Physics

A fractal universe?

The theories of particle physics and cosmology seem to be uniting lately to tell us that the universe must have more dimensions than we perceive. To do what they want to do, the people who make these theories have to work in more than the three spacelike and one timelike dimensions that we have up to now thought defined the universe. The most popular theories (SN: 7/7/84, p. 12) require a dozen dimensions, give or take one or two, but numbers into the hundreds have been suggested from time to time.

Although some physicists believe that these extra dimensions are nothing but mathematical conveniences, others regard them as real. If they are real, they must exist in a way in which we don't perceive them directly. Most theorists "arrange" this by "compacting" them, or curving them tightly into ultramicroscopic balls around every point in space, so that an object that tried to move in one of those directions would almost immediately return to its starting point. We are much too big to perceive anything so fine-grained.

However, if the extra dimensions are real, even submicroscopically, their presence could affect the dimensionality we perceive. Instead of a precise integral three dimensions, the perceived spacelike dimensionality might be a fractal, three-point-something. While working at the University of Tokyo, Berndt Müller and Andreas Schäfer of the Johann Wolfgang Goethe University in Frankfurt, West Germany, did some calculations to find out if this might be so. They report their conclusions in a paper in the March 24 PHYSICAL REVIEW LETTERS.

Fractals, figures with fractional dimensions, have become an important topic in mathematics and science only in the last few years, but they have found so many applications in all branches of science that scientists are becoming accustomed to thinking in fractional dimensions. The notion of a fractal universe, which would have been a joke 10 years ago, is now a serious question.

To investigate the question Müller and Schäfer chose two physical effects at extreme ends of the range of our perception, the Lamb shift in atomic hydrogen and the precession of planetary orbits. The Lamb shift is a subatomic effect; it happens to the electron inside a hydrogen atom. Planetary precession has the whole solar system for its range. So, from the atom to the solar system, are there any fractal effects?

The Lamb shift depends on electromagnetic forces; planetary precession depends on gravitation. Both kinds of force have similar mathematical descriptions. Particularly they both depend in the same way on the distance between bodies. Because the forces depend on the distance, any fractal quality in the three spacelike dimensions of the universe is going to affect them slightly. Both effects have been well researched experimentally; very precise numbers are known for both. Calculating what fractality might do and comparing that to the measured quantities, Müller and Schäfer find that if they take the planetary precession as a criterion, the fractality of the universe has to be less than 1 part in 1 billion; using the Lamb shift, the fractality has to be less than 3.6 parts in 100 billion. They note also that in a work not yet published, C. Jarlskog and F. J. Ynduráin of the CERN laboratory in Geneva, Switzerland, using the precession of orbits in binary stars, also find a limit of 1 part in 1 billion. Thus, if there is any fractality to the three spacelike dimensions, it has to be extremely small, almost imperceptible.

"[We] have shown that the dynamical symmetry associated with motion in [the relevant kind of force field] provides extremely stringent limits on any possible deviation of the number of dimensions from the integer value of 3, on both atomic and astronomical length scales," they conclude.

Technology

From supermarket to dome control

Practically every supermarket product carries a striped patch that can be read by a laser detector at the checkout counter. This code allows a store's computer to identify the product. A modified form of this technology is now showing up in astronomical observatories — to keep a dome's slit properly lined up with the observatory's telescope.

At many observatories, astronomers no longer endure chilly nights standing at a telescope's eyepiece. Instead, they work in comfortable control rooms that may be miles away. But when images of stars suddenly begin to dim, it's often hard to tell what's causing the problem. Clouds may be passing overhead, ice may have formed on the detector or the observatory's rotating dome may have shifted enough to block the telescope's view.

The dome problem was particularly severe at the Lick Observatory's heavily used 1-meter telescope on Mt. Hamilton in California. Originally built a century ago to house a 12-inch refracting telescope, its wooden, copper-sheathed dome, starting in the late 1970s, had to cover a much larger reflecting telescope. The slit opening was widened but it was still barely large enough for the new telescope. "It was an extremely tight fit," says Robert Kibrick, Lick's senior programmer. "The positioning of the dome in front of that telescope was more critical than on any other telescope we've had."

Moreover, the dome isn't perfectly spherical; when it rains, swelling wood further distorts the dome's shape. And when the dome rotates, it sticks and slips. "Its speed can be incredibly irregular," says Kibrick. All this meant that conventional methods to track the dome's position weren't accurate enough. Rubber rollers set against the dome's rim, for example, could easily slip, sending incorrect information to an encoder that translates roller movements into dome positions.

The answer that Kibrick and Calvin R. Delaney came up with was to glue the equivalent of a "universal product code" along the dome's circumference. They used two tracks. One carries an evenly spaced pattern of vertical black and silver bars. Two sensors determine the dome's speed and direction of travel. The second track is tagged at regular intervals so that the dome's actual position can be determined. Each coded "label," read by a third sensor, defines one of 18 positions.

The track patterns were generated by computer and then printed on sheets of transparent plastic. It took two people only 45 minutes to paste the tracks along the dome's 72-foot circumference. The result, says Kibrick, is an inexpensive, highly reliable means for establishing dome position. A similar encoder is to be installed at Lick's 3-meter telescope.

Kibrick reported his work last month at an International Society for Optical Engineering meeting in Tucson, Ariz.

More engineering research centers

The National Science Foundation is creating five new engineering research centers, bringing the total number of these centers to 11 (SN: 6/15/85, p. 378). The five centers together will receive as much as $56.3 million from the foundation over the next five years. Each center is expected to receive substantial support from industry as well.

The winners of the competition, which attracted 102 proposals from 75 institutions, are Carnegie-Mellon University in Pittsburgh (improved product design methods), the University of Illinois at Urbana-Champaign (microelectronics and compound semiconductors), Lehigh University in Bethlehem, Pa. (large-scale structural engineering), Ohio State University in Columbus (manufacturing processes like extrusion and casting) and a joint venture between Brigham Young University in Provo, Utah, and the University of Utah in Salt Lake City (combustion engineering).

Science Service, Inc. is collaborating with JSTOR to digitize, preserve, and extend access to Science News. www.jstor.org