RESEARCH FACILITIES AND PROGRAMS

Icarus and general relativity

In a recent *Astronomical Journal* article [**76**, 395 (1965)] R. H. Dicke has suggested that the regression of nodes of the minor planet Icarus can be a sensitive test for possible oblateness of the sun and, by inference, for the existence of a cosmic scalar field that produces forces between pieces of matter.

Dicke and C. Brans proposed the scalar field in question [Phys. Rev. **124**, 925 (1961)] as a modification of general relativity that would provide locally observed effects of redistribution of matter in far reaches of space. So long as isotropy of matter distribution is preserved, Einstein's theory does not contain such effects, and their absence was considered a difficulty inasmuch as the theory then disagreed with certain interpretations of Mach's principle.

The scalar field, existing alongside a tensor field of gravity, would produce a number of effects of serious cosmological importance. It would cause an attractive force between bodies that would be so much like gravity that a practical identifying test has not yet been devised. The scalar interaction with a particle would be possible only if the particle mass is a function of the scalar. Since the local value of the scalar is determined by the past history of the total mass distribution in the universe, the scalar would serve as a mass regulator and adjust particle masses until gravitational force between two masses was of the same order of magnitude as the scalar interaction. Expansion of the universe would cause a gradual increase in the scalar accompanied by a decrease in the strength of gravitation.

Existence of such a field is expected to decrease both the gravitational deflection of light and the relativistic rotation of planetary perihelia by about ten percent. One way of determining whether the scalar exists is to find out whether all of the perihelion effect predicted by Einstein is really there.

If the sun were oblate by as much as $\Delta r/r = 5 \times 10^{-5}$, its gravitational field would be so altered as to produce a motion of planetary perihelia equal to about ten percent of that predicted by Einstein's general relativity. Since observation of the motion of Mercury confirms that the amount of motion present is no more than that predicted by Einstein, the existence of an oblate sun would mean that ten percent of the general relativistic effect is missing, and some new mechanism would have to be adduced to explain the decrease. The Brans-Dicke tensor-scalar theory could be the mechanism since it predicts about that much decrease in the Einstein effect.

The asteroid Icarus provides a good opportunity for a test since it comes close enough to the sun for any solar oblateness to affect its motion measurably. The effect to be sought is an excess regression of the nodes of the planet's orbit. (Although the perihelion motion would also be affected, the predicted amount is not great enough for an unambiguous determination.) Icarus moves in an orbit of large inclination, and the longitudes of its nodes can therefore be more precisely determined than those of Mercury (the only other near candidate for a test) whose orbital inclination is very small. The next close passage of Icarus will occur in June 1968, and Professor Dicke hopes for efforts at that time to determine the longitudes of the nodes.

Natural neutrinos

The attempt by F. Reines and others to detect high-energy neutrinos from outside the earth's atmosphere has yielded seven counts that the experimenters believe represent the particles they are looking for. The experiment is housed 3200 m underground in the East Rand Proprietary Mine near Johannesburg, South Africa, and is a cooperative effort of Case Institute and the University of Witwatersrand. It uses a large-area (110 m^2) scintillation counter to record muons produced by interaction of neutrinos with the surrounding rock.

The overburden above the counters reduces background and collimates residual muons from the atmosphere so that they peak strongly in a vertical direction. In contrast, muons produced in the surrounding rock are expected to show a slight peak in the horizontal direction, and the equipment is biased in favor of particles moving horizontally. The seven significant events were recorded between February 23 and July 1 and reported in *Physical Review Letters* for August 30 [**15**, 429 (1965)].

Phase interaction in the D layer

Researchers at the Pennsylvania State University are studying the *D* layer of the ionosphere with a technique that depends on phase interaction of radio signals. Observations are made by comparing two radio pulses of the same frequency that have been reflected from the *D* layer. One pulse is "disturbed" by interaction in the ionosphere with a signal of a different frequency, and the other is not. What happens in the interaction between the signals is determined by the electrical characteristics of the layer.

This sort of phase interaction was first demonstrated in 1933 to the surprise of certain radio listeners in Eindhoven, Holland. They were tuned to a station in Beromunster, Switzerland, but instead of the Swiss broadcast, they got a signal from Radio Luxembourg. The phenomenon was later explained as a transfer of modulation from the Luxembourg signal to the Beromunster signal that had been caused by localized heating of the ionosphere by the Luxembourg signal.

The system at Penn State uses two synchronized transmitters, one of which acts as the "wanted" station, and the other as the "disturbing" station. The wanted signal is broadcast at 2.2 Mc/sec and 80 pulses per second; the disturbing signal at 300 kc/sec and 40 pulses per second. Thus, every second pulse from the wanted transmitter interacts with a disturbing pulse. The other half of the want-