# The earth's slowly changing shape

Changes in the orbit of the Lageos satellite have allowed scientists to observe a change in the earth's gravity field and shape for the first time, and to study factors that may affect satellite orbits. The plane in which the spherical satellite revolves shifts because the shape of the Lageos orbit is keyed to the earth, which is not round but is flattened slightly at the poles by the forces of rotation. A perturbation observed in the Lageos orbit, scientists reason, reflects a change in the earth's gravity and ellipticity.

The change detected in the gravity field, which depends on the distribution of mass, is close to that predicted by the theory of post-glacial rebound, and in essence confirms it. The rebound idea maintains that the earth at high latitudes is springing back after the rapid retreat of the great ice caps beginning 20,000 years ago. This means the earth is becoming a little rounder as more of the planet's mass moves toward the poles, the way a hard ball of putty reclaims its shape when the confining pressure of a thumb is removed.

The findings, reported in the June 30 NATURE, are based on five and a half years of data, and are reported by Charles J. Yoder of the Jet Propulsion Laboratory in Pasadena, Calif., and colleagues at JPL and the University of Texas at Austin.

The change in the satellite orbit reflects a change in a quality of the earth's shape called "$J_2$," the oblateness, or flatness, of the earth. The difference between the equatorial radius and the polar radius is only 20 kilometers, but this difference has huge implications for the earth's rotation and length of day.

"The gravity field of the earth does change with time, but the changes are so small that it was not thought you'd be able to detect them over lifetimes," says James Murphy of the National Aeronautics and Space Administration's Geodynamics Program in Washington, D.C. The measurement is possible because the Lageos orbit, deviations and all, can be determined precisely. When the satellite was launched in 1976, it entered an orbit 6,000 km above the earth, high enough to be free from drag by the most remote fringes of the atmosphere. To further avoid any disturbance, the satellite is particularly heavy. It's about the size of a bushel basket and weighs 903 pounds. The satellite carries no instruments or power supplies. It was designed simply to provide an accurate, passive target for lasers beamed from earth, to be used in precise measurements of plate movements and other earth properties.

That the gravity change could be detected over such a short period by lasers bounced off the satellite "tells you how excellent a satellite Lageos is for this kind of research," Yoder says. Lageos can be used to measure other changes in the gravity field besides flatness, and these studies will be conducted over the next 10 years. By far most of the earth's elliptical shape is caused by rotation or dynamic processes such as mantle convection — circulation of molten material in the earth's interior. The effect of climate accounts for 10 percent at most of the total ellipticity, Yoder says, and that percentage is decreasing with time from the last deglaciation. The researchers also have detected seasonal variations in the earth's shape caused by exchanges of water between land and oceans.

Another quirk in the Lageos orbit puzzles scientists. Soon after the launch, it was noticed that the radius of the orbit was decreasing at a rate of one millimeter per day. The satellite was supposed to circle the earth for hundreds of millions of years; at that rate of descent, it would return in a few million years. Why was the orbit decreasing?

The most likely explanation is that charged particles in space are causing the orbit to decay, possibly in combination with solar pressure from the earth's reflected light, or albedo. An editorial in the July 7 NATURE reports that the orbit appears to be increasing again, and says that "if this is the case, charged particle drag cannot be the sole explanation and earth albedo becomes a vary probable second cause." *—C. Simon*

# Quarks may burst their bag

According to the current physical theory, quarks, the objects out of which most subatomic particles are built, should never appear as free bodies. They should always be bound inside the structures they make: Each subatomic particle is viewed as a kind of "bag," holding in its appropriate quarks. However, this basic theory is being complicated by suggestions that at very high energies the bags may break. The quarks would be deconfined and form with gluons, the particles that embody the forces between quarks, a quark-gluon plasma. Anomalons (SN: 7/9/83, p. 20) might be such plasmas.

At the recent Sixth High Energy Heavy Ion Study and Second Workshop on Anomalons, Y. Takahashi of Louisiana State University in Baton Rouge, representing the Japanese-American Cooperative Emulsion Experiment (22 physicists from 4 institutions in Japan, four in the United States and one in Poland), presented several "possible candidates for quark-gluon plasma." They occurred in interactions of high-energy atomic nuclei in the cosmic rays with nuclei in a target sent into the stratosphere. The products of the interaction had total amounts of momentum perpendicular to the direction of the incoming cosmic ray that exceeded the theoretical threshold for breaking the bags and forming a quark-gluon plasma.□

# Tantalizing whiff of fractional charge

Current physical theory holds that electric charge should not be observable in fractions of the basic unit, which is the charge of the electron. Yet for years, one experiment, supervised by William Fairbank of Stanford University in Stanford, Calif., has been finding fractional charges on little balls of niobium (SN: 1/31/81, p. 68). Other groups in various parts of the world have tried to duplicate the finding with no success. Now there is an experiment, a collaboration of a group of physicists at the Lawrence Berkeley Laboratory (LBL) in Berkeley, Calif., with other groups at 10 institutions, that may have found something. Officially their result is still null, but they have found one drop of mercury that shows fractional charge. Unfortunately the preconditions of the experiment force them, reluctantly, to dismiss it from consideration.

Fractional charge could represent free quarks. Quarks are the basic things from which most of the subatomic particles are supposed to be built. Theory holds that quarks cannot be free.

In the experiments, liquid drops or metal balls are levitated in a combination of electric and magnetic fields. The charge on the ball or drop is measured by the field strength that will support it against gravity. Experimenters examine large numbers of balls or drops hoping to find some with fractional charges.

What the LBL group has added, as G.L. Shaw of LBL reported at the recent Sixth High Energy Heavy Ion Study and Second Workshop on Anomalons, which was held at LBL, is an attempt to make free quarks by hitting beams of iron ions accelerated to 1.9 billion electron volts per neutron or proton against targets of iron or lead plus indium. Behind the targets were 26 five-gallon containers of carbon tetrachloride, calculated to catch one percent of quarks that might be freed. In the centers of the tanks were metal wires to gather the quarks — gold, copper, indium, wolfram or niobium — "whatever each of the 10 groups wanted," Shaw says. The wires were sent to the 10 groups to be dissolved in various liquids and put through the drop experiments.

The gold, dissolved in mercury, was analyzed at San Francisco State University, and Roger Bland of that institution reported finding the one fractional-charge drop. However, the drop is over the maximum size the experiment was designed to handle. A suggestion after that fact — that would strengthen the case for fractional charge — is that this drop may have had a piece of undissolved gold in it and so have been denser than usual and therefore only seemed to be too big. Whatever the fate of this particular drop may be, analysis continues. *—D. E. Thomsen*