known as W and Z. Their function in physics is to serve as embodiments of certain kinds of forces, those that represent what is called the weak subatomic interaction. (It is responsible for a large number of radioactive decays.) If two bodies feel a force of this kind, that is equivalent to saying that Ws or Zs are being exchanged between the bodies. The existence and characteristics of these Zs and Ws are a central prediction of the new unified field theories that promise to unite all of physics in a single theoretical framework.

The Ws and Zs are believed to be more massive than any particles now known. Although the theory does not specify their masses, the amounts are generally expected to be well under 540 GeV. The difficulty in finding them seems to be statistical. Ws and Zs are much too short-lived to be directly observed. Their existence has to be inferred by finding characteristic products of their radioactive decay. The decay products that can be measured in the CERN experiments represent quite rare events, and so the number of proton-antiproton collisions must be large to give a reasonable chance of detecting them.

Antiprotons do not exist naturally on earth. They must be produced in collisions of high-energy protons with atomic nuclei, and gathered and stored. According to one of the CERN spokesmen, Luigi Dillela, the experiments are designed for a beam "luminosity" of 10^{30}, which translates to about 60,000 collisions a second. They have been running so far at a few times 10^{26} or between a thousandth and a ten-thousandth of that. In the next run, scheduled for Sept. 27 to Nov. 29, they hope to reach a luminosity of 10^{29}, one-tenth of the original expectation. Given that, Dillela says, they can expect one decay of a neutral Z into an electron and a positron in 24 hours of running. That could be enough. Ws are expected to be even harder to find. *—D. E. Thomsen*