Gravity's Repulsive Side

A means of reversing or screening the pull of gravity has been a fascination for many. Antigravity is one of those scientific cats that keep coming back no matter what effort is taken to put them out. Physicists have often found themselves explaining to enthusiastic people exactly why it is impossible. Now perhaps they may have to begin explaining how it is possible.

J. Scherk of the Laboratoire Normale Superieure in Paris suggests in a recent issue of PHYSICS LETTERS (Vol. 88B, p. 265) that such a thing as antigravity may really exist. The suggestion arises from current efforts to unify everything in physics into one theoretical description, a totally unified field theory. A part of these unifying efforts is a theory called supergravity, which in the opinion of some specialists, notably P. C. W. Davies of Kings College, London, writing in the Feb. 21 NATURE, could show the way to a successful theory of gravity as applied to the level of subatomic particles — that is, a quantum theory of gravity, something that has eluded theorists for 60 years.

It is supergravity that contains antigravity, and it contains it through the sort of complication that frequently attends these unifying field theory efforts. In physics to unify different collections of phenomena, different interactions, different transformations, means finding ever larger symmetry principles in nature that can order and interrelate all the different happenings the theorist desires to unify. Finding such a pattern of symmetry, such a larger symmetry group, sometimes brings an extra into the bargain. Filling out the symmetry properly means going back and searching for complications, new effects in old departments, that had not appeared to exist before.

This seems to be what is happening in the case of antigravity. It's a story of the multiplication of gravitons. On the level of particle physics every kind of force has one or more intermediate particles, particles that embody the force, as it were, and mediate its effects. If two other particles exchange the intermediate particle of a given kind of force, that means that a force of that sort exists between them or some related effect occurs between them. For example, if two particles exchange a photon, which is the intermediate particle of electromagnetism, an electric force may exist between them or some other electric or magnetic effect may take place.

In the older theory gravity was believed to have one intermediate particle, called a graviton. There is no experimental evidence for the existence of gravitons, but theory can describe several of their properties. One of the most important is spin. A graviton has two units of spin. (A photon has one unit of spin.) The mathematics will show that a particle with two units of spin will mediate an attractive force between bodies with the same kind of charge. Gravitational charge is mass, and there is only one kind, so gravitational forces with a spin-two graviton should always be attractive. That seems all right; it squares with what has been observed since Isaac Newton's day. (A particle with one unit of spin mediates a repulsive force between like charges; electric and magnetic charges of like polarity do repel one another as they should operating through the spin-one photon.)

Supergravity, in attaching gravity to larger and larger symmetries, theorizes the multiplication of gravitons. The single spin-two graviton is expanded to a family of four, one of them with two units of spin, two with one-and-a-half units of spin and one with one unit of spin. This spin-one graviton ought to mediate a repulsive force in exactly the cases where the spin-two graviton mediates attractive ones. Antigravity from antigraviton.

But not so's you'd notice. It seems at first look as though antigravity should go along with gravity, and Scherk points out cases where they might cancel each other, the gravity and antigravity between two neutrons, for example. Davies calls this nonsensical, pointing out that more than half the earth's mass is in neutrons. Such a cancellation would remove a strong reason for the world's sticking together. Nor do we see anyone leaping tall buildings in a single bound.

Scherk gets out of the trap in two, not necessarily unrelated, ways. One is to propose that gravity and antigravity view a given particle in different ways: Gravity connects to the whole of the body; antigravity to its constituents, the quarks. There is a tremendous mass difference between the view of a whole neutron and of the three quarks that compose it. The binding energy that the quarks give up is enormous. The mass of this binding energy and the differences in composition of different particles combine so that Scherk can estimate that the earth's gravitational force on a body would lose about one part in a million due to antigravitation depending on the proportion of neutrons to protons in the body.

The second way out is to propose that the symmetry that decrees the existence of the four-graviton family is not as perfect as it might be, but slightly broken. By this means the spin-one graviton will be found to have some mass. The spin-two graviton has zero mass as it did in older theories. Positive gravity thus remains a force of infinite range (because of the zero-mass intermediate particle). Antigravity becomes a fairly short-range force that is much weakened by comparison with gravity.

Antigravity may thus exist, but it does not seem as if it will ever power a speeding spacecraft. Its effects as calculated by Scherk lie somewhat beyond the reach of current experiment so nothing can be inferred from their not having been seen. If experiment ever gets good enough to find antigravity, the procedure is more likely to cost money than to make money. □

INFCE: Tying nuclear power and weapons

A 66-nation investigation on how to divorce the proliferation of nuclear-weapon states from the proliferation of nations harnessing nuclear power was undertaken at the request of President Jimmy Carter two years ago. Conclusions of the study, issued last week in Vienna, came to the less-than-profound conclusion that such a divorce was effectively impossible. So the U.S. position that the International Nuclear Fuel Cycle Evaluation "has been a success" may need an explanation. Even more important, the fact that sections of the report run counter to major components of the Carter administration's antiproliferation stance brings into question just how meaningful any consensus among INFCE participants is.

By any reckoning, the essence of Carter's antiproliferation posture — that both the reprocessing of spent nuclear fuel and the commercialization of breeder-reactor technology be forestalled as long as economically possible — won no stunning endorsement. Although the study generally backed Carter's contention on reprocessing, saying that plutonium recycling in light-water reactors "may be regarded as a relatively marginal matter," it came out supporting breeder reactors. And whereas Carter claimed the once-through light-water-reactor cycle minimized accessibility to weapons-grade nuclear materials, the study chose not to single it out as the overwhelmingly best choice for all.

What's more, the INFCE report stressed a perceived need that new international agencies or associations be created to assure that supplies of nuclear fuel not be interrupted so long as fuel-short nations abide by international nuclear safeguards to prevent the diversion of fuel for weapons production. Why are these agencies necessary? An INFCE working paper by David Fischer of the International Atomic Energy Agency, and reported in the