

that the unitless parameter that governs vorticity in cosmological equations probably had an initial value close to one. Conservation of angular momentum dictates that the rotation speed will decrease as the universe expands and ages, but the amount of expansion predicted by the big bang theory is not sufficient to account for the lack of presently detectable rotation assuming an initial rotation. The recent work of Ellis and Olive in the June 23 NATURE indicates that a short era of phenomenal expansion in the universe's youth could have diminished a relatively large rotation rate to a rate today that is consistent with the lack of observed rotation. The super-cooling stage, predicted by the inflationary model, is accompanied by just such an expansion, which could increase the radius of the early universe by as much as a factor of  $10^{30}$  in just  $10^{-32}$  seconds.

Although it is not known exactly how the short reheating period (caused by a phase transition similar to water freezing), which follows the inflationary expansion, would affect rotation. Ellis feels that Guth's model can explain present observations. This adds to the inflationary theory's list of successes, which include explaining the present rate of universal expansion, the isotropy (sameness in all directions) of the cosmological background radiation and the apparent scarcity of magnetic monopoles. —P. D. Sackett

## The longest day

Even the earth can't escape the clutches of old age; it too is slowing down and showing signs of irregularity. As a result, time stations around the world cooperated late last month to give the aging earth and its inhabitants a break—a one-second break to be exact. The earth's rotation about its axis is continually slowing, but not at a steady rate. This irregularity has been observed with photographic instruments since about 1932, according to Laura Charron, an astronomer at the U.S. Naval Observatory in Washington, D.C. The insertion of "leap seconds" every year or so is required to keep world clocks—which use the "ticking" of the cesium atom as a standard—in step with the rotation of the earth.

The extra second was added this year on June 30; the minute beginning at 7:59 p.m., EDT, of that evening was 61 seconds long. It was the twelfth such second to be added since the adjustment process began in 1972, when two leap seconds were added. In that year, says Charron, the time for the earth to complete one turn on its axis was decreasing by four-thousandths of a second every day. This year, the rate is only about three-thousandths of a second per day. The variability of the rate of the earth's rotation is believed to be caused by a variety of factors, including friction in the earth's atmosphere, oceans and core. □

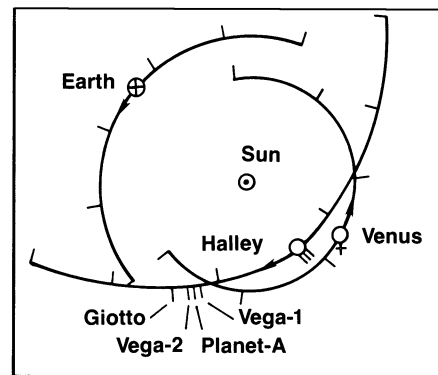
## Pioneer Venus craft to study Halley

The Soviet Union, Europe and Japan all are at work on spacecraft to be launched toward comet Halley as the famed comet takes its first swing through the inner solar system in 76 years. The United States is not. Yet one U.S. probe not only will be well-placed to take a good look, but will be in a unique position to study one of the rare event's most scientifically significant phases: the final days as Halley approaches its perihelion, the most sunward point in its orbit, when the comet's most active outpourings will begin.

The craft is the Pioneer Venus orbiter, which has been circling Venus since December of 1978. It was not designed with Halley in mind, and no one is planning to send it there. But as Venus circles the sun early in 1986, Halley will be coming around in the other direction, passing about 40 million kilometers from planet and orbiter on Feb. 4—just five days before the comet's perihelion.

The various probes being deliberately sent Halley-ward are expected to get much closer (the European Space Agency's Giotto is to be aimed within 1,000 km of the nucleus), but they will all do so in early March, about a month after perihelion. Pioneer Venus will have the immediately pre-perihelion scene all to itself. At 40 million km, the craft's "camera" (an imaging photopolarimeter, equipped with only a 3.7-cm telescope) and its radar mapping instrument will be too distant for meaningful results, but its ultraviolet spectrometer (UVS) says Ian Stewart of the University of Colorado in Boulder, definitely has a role to play. As Halley nears the sun, the growing heat will free more and more of the material that has been frozen in the icy nucleus, while the UVS looks on to measure the amounts and production rates of atomic hydrogen, oxygen, carbon, nitrogen and possibly other species such as sulfur. In addition, says Stewart, it will be in position to monitor any irregular outbursts, which could become more frequent as the heat approaches its maximum.

Various particles-and-fields sensors aboard Pioneer Venus will also be part of its Halley watch, observing the interaction between the comet and the solar wind. On Nov. 9, 1985, for example, while Halley is still on its way in, the spacecraft will fly through a region of the solar wind that came from the same part of the sun as solar-wind streams that were flowing past the comet only 10 days before. According to Devrie Intriligator of Carmel Research Center in Santa Barbara, Calif., this offers hope of providing a back-looking "calibration" of the solar wind's input to the comet. A similar alignment, she says, will exist on about March 11, 1986, when Halley is outbound. □



Venus closest approach 2/4/86  
Perihelion 2/9/86  
Vega-1 encounter (USSR) 3/5/86  
Planet-A encounter (Japan) 3/7/86  
Vega-2 encounter (USSR) 3/9/86  
Giotto encounter (ESA) 3/13/86

Positions of Comet Halley, Venus (including PV orbiter) and earth are all shown as of Halley's perihelion. Orbit sections show 30-day intervals, beginning 12/1/85. Indicated along Halley's orbit are its positions during closest approaches by the four Halley-bound probes.

Data from other U.S. spacecraft will also be included as scientists try to improve their understanding of how the solar wind and Halley—or any comet, for that matter—affect each other. The Pioneer 7 probe, for example, has been doing solar-wind studies for 17 years from a huge, heliocentric orbit. Its position in 1986, Intriligator says, may possibly put it conveniently in the way as Halley's tail sweeps past, or at least in the way of solar-wind streams carrying traces of Halley-stuff along. Also taking part will be ISEE-3, a probe now on its way to fly through the tail of comet Giacobini-Zinner in September of 1985. Shortly after that event, says Frederick L. Scarf of TRW Inc., ISEE-3 will be "upstream" from Halley in the solar wind, enabling it to report on the solar wind's "raw state" so that researchers can get an idea of what sun-spawned material is showing up in downstream measurements of the comet. —J. Eberhart

## Fermilab sets new record

In the wake of European rejoicing over the recent discovery of the long-awaited W and Z<sup>0</sup> particles at the CERN laboratory in Switzerland (SN: 2/5/83, p. 84, 6/18/83, p. 388), U.S. scientists at Fermi National Accelerator Laboratory in Batavia, Ill. have fired a shot of retaliation in the international physics technology competition.

On July 3, protons circling in the same underground tunnel used by an old Fermilab machine were pushed to unsurpassed speeds by new energy-efficient superconducting magnets. The \$130-million dollar "Tevatron," which gave the protons the record-breaking energy of 512 billion electron volts, will be one-trillion electron volts (1 TeV=10<sup>12</sup>eV) within a few months. At the higher energies provided by the Tevatron, physicists hope to explore the structure of the smallest particles of matter and begin to determine whether quarks represent the end of the subatomic lineage. □