Assuming that each plasma vortex ring eventually breaks and forms a planetary ball (there is some experimental evidence for this behavior of plasma rings), the relative quantized parameters and configuration of the solar system are accounted for, without taking gravitational effects into account. And thus, the Wells theory confirms the efficacy and efficiency of the original Kepler hypotheses concerning the ordering of the physical geometry of the solar system.

The Bell Labs results

While searching for the cause of a series of communications satellite failures in 1994, a team from AT&T Bell Laboratories inadvertently discovered a wide range of coherent waves in the motion of plasma electrons and ions in the solar wind, by examining data from the Ulysses satellite. The discovery was reported in a paper by David Thomson, Carol Maclennan, and Louis Lanzerotti in the July 13, 1995 issue of *Nature*.

This finding was totally contrary to all prevailing models of the solar wind. According to the standard view, as the magazine of the American Physical Society and American Institute of Physics, *Physics Today,* pointed out in a September 1995 report on this Bell Labs paper, "The solar wind is turbulent and possesses no long-lived structures, other than those associated with solar rotation and structure."

The Bell scientists did not set out to create a revolution in astrophysics; they discovered these coherent modes in the solar wind almost by accident. They were originally looking for the cause of intermittent fluxes of high-energy particle beams that were responsible for the satellite failures. They sought to correlate the bombardment of the Earth and its satellites by these intermittent particle beams, with the appearance

SOHO's recent discoveries

This report is based on a NASA press release.

The SOHO (Solar and Heliospheric Observatory) Satellite was launched Dec. 2, 1995 as a joint program of NASA and the European Space Agency. It gives scientists the ability to study the Sun continuously, 24 hours a day, 365 days a year, with telescopes and a dozen other diagnostic instruments.

Combined with the Global Oscillation Network Group (GONG), a worldwide, ground-based system of solar telescopes to record the Sun's oscillations, also established in 1995, SOHO is revolutionizing our understanding of the physics of the Sun, and thereby, of the universe.

These closer, continuous observations of the Sun's oscillations have already revolutionized our understanding of the solar wind and provided new evidence against currently held assumptions about how the Sun is organized and how it works. For example, the standard star model assumes that it is an isolated thermal system and a thermal gas system in equilibrium for the most part. But the measured mass solar wind outflow has shown this to be incorrect. (See box on Eddington's folly.)

Rivers on the Sun

The latest data from SOHO show that there are "jet streams" or "rivers" of plasma flowing deep beneath the surface of the Sun that are coupled to the structure of the solar magnetic field. "We have detected motion similar to the weather patterns in the Earth's atmosphere," says Dr. Jesper Schou of Stanford. "Moreover, in what is a completely new discovery, we have found a jet-like flow near the poles. This flow is totally inside the Sun. It is completely unexpected, and cannot be seen at the surface."

Ringing the Sun at about 75° latitude, these jet-like flows consist of flattened oval regions about 17,000 miles across where material moves about 10% (about 80 mph) faster than its surroundings. Although these are the smallest structures yet observed deep inside the Sun, each is still large enough to engulf two Earths.

Features similar to the Earth's trade winds have also been found on the surface of the Sun. While the Sun rotates much faster at the equator than at the poles, there are also belts in the northern and southern hemispheres in which currents flow at different speeds relative to each other. Six of these gaseous bands move slightly faster than the material surrounding them. The solar belts are more than 40,000 miles across, and they contain "winds" that move about 10 mph relative to their surroundings.

The first indication of these belts was found more than a decade ago by Dr. Robert Howard of the Mount Wilson Observatory. The Stanford researchers have now shown that, rather than being superficial surface motion, the belts extend down to a depth of at least 12,000 miles below the Sun's surface.

"In one way, the Sun's zonal belts behave more like the colorful banding found on Jupiter than the region of trade winds on the Earth," says Stanford's Dr. Craig DeForest. "Somewhat like stripes on a barber pole, they start in the mid-latitudes and gradually move toward the equator during the 11-year solar cycle. They also appear to have a relationship to sunspot formation, as sunspots tend to form at the edges of these zones."

The SOHO scientists have already speculated that the of a hole in the solar corona, and thereby to show that the particle beams were being generated in association with the coronal hole. This connection could be established if the particle beam eruption correlated with the 27-day rotation period of the Sun, since the coronal hole makes its appearance opposite the Earth at that same frequency. Using hourly averages of ion flux measurements from the HISCALE detector on the Ulysses satellite for the 27-day period in question, the Bell Labs group found the expected correlation. But they also found a large number of other coherent oscillations in the ion flux, with periods ranging from hours to several days.

The Bell group was the first to take data from solar wind oscillations over extended periods of time. It was also the first to apply the most recently developed, advanced computer correlation test and associated spectral analyses to astrophysical data, that is, analytical methods which had been originally developed by the telephone companies for communications applications.

When they checked to see if these waves correlated with previous measurements of oscillations in the motion of the solar surface—what are called acoustic or p-waves—they found matches in 90 of 118 frequencies examined. They then checked data from the Voyager II satellite, taken seven years earlier, to make sure that these signals were not an artifact of the particular instruments or satellite trajectory. They also checked the data from IMP-8 and ISEE-3 science satellites.

Besides finding a correlation with these surface acoustic waves, they also saw waves in the solar wind which would correlate with longer-period solar oscillations that have been hypothesized to exist, but have not so far been measured with much certainty. These longer-period oscillations would come from seismic motions of the deep interior regions of the Sun.

differences in speed of the plasma at the edge of these bands may be connected with the generation of the solar magnetic cycle, which, in turn, generates periodic increases in solar activity. “But we’ll need more observations to see if this is correct,” DeForest reports.

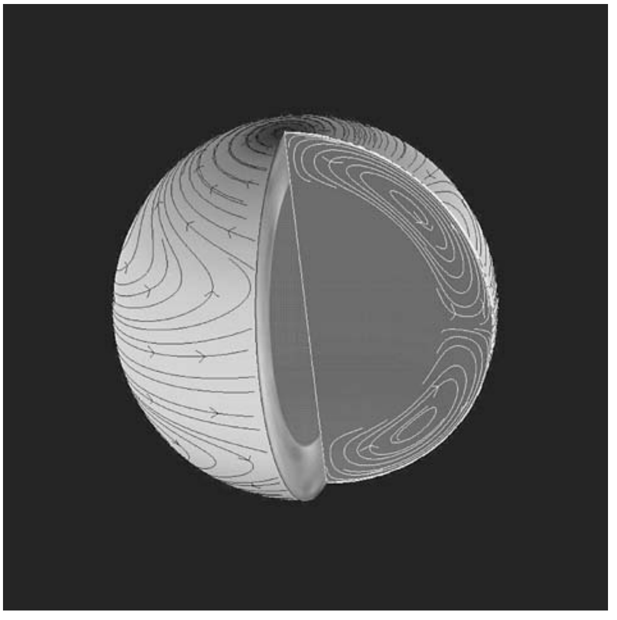
SOHO data also show that the entire outer layer of the Sun, to a depth of at least 15,000 miles, is steadily flowing from the equator to the poles. The polar flow rate is relatively slow, about 50 mph, compared to its rotation speed, about 4,000 miles per hour; however, this is fast enough to transport an object from the equator to the pole in a bit more than a year (see **Figure 2**).

“Oddly enough, the polar flow moves in the opposite direction from that of the sunspots and the zonal belts, which are moving from higher to lower latitudes,” according to DeForest.

The polar flow had previously been observed at the Sun’s surface, but scientists did not know how deep the motion extended. With a volume equal to about 4% of the total Sun, this feature probably has an important impact on the Sun’s activity, argue Stanford researchers Scherrer, Dr. Thomas L. Duvall, Jr., Dr. Richard S. Bogart, and graduate student Peter M. Giles.

Over the last year, SOHO has been aiming its scientific instruments at the Sun from a position 930,000 miles sunward from the Earth. The Stanford research team has been viewing the Sun’s surface with one of these instruments, a Michelson Doppler Imager, that can measure the vertical motion of the Sun’s surface at one million different points once a minute. The measurements show the effects of sound waves that permeate the interior. The researchers then apply techniques similar to Earth-based seismology and computer-aided tomography to infer and map the flow patterns and temperatures beneath the Sun’s roiling surface.

FIGURE 2
Flow of plasma toward the poles of the Sun



Streamlines of plasma on the Sun, as detected by the SOHO satellite. The combination of differential rotation and poleward flow has been previously linked to the measured contorted shapes of the solar magnetic field regions, when those regions migrate to the poles and get stretched to the left. These new observations demonstrate for the first time that the poleward flow is not just a surface phenomenon, but extends deep below the Sun’s surface and protrudes through at least 12% of the convection zone of the Sun.

Source: NASA and Solar Oscillations Investigation group at Stanford University.