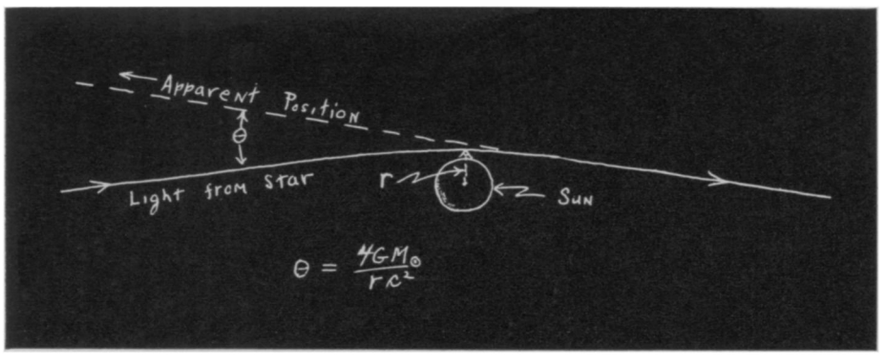


Physics Today

Sun's gravity bends a light beam: but how far? Experiment raises questions.

Einstein Under Siege

The general theory of relativity joins the special theory as the subject of critical experiments.

by Carl Behrens

For close to 50 years physicists have repeatedly challenged the revolutionary conclusions expressed in Albert Einstein's relativity theories. Experimentalists have devised many tests of the assumptions on which they are based and the predictions they make. But somehow, both the special theory, which deals with electromagnetism, and the general theory, which treats gravitation, have survived the onslaught.

A new challenge to general relativity theory, which is far more vulnerable than the special theory, has just been announced by Princeton physicist Dr. Robert H. Dicke. The new attack is aimed at one of the few precise pieces of evidence supporting the theory: the shift in the planet Mercury's orbit.

The orbit of Mercury is an ellipse which rotates very slowly around the sun. Astronomers long ago measured the rate of rotation and found that all but a very small amount of it could be accounted for by such causes as the gravitational pull of other planets. But they were plagued by the difference.

Einstein came to the rescue, and brought concrete support to his general relativity theory, by showing that if the theory was correct Mercury's orbit should rotate 43 seconds of a degree more every 100 years than previous theoretical predictions said it should.

Since that was exactly the amount by which the observed and the computed rotations differed, it was strong evidence that the Einstein formulation was correct. It has remained the one clear test of the general theory.

Now Dr. Dicke has announced that part of that 43-second shift, about eight percent of it, comes from the oblateness of the sun and the consequent distortion of its gravitational field. This means that Einstein's prediction, instead of being right on the button, is off by eight percent. The disturbing effect of the sun, according to observations which Dr Dicke made, comes from a strongly rotating core deep within the sun, causing that body to be flattened at its poles. Dicke's collaborators were Dr. H. Marks Goldenberg of Princeton and Dr. Henry Hill, of Wesleyan University.

In addition to the lack of experimental evidence for or against the general theory—besides the Mercury orbit observation—a major factor in its survival has been the elegant simplicity of the mathematical formulation in which Einstein expressed it.

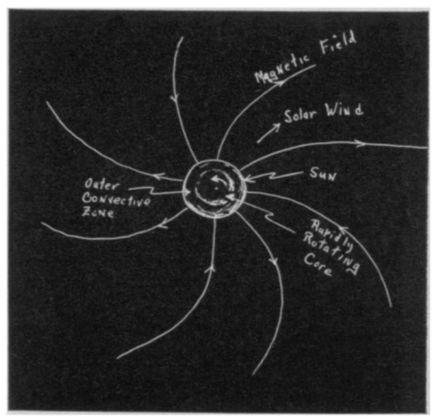
Predictably, those who challenged Dr. Dicke's findings attacked them because they complicate the Einsteinian picture of the universe needlessly.

Dr. G. C. McVittie of the University of Illinois Observatory, for example, says he believes that any changes in Einstein's theory should result in more simplified predictions rather than allowing a large array of possible solutions.

According to another critic, Dr. Peter Bergmann of Syracuse University, in the 1930's Einstein himself investigated the type of theory currently favored by Dr. Dicke, but dropped it then.

Dr. Dicke was well aware that his more complicated theory would be unpopular, but says his observations leave him no choice.

The Dicke theory, which he terms a "poor cousin of general relativity," does not challenge the primary conclusion of the Einstein theory, that light is bent when it comes near a gravitational field. Rather, it contends that the amount of bending is less than what Einstein's formulation says.



Physics Today

Flat sun affects Mercury's orbit.

Another test of the bending of light by gravitation was the measurement of light from a star as it passes by the sun during an eclipse, to see how much the star appears to be displaced. Although numerous tests have been carried out which tend to support general relativity, the limits of accuracy of measurement have been wide. Dr. Dicke claims that predictions from his theory fall within the range of limits of accuracy of those same observations.

In contrast to the general theory, the special theory of relativity has been widely accepted as beyond challenge. One reason is that it has found applications in the booming field of nuclear physics. Gravitation has received little attention, and the general theory has had few applications, though some may be emerging as astronomers reach deeper into the universe.

Even the special theory has been challenged, however, particularly the postulate on which it is based, that light moves at a constant velocity regardless of the motion of its source. An experiment in 1962, by Wallace Kantor of California Western University appeared to show that light travelled faster going through a glass window that was rotating in one direction than it did going through the window rotating in the opposite direction. Although later repetitions of the experiment did not get the same results—one physicist suggests that rotation of the glass windows might be causing molecular strain in the material—further experimentation continues.