'Stretching' Sun Sparks Questioning of Relativity

Die Sonne tönt nach alter Weise, Goethe wrote at the beginning of the Prologue in Heaven to his *Faust,* "The sun resounds to its age-old tune." Goethe was referring to the "music of the spheres," the ancient way of esthetically appreciating the mathematical harmonies in the motions of the solar system. Lately, however, scientists have discovered that the sun actually does ring; it vibrates acoustically in a number of modes. Now, as a result of a report made last week to a meeting in Dublin of the Royal Astronomical Society by one of the discoverers of those vibrations, Henry A. Hill of the University of Arizona, those vibes are causing a certain shaking in the realm of gravitational theory, raising questions about the complete adequacy of Albert Einstein's theory of general relativity.

The story starts with a search for an oblateness in the figure of the sun. The question is whether the sun's shape is a perfect spheroid or whether it bulges slightly at the equator. For decades certain observers have claimed that there is an oblateness. For just as long Hill has been looking to prove that assertion and has previously been unable to. Now, he reports an observation that seems to show that there is an oblateness and that it has consequences in gravitational theory. His associates in this work are Philip R. Goode of the University of Arizona's Arizona Research Laboratories and graduate student Randall J. Bos.

For years Hill has been studying the edges or limbs of the sun by masking the sun's image in a telescope in such a way that only light from several stretches along the very edge of the glowing sphere gets into a spectrograph. As the sun rotates, the limb on one side is advancing toward earth, the limb on the other side is receding from earth. The particular wavelengths of emission and absorption that make up the sunlight, and that the spectrograph sorts out, will be shifted toward the blue on the advancing side and toward the red on the receding side compared to what they would be if the system were at rest in a laboratory. This motion-induced shift is called the Doppler shift, and by studying it from limb to limb astronomers can calculate the solar rotation rate.

While studying these things, Hill and various co-workers found that the sun is subject to large-scale vibrations. Vibrations of different periods penetrate to different depths in the sun. Hill, Goode and Bos say they were able to separate the effects of different vibrational modes so as to determine the rotation rates at different depths from the surface of the sun to its core.

That the sun does not rotate as a rigid body has been known for a long time, but the figures determined in this survey are likely to cause some surprise among solar physicists. Hill, Goode and Bos find that the sun's core rotates about seven times as fast as the surface; the period in the core is about 3.5 days compared to 25 days at the surface. Such a large difference causes what Goode calls "a gravitational stretching," and so the sun has to be oblate.

Solar oblateness brings gravitational theory and the planet Mercury into the act. As Mercury revolves around the sun, the orientation of its elliptical orbit also swings around the sun. That is, the long axis of the orbit swings like a clock hand, and as it does, it carries the point of Mercury's perihelion approach around. This precession of perihelion, as it is called, is measurable against the background of the fixed stars.

The precession of Mercury's perihelion has been measured for centuries. It pointed up a great flaw in Isaac Newton's theory of gravitation. After adding up all contributions under Newtonian theory to the advance of Mercury's perihelion, some 42 seconds of arc per century remained unaccounted for. It was a great triumph of Einstein's theory to account for those 42 seconds. However, Einstein's theory accounts for them only if the sun is a spheroid. If the sun is oblate, another term has to be added, and the Einsteinian calculation no longer fits observations.

The one person who seems to have a theory that fits, according to Goode, is John William Moffat of the University of Toronto. Moffat says his theory contains those of Newton and Einstein in clearly defined limits. He claims it is mathematically consistent, and consistent with other experimental tests of relativity. In this case it provides yet another term — which, when added in with everything else (including solar oblateness) that affects the rate of advance of Mercury's perihelion, makes the total come out again in accord with the best recent measurements.

The correction factor is connected to the number of protons in the sun (about 10^{57}). This comes about because the physical motivation for working out the theory, as Moffat tells it, was a desire to explain the stability of the class of subatomic particles called fermions, which includes protons and electrons, in a world that has gravitational fields. That is, it is necessary to explain how matter, which is based on protons and electrons, can be stable in interaction with gravitational fields.

Moffat's theory differs from Einstein's mathematically in that space-time is curved in a different way. In particle physics terms, every kind of force (electromagnetism, gravity, the two kinds of subatomic force) has one or more intermediate particles, that embody the force and carry its effect from one thing to another. In Einstein's theory gravitation has one of these intermediaries, called the graviton and characterized by two units of spin. Moffat's gravitation has two, the aforementioned graviton and another particle with zero spin.

This finding and its interpretation are very likely to arouse an amount of controversy or at least vigorous discussion. In the near future SCIENCE NEWS will report on the peer group response.

—D. E. Thomsen

JPL director to step down

Bruce C. Murray, the director of Jet Propulsion Laboratory in Pasadena, has announced that he will step down from the post later this year. JPL is a California Institute of Technology facility that has operated for years under contract from the National Aeronautics and Space Administration as the Agency's chief center for planetary exploration. Murray, a professor of planetary science at Caltech, assumed the lab's directorship on April 1, 1976, about 10 weeks before the Viking spacecraft (controlled from JPL) reached Mars, and has seen the Voyager encounters with Jupiter and Saturn, the Seasat earth-orbiting radar mission and other activities.

A strong proponent of planetary exploration — he is vice-president of the Planetary Society — Murray has also been at the helm during the budget cuts that eliminated a U.S. mission to comet Halley, a U.S. spacecraft in the International Solar Polar Mission and a Venus-Orbiting Imaging Radar spacecraft, all programs that would have been administered through JPL. In addition, Caltech last year approved an increase from six percent to 30 percent in the proportion of JPL's work that could come from the Department of Defense.

Associates also note, however, that Murray has said from the beginning that he envisioned occupying the job for only five to 10 years, and his departure announcement came after six years and a day. Although development continues at JPL on the Galileo orbiter-and-probe of Jupiter, and studies are underway of possible low-cost planetary missions for the future, Murray feels that the facility is in a transition period, "on the threshold of a new era extending through the 1980s and beyond." At this time, he says, it is thus important that the lab have a director who will "commit himself to leading JPL through the remainder of this decade." ☐