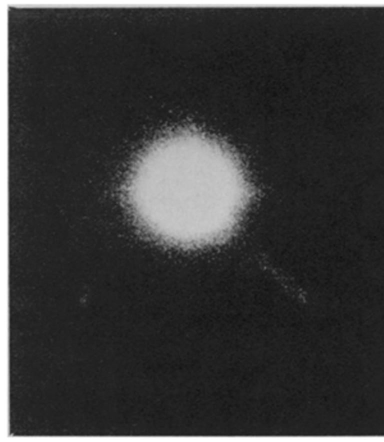
Science News of the Week

Is Gravity Weakening?

The unsettled scene in cosmology today



Quasar 3C 273/Hale Observatories

Van Flandern sees evidence for lessening of the gravitational constant. Meanwhile arguments on quasar distances still rage.

The great reaches of the cosmos are the domain of the force of gravity. It directs the motions and associations of the objects there. Theorists of cosmology have always had to deal with it as the controlling force of the universe.

Now what if gravity varies? Suppose that instead of being constant for all time, the intrinsic strength of gravity weakens as the universe ages.

The question has been considered by theorists for a long time, and they have tended to take sides on it. Now a man from the U.S. Naval Observatory, Thomas C. Van Flandern, is making an observational question of it. He says he sees evidence for a gradual weakening of gravity. He has said so before. He came to the meeting of the American Astronomical Society in Rochester, N.Y., last week with further evidence, some numbers and some discussion of rival cosmological theories.

The question is of crucial importance. Many effects flow from such a discovery. One of the first is a possible choice among cosmological theories. Einstein, whose general relativity is the dominant cosmology at the moment, said that gravity does not vary. In this he was following Newton.

To put it in terms of the mathematics, this means that Newton's universal gravitational constant is truly a constant. What Van Flandern is saying the evidence shows is that the constant is really a variable, slowly declining in value as the universe ages. There are theories on this side too. They include the three most viable alternates to the Einsteinian theory, the postulations of Dirac, of Hoyle and Narlikar and of Brans and Dicke.

If gravity weakens, astronomical orbits will expand, and the orbital periods of the bodies will lengthen. Thus one could determine the weakening of gravity, if any, by studying the motions of bodies in the solar system over long periods of time. The moon is a good one for the purpose, being close and easy to chart. Van Flandern used data from occultations of stars by the moon over the last 19 years to deduce changes in its motion. For 19 years accurate atomic clocks have been available as a time check independent of the motions of astronomical bodies. He finds a deceleration of the moon's motion that is twice what would be expected from the action and reaction of tides on the earth and the moon, and says the best interpretation of the excess is as a result of change in the value of the gravitational constant. The numerical figure for the change is usually quoted as the ratio of the rate of change to the value of the constant. It comes to about one part in 10 billion per year, and is negative, representing a decrease. Van Flandern says the amount is about what is expected by the Hoyle-Narlikar theory but is more than that required by the Brans-Dicke theory.

Van Flandern says there is supporting evidence in a discrepancy in the deceleration of the earth's rotational rate. The hypothesis of changing gravity can explain this discrepancy and give a figure for it that is close to what is observed. Another point is that there is a seemingly excessive number of binary star systems with wide orbits. The decreasing gravity hypothesis could explain this: With weakening gravity, orbits tend to increase in size. At the present date, billions of years after the formation of many of the stars, the orbits of a large number of binaries would be greater than they were when the stars were formed.

One of the most interesting consequences of weakening gravity is a gradual increase in the size of the earth. This could explain such things as seafloor spreading and the movements of crustal plates. "We do not have to depend on the results of one experiment," says Van Flandern. Other experiments are in progress that could confirm or deny his result in a relatively short time. They include laser ranging of the distance to the moon, radar studies of Mercury and certain laboratory experiments. In spite of the revolutionary nature of Van Flandern's conclusions, he was not challenged on principle, although several prominent cosmologists were in the room. The only questions asked were technical ones.

In a somewhat different way gravity has an important role to play in the question of how the quasars relate to cosmology. If the quasars are at the ends of the known universe, their numbers, distribution and physics are important to cosmology. The hypothesis that they are at such distances depends on the interpretation of the redshifts in their light. If such a shift is a doppler effect, the result of a quasar's velocity with respect to the earth, then they are at cosmologically important distances because the expanding universe hypothesis says that the faster an object is going, the farther away it is. There is an alternative view, which says that all or part of the quasar's redshifts are due to the effect of gravity. Einstein's theory predicts that light emitted in a strong gravitational field will be redshifted. If this is true of the quasars, then they may not be at cosmological distances.

This view has never been very popular, admits R. C. Barnes of the University of Missouri at Columbia, because it requires physical models for the quasars that are unstable. One such, for example, is a thin shell surrounding a supermassive body. The shell turns out to be dynamically unstable.

Working with Y. Y. Wang, Barnes has found a model that could be stable and have a reasonable gravitational redshift. It is a cluster of supermassive stars with gas at the center. The total mass of the cluster runs from tens of billions to tens of trillions times the mass of the sun. The ointment still has a fly, however. There are a number of cases in which quasars appear to be closely associated with galaxies. Clusters that massive should cause tidal effects on the galaxies. None are seen. Then there is a man who thinks that quasar redshifts are neither cosmological nor gravitational but artifacts of astronomers' procedure. He is Y. P. Varshni of the University of Ottawa. The way to calculate a redshift is to look for the pattern of wavelengths or spectral lines given off by a known substance. Each substance has its characteristic pattern, and if a source happens to be moving, the pattern will shift to the red. The individual wavelengths change, but the proportions of the pattern remain the same. When the pattern is established, the amount of redshift can be calculated.

Varshni's contention is that much of this redshift determining is done not from large patterns but from pairs of lines. This can be highly misleading because there is a good chance of misidentification of lines this way, and the ratio between the wavelengths of a pair of lines arbitrarily chosen and assigned to some emitting substance can lead to ludicrous results. He cites one example that leads to a redshift of 832. A redshift of three is considered huge.

Varshni does all this in furtherance of his contention that quasars are objects local to our galaxy and that their line emissions are due to a natural laser action. The view is highly disputed, and one of the prominent quasar people, E. Margaret Burbidge, took pains to try to shoot this contention down. The redshifts must be looked at spectroscopically, she insists, and the ones most quoted depend not simply on pairs of lines but on larger and unmistakable spectral patterns.

Finally, if the redshifts are real, there is a man, Bert W. Rust of the University of Illinois and Oak Ridge National Laboratory, who proposes that by observing events in distant galaxies, we can gain some numerical idea of the expansion of the universe. This is important too, because different cosmological theories tend to give different numbers. The events to be studied are supernova explosions. Characteristically these produce bright bursts of light that flare up suddenly and then slowly fade away. If the redshifts are doppler shifts, it follows that there should be a time lag in our view of supernova fading in distant galaxies compared with the supernovas we see nearby.

Rust has studied 36 such distant supernovas. From the way their light behaved he calculates that he can reject the classical flat Euclidean universe that our ancestors believed in with 93 percent confidence. Unfortunately the results at present don't agree very well with the usual expanding-universe hypotheses. They work best with a postulate of Irving E. Segal. This theory is so little known among astronomers that Rust had to tell them who Segal is (a mathematician at MIT).

To sum it all up, cosmology is far from settled (if we can hope that it ever will be). Observation, theory and argument bubble on. If weakening gravity is upheld, this session may have seen the beginning of an important theoretical and observational shaking out, but it will be a while before the effect is known. □

Nuclear safety: Study finds risks small

A long-awaited study of nuclear power plant safety has been released by the Atomic Energy Commission (AEC), removing from that agency what one observer calls "a rotting albatross" of 17 years duration. Like most information in the controversial nuclear power field, the report has been both attacked and praised in the week since its release.

The study, directed by Massachusetts Institute of Technology nuclear engineer Norman C. Rasmussen, focuses on the risk of accidents in commercial nuclear power plants. It was begun in 1972 and replaces a 1957 report on accident risks that has been fertile ground for nuclear critics for years. The reports differ in method and conclusion: The Rasmussen study assesses the accident risks as much lower than the earlier Brookhaven report.

Rasmussen and a technical staff of 60 scientists from the AEC, industry and universities studied the total public risks involved in the operation of 100 large pressurized water and boiling water reactors. (That number of plants is projected for U.S. operation by 1980. Fifty are currently operated.) They studied the probabilities and consequences of dozens of hypothetical accidents and found that nonnuclear accidents, both natural and man-made (plane crashes, auto accidents, etc.) are in general much more likely to occur than even minor nuclear accidents.

The likelihood of 1,000 or more fatalities occurring as a result of a major nuclear accident with 100 plants operating would be about one chance in a million per year, they found. The chance of losing that many lives by fire is 1,000 times greater; by catastrophic air crash, 5,000 times greater; by earthquake, 20,000 times greater; and by hurricane, 40,000 times greater. Large property loss, $100 million damage, was "expected" once every five centuries from nuclear accidents; similar damage from fire is experienced every two years.

A major nuclear accident would most likely involve a loss of core coolant, core meltdown and atmospheric release of radioactive gases. A nuclear explosion is considered not possible.

The 3,300-page, $3 million report was aimed in part at making accident comparisons so the general public will realize how unlikely death or injury from nuclear accidents is compared with man-made and natural risks now taken for granted. A Washington, D.C., nuclear consultant, Ralph E. Lapp, says he believes such comparisons should help end the double standard of risk assessment with regard to nuclear power. Nuclear risks are more feared and regulated than other, more likely risks, he says. Society should not pay less attention to nuclear safety, he says, but more to other areas of higher risk such as automobile and airplane safety.

The Rasmussen group emphasizes that the Brookhaven report was written during the early years of the nuclear power industry and it projected risks from limited experience with less-safe reactors. It also used inaccurate population density figures, projections of radioactive release and weather factor assessments, they say. All of these variables caused the accident probabilities to appear much higher and have added grist to critics' mills for years.

One group of nuclear critics is not impressed with the report and its new figures. Thomas Cochran and Arthur Tamplin, consulting scientists with a Washington law firm, characterize the report as "not meaningful." They charge that because the report does not consider the likelihood of sabotage, industry development past the 1980 mark and other areas of the fuel cycle such as waste storage, fuel reprocessing and transportation, "the numbers are meaningless in terms of overall public health safety." They charge that it merely confirms a preconceived viewpoint, and they are especially critical of the particular analytical methods used for risk projections (called fault tree analysis). The method concentrates on minor design comparisons and does not reveal gross design errors, Cochran says, and it can be used "backward" to arrive at preset confidence numbers. The method is valid only for comparing safety designs and not assigning overall plant risks, he says, but the Rasmussen report specifically warns against its use for comparison purposes.

An AEC scientist on the Rasmussen staff explained this apparent contradiction by saying the study combined the fault-tree method with several other more subjective analytical methods in order to gain a full picture of nuclear risks. Therefore he says the study can't be used for specific technical comparisons. The critics are forgetting these other approaches, he says.

Lapp calls such criticism "shooting from the hip." He says the Rasmussen study will be a real test for the credibility of the critics. They will have lost important ammunition (the threat of nuclear accidents) if they don't fault the study he says, but he cannot foresee any valid criticism. "One thing they forget is that we're no longer dealing with the old AEC. Madame Chairman [Dixy Lee Ray] has opened it up tremendously. This report is scarcely the technique of a stealthy group trying to force unsafe reactors down our necks." □