This warning against too quick an acceptance of the theories and ideas of Albert Einstein is by the professor of celestial mechanics at Columbia University. Professor Poor presents his reasons for thinking Einstein a false prophet when the majority of scientists accept him—blindly, he contends.

What Einstein Really Did

BY CHARLES LANE POOR

Artistic proof is, like artistic anything else, simply a matter of selection. If you know what to put in and what to leave out you can prove anything you like, quite conclusively.—ANTHONY BERKELEY.

SCARCELY had the thunders of cannon ceased to reverberate when in 1919 the entire world was startled and amazed by the announcement of a new theory of the universe—a theory so bizarre that it shocked common sense. This theory of relativity, it appeared, involved the ideas, or concepts, that the speed of light is one of the fundamental controlling factors in all natural phenomena, that space and time are inseparable and are united together into some kind of independent reality, and that gravitation, or the attraction of body for body, is due to warps and twists in this space-time continuum. And with these new laws and these new concepts of time and space, one must accept, it was asserted, the formulas and methods of non-Euclidean geometry, and must abandon all the guiding precepts, axioms, and mental processes and reactions which have been evolved by test and trial during the æons since man first trod this earth. It was claimed that this theory of Einstein was founded upon a newly discovered law of nature and was firmly based upon the decisive experiments of Michelson and Morley; it was claimed that Einstein had mathematically proved every step in the complicated maze, and that this mathematical proof was supplemented and rendered incontrovertible by the fact that the theory "works."

Among all the vague generalities about time, space, and geometries of four and five dimensions, one concrete specific result of the theory was claimed by Einstein: the discovery of a new law of gravitation; the specific claim that there is something radically wrong in Isaac Newton's law of inverse squares. This new law, involved in the formulas for planetary motion, was derived, according to Einstein, from his fundamental law of relativity, from his reservoir of all knowledge "without any particular assumption, whereas Newton had to introduce the hypothesis that the force of gravitation between mutually attracting material points is inversely proportional to the square of the distance between them." And in support of this concrete claim Einstein states that his theory and his law of gravitation have accounted for a slight irregularity in the motion of the planet Mercury; states that his theory has worked in predicting that light-rays from distant stars are bent as they pass near the edge of the

eclipsed sun; has worked in predicting that the spectral lines of sunlight are displaced toward the red end of the spectrum as compared with the corresponding lines from terrestrial sources.

But no one seems to know just what this relativity reservoir of knowledge really is; no one seems to know anything about the new law of gravitation, how or why it differs from that of Newton, how it really accounts for the motion of Mercury; or how a new law of gravitation can bend a ray of light. Viewed through the eyes of the layman, the biologist, the chemist, and the philosopher unversed in the intricacies of astronomical calculation, the illusion is perfect. One stares with wonder at the soldierly ranks of tensors of many kinds and types, at covariant vectors, and at all the strange symbols of the tensor analysis, and one readily believes that Einstein's formulas are unimpeachable and impregnable. The observations, cited in support of these wonders, appear authentic and seem to have been made, with painstaking care, by astronomers and physicists of the highest rank. Yet one wonders, wonders whether it may not all turn out to be a display of magic. The merest tyro knows that you cannot get something out of nothing, knows that the conjurer does not materialize the rabbit out of the hat. One knows that the conjurer has invisible assistants behind the scenes, and that he has carefully prepared his apparatus before he makes his bow to the public.

So the illusion of relativity required long and careful preparation before it was publicly exhibited. Einstein began his work at some time prior to 1905, and during all the years that followed, many preparations were made behind the scenes. The first of these was gradually to transform the few inconclusive measures of Michelson and Morley into a long series of crucial and decisive experiments. It will be remembered that Michelson invented a complicated optical device and, with the assistance of Morley, tried in 1887 a new method of measuring the well-known motion of the earth through the ether of space. This luminiferous æther, as it was originally called, is the material medium, or ocean, which fills all space, and which serves for the transmission of light waves just as the waters of the Atlantic serve to transmit waves produced by gentle breezes, by hurricanes, and by volcanic upheavals. This light medium has been thought to be at rest, to be as a whole stationary; and in it and through it travel the earth, the sun, and the countless stars. Now by one of those peculiar verbal inversions which often happen, this motion of the earth through the ether has been termed "ether-drift." This is just as much an actual misnomer as it would be to call the passage of the *Mauretania* through the waters of the Atlantic "ocean-drift." The waters pass by the *Mauretania* at the same speed as the *Mauretania* passes through the waters, and the earth travels through the stationary ether of space at exactly the same speed as the ether "drifts" by the earth. The Michelson experiments were, in fact, made to determine the "world-drift" through space.

These now celebrated experiments were made in a basement room at Cleveland on three days in June, 1887. The results of these six measures on a beam of light were disappointing. They failed to give the known motion of the earth in its orbit about the sun, a motion of some nineteen miles per second. According to Michelson's published results the apparatus indicated a speed of only about three to five miles per second. This failure of Michelson to get the expected result might be explained on any one or more

of several grounds: miscalculations as to the motions of the earth which the instrument actually measured, errors in the physical theories of light upon which the instrument was based, or errors in the theory of the ether. The ether in the closed basement room might have been entrapped and have been carried along with the instrument; it might have been only partially entrapped. A steamship, moving through still water, drags the particles of water, in immediate contact with its sides, along with it. Particles an inch or two from the steel side of the vessel cling less tenaciously and are slowly passed; particles a foot or two away show no frictional effect and are left at rest by the passing vessel. This effect of dragging water is the well-known "skin friction" of the naval architect. May there not be a similar friction between the earth and the ether, and may not the three to five miles, measured by Michelson, be due to the effect of some sort of "ether drag"? May it not have been due to some obscure optical effect of the many reflecting surfaces in the instrument? Whatever may have been the real cause of Michelson's failure to measure the full speed of the earth through the ether, it is clear that Einstein made no attempt to explain the actual results of the experiments. He assumed that such result ought to have been zero, and upon this assumption he built his amazing structure. The Michelson experiments furnished no warrant for this basic assumption of relativity. But somehow during the succeeding years of relativity building, this assumption became transmuted into a scientific fact, and the six meagre observations of Michelson were transformed into a long series of observations made at many places and at many times of the year. Einstein refers to the "unsuccessful attempts to discover any motion of the earth relative to the 'light medium,'" and now states that these experiments of Michelson "must be decisive." Eddington, the protagonist of relativity, states, in popular works and in his serious mathematical treatises, that Michelson repeated his experiments many times, that he "detected no difference" in his various observations, and that he failed "to detect our motion through the ether." Not only have the Michelson experiments been thus stretched and distorted out of all resemblance to the original, but the "assumed" results have been generalized into the statement that "it will never be possible to determine our motion through the ether."

While it is certainly true that Michelson failed to get his expected results, yet these broad assertions of the relativists have not the slightest basis in fact. Over a century before Michelson was born Bradley, in 1725, directly measured the motion of the earth by means of light rays; and since that memorable date, night after night, astronomers have noted and measured the effects of such motion upon the apparent positions of all heavenly bodies. No mention of this aberration of light, as this particular effect is called, is to be found in Einstein's popular expositions; no discussion of it appears in Eddington's mathematical works. Not even the word "aberration" is to be found in the index of this supposedly complete treatise of relativity. And since 1919 Dayton C. Miller has repeated the Michelson experiment many thousands of times, and always with results consistent with the original observations of 1887. The apparatus shows the motion of the earth through space, indicates clearly the direction in which the earth and sun are moving; but for some, as yet unexplained, reason it does not show the full and correct speed. Its speed scale is apparent-

ly wrong. That is all. Find the correct speed scale of the instrument, and the earth's motion would be fully determined. To base a theory of the universe upon the failure of a single instrument to give correct speed results is as logical as it would be for a motorist to insist upon correcting all maps and charts of the earth's surface to conform to the speeds and distances shown by his untested, unverified speedometer.

But the new law of gravitation and the supposed effects of gravitation upon light remain to amaze and mystify, and to prove that Einstein's "ought to be" really is. Not only is this new law mysterious and intangible, but it seems to have been materialized out of the fathomless depths of relativity. Neither Einstein, nor any one of his followers has ever explained in simple, understandable language just what this law really is, or how it differs from that of Newton. Einstein's fundamental mathematical paper, in which the findings and results of relativity were promulgated, is probably the most clever presentation of a philosophical theory ever written. But it violates every canon of scientific procedure. The major portion of the paper is taken up with meticulous explanations of the many formulas and methods of the new and intricate tensor analysis. But nowhere in this celebrated paper can one find a clear and specific statement as to the basic hypotheses, or assumptions, upon which the theory of relativity rests. These assumptions are so cleverly inserted into the intricate explanations of the unusual mathematical processes, that somehow one is led to believe that they are not assumptions at all, but are necessary and logical deductions drawn from some fountain of all truth by means of the wonder-working methods of mathematical analysis.

In this remarkable paper Einstein first brings forth Newton's law of gravitation, the well-known law of inverse squares. He then casts this law back into his mathematical machine and brings out something quite different, a new law of planetary motion. Whence came Newton's law? What really happened when it was thrown back into the maze of relativity mathematics? Einstein's paper gives no hint: Einstein's followers, Eddington, Schwarzschield, Russell, and many others, do not, possibly cannot, tell. These mathematical formulas and amazing transformations must have been prepared somewhere and somehow. But where and how? Fortunately an innocent-looking foot-note, apparently referring to a mere numerical calculation, led to a paper printed in Berlin in 1915. This obscure paper does not form a part of the regular series of Einstein's relativity articles, nor was it published in the regular journals in which the relativity papers were printed. It is today practically unknown to scientists, for it is not reprinted in standard collections of papers and documents of relativity. Yet it is in this practically unknown, unsung paper that the conjurer's trick was performed; it was in this paper that Einstein inserted Newton's law of gravitation into his basic formulas.

Every schoolboy, who has ever been plagued with problems in algebra, knows full well that every symbol in his equations must have a definite meaning, or value, assigned to it. He knows that the first step in solving any one of his troublesome problems is to say: "Let x equal the number of horses," or pigs, or bushels of potatoes, or whatever the necessities of the particular problem may require. He knows full well that he cannot just jumble up x's and y's, and a's and b's, and have them all automatically sort themselves out; he knows that he

cannot draw the required meanings of these symbols from some unknown mathematical reservoir of knowledge. The intricate tensor mathematics of an Einstein is subject to the same limitations as the common algebra of the schoolboy. And in this paper of preparation Einstein was forced, just as the schoolboy is forced, to define his symbols. He calls this definition an "Ansatz," a writing-in, or an assumption. He starts his wonderful fabric by defining his tensor symbol, g_{44}, in such a way as to make it the exact equivalent of the Newtonian potential of ordinary astronomy. This gravitational potential is merely a mathematical expression, or symbol, which summarizes Newton's law that the force of attraction diminishes as the square of the distance increases. Einstein, thus, assigns to his basic symbol of relativity mathematics a value so as to make it "play the part of the gravitational potential." He put the Newtonian law of gravitation into the relativity hat behind the scenes; and, after building an elaborate edifice of mathematical formulas, after using intricate and unfamiliar systems of tensor analysis, he suddenly brings forth the concealed rabbit, and exclaims, "Remarkable!" I have produced Newton's formulas "without any assumption."

Having thus materialized Newton's law of gravitation and Newton's formulas for planetary motion, Einstein drops them back into his magic box of tensor analysis, and, after a few vague phrases, brings them forth again. But now both are changed. He appears to have produced a "somewhat different law of attraction," and from this different law to have found "a deviation" from Newton's laws of planetary motion. It will be remembered that, according to current astronomical facts and theories, the undisturbed path of a planet about the sun is an ellipse fixed in space. No real planet actually travels in such an orbit, for the Solar System consists of many planets, and they interfere one with another; and each planet's orbit is disturbed, or turned, by this mutual interference, into a sort of rotating, wavy curve. But, under the Newtonian law of attraction, the primary path of a planet, the path it would describe were it and the sun the sole bodies of the system, is an ellipse. It appears to be otherwise, however, with Einstein's new formulas, or theory of planetary motion. According to him, the primary, or undisturbed "orbital ellipse of a planet undergoes a slow rotation in the direction of motion." And the amount of this unexplained relativity rotation of the orbit of Mercury is stated by Einstein to be just sufficient to explain a rather puzzling irregularity in the motion of that body.

This observed irregularity in the motion of Mercury might be expressed as a slow rotation of the orbit. But the exact amount of this rotation is unknown, and it is tangled up and confused with several other minute irregularities. It was first discovered by Leverrier in 1859, and was confirmed by Newcomb in 1895. Both these astronomers, however, showed that its exact value was uncertain, and that it is not the only factor to be considered. Newcomb, in fact, named ten other minute irregularities in the planetary motions. The largest of them all is the rotation of Mercury's orbit, which has been variously estimated as being from 25″ to 50″ per century: Leverrier's original calculation was 38″ per century. This is such a minute quantity that it would take several hundred years for the departure of the planet from its theoretical Newtonian position to become noticeable to the naked eye. And all these very slight departures from

regularity can be perfectly well accounted for by well-known conditions in the Solar System. They can be fully explained by the known ellipsodial shape of the sun and of the planets, and by the presence of swarms of meteoric matter, known to exist between the sun and the various planets. Einstein, however, disregards all these facts, disregards the plain statements of Leverrier and Newcomb; and asserts that the perihelial motion of Mercury is the "sole exception" in an otherwise ordered system. He shows that his new, unexplained formulas of planetary motion, the formulas found by dipping Newton's into the cleansing waters of relativity, give for Mercury "a rotation of the orbit of 43″ per century, corresponding exactly to astronomical observation (Leverrier)." Thus, while changing the facts and figures found by Leverrier through long and painstaking astronomical research, Einstein claims that his theory of gravitation not only excels "in its beauty" that of Newton, but that it has also "explained a result of observation in astronomy, against which classical mechanics is powerless."

Again the obscure paper of 1915 discloses the mathematical processes. But in this case it would seem that the conjurer deceived himself as well as mystifying his public: deceived himself by the very intricacies of his own mathematical methods, and by his unfamiliarity with astronomical facts and methods.

When he dropped Newton's formula for planetary motion into his mathematical machine, it was for the avowed purpose of changing the units of time and of space in which this motion is measured. The fundamental precept of relativity is that the fixed units of time and space, heretofore used in all problems of physics and astronomy, are unsatisfactory and unworkable. According to the relativity theory of the universe, each observer has his own individual "clock" and "yardstick," and the rate of his clock and the length of his yardstick vary as he moves about from place to place. Thus an observer on Mercury will measure the motions of that planet by means of clocks and yardsticks that differ, in rate and in length, from those used by a mere astronomer on this effete earth. The second plunge into the mathematical bath was to effect a transformation; to express the motions of that planet in terms of the "more accurate" units of length and time used by the advanced observer in his modern relativistic observatory on a Mercurian mountain top.

But when the cleansed formula was brought forth, it was not only transformed as to units, but apparently also as to the law of motion. To a logical mind this latter is impossible. The mere change of units in which a quantity is expressed cannot change that quantity, be it acceleration, planetary velocity, or the weight of lumps of gold. The weight of a heap of golden nuggets can be expressed in pounds, in ounces or in kilograms; but the changing of the units does not change the weight of the nuggets. The fact is that Einstein made a slip in his preparations for his public exhibition of relativity: he did not work his mathematical machine correctly. He forgot to transform the weight of one of his golden nuggets from the pounds of astronomy to the kilos of relativity; added pounds to kilos, and got an inconsistent and illogical result.

The golden nugget that Einstein thus forgot to transform is the mathematical symbol which represents the mass of the sun. This slip, which should have been caught, may perhaps be excusable in one who has had no training in astronomical calculation; for the methods of

celestial mechanics differ from those of physics, chemistry, and other terrestrial sciences. In terrestrial physics, mass, or quantity of matter is a fundamental unit independent of the units of time and of space; but in all celestial mathematics mass is expressed in terms of time and distance. The unit of mass in use in all mundane affairs is defined as being the quantity of matter contained in a certain definite metal bar deposited in the International Bureau of Standards. The amount of matter in any other body on the surface of the earth can be found by a comparison, by weight, with this standard, or by a comparison with one of the many authenticated copies of this standard. And such measure of the mass of a body may be used with any one of the several systems of time and length units; may be used with the second of time and the centimetre of length, or may be used with the day and the mile. Whatever system be thus used, the number of kilograms, or units of mass in a definite battleship remains the same. Whether we reckon the speed of the battleship in miles per hour, or in metres per second the number of tons in its displacement remains the same. But in astronomical calculations the case is different. We cannot directly weigh the mass of the sun against any such fixed physical unit, nor can we directly measure the mass of Jupiter, nor of Mercury. We can only indirectly estimate the mass of the sun through the motions it causes in the various bodies of the solar system. In astronomy, thus, the unit of mass is defined in terms of motion, is defined as that mass which will cause unit motion (acceleration) in unit time. The astronomical measure of mass will then change with changes in the units in which time and space are measured. If one change the unit of time from the day to the month, or to the year, one automatically changes the unit of mass in terms of which the sun is reckoned. The usual units of astronomy are the day and the distance of the earth from the sun (93,000,000 miles), and in terms of these units the mass of the sun is expressed by the small fraction 1/3379; but in terms of the units of the physical laboratory, the second and the centimetre, the mass of the sun is expressed by the immense number, by 1 followed by 26 zeros.

Whether or not Einstein had ever made a serious astronomical calculation he certainly overlooked this fact, and kept his mass constant expressed in terms of astronomical units while transforming all other factors of his formulas to the "more accurate" units of relativity time and space. When this slip is corrected, and when every term and every symbol in Einstein's formula is expressed in terms of his own relativity units, then the form of the equation is identically the same as that of Newton, and the orbit of the body is seen to be an ellipse, fixed in space. This is as it should be. The mere change in the units in which a planet's motion is expressed cannot change that motion, cannot change the orbit, or change the law which governs the motion.

Thus the so-called relativity rotation of planetary orbits is a mathematical illusion;—an illusion due to an incomplete mathematical transformation and to an illogical interpretation of the resulting formula. There is no relativity rotation of Mercury's orbit, and there is no Einstein law of gravitation.

Notwithstanding all this, it is claimed that the "bent-light" observed at recent solar eclipses is clear proof that Einstein did find a new law of gravitation, and that the entire relativity theory has been conclusively proved. Bent-light and the wonders of solar eclipses caught the

public fancy and were sedulously cultivated by the many writers on relativity and by the organizers of eclipse jaunts to the interesting and picturesque countries of the far East. Eddington, the organizer of the first party to "verify" the Einstein theory, wrote most entertainingly of how the new gravitation attracted and bent light rays, of how it was possible to "weigh" light, and he even envisaged the possibility of future public service corporations selling their light by weight, just as a coal dealer now supplies his customers with tons of coal. Einstein's own statement as to the cause of this wonder phenomenon, however, was somewhat different. According to his popular exposition of relativity, one-half of the predicted bending of the light-ray is due to the Newtonian attraction of the sun, and the other half is produced by the "curvature" of space. But he failed completely to explain how gravitation acted upon a ray of light, or how the intangible nothingness of space could be warped by the sun.

All of these weird explanations were apparently accepted without question, and funds were poured out to build instruments and to finance the many expeditions from England, from America, from Canada, and from other countries. The astronomers at the heads of these expeditions do not seem to have bothered themselves as to what it was all about, or as to what their costly trips might or might not prove as to bent-light and the Einstein theory. The voluminous reports of these expeditions do not contain a single statement as to the real basis of Einstein's claim, nor the slightest hint as to how he actually made his calculation that rays of light should be bent by just 1.75″ of arc in passing the edge of the eclipsed sun.

This is all the more remarkable because Einstein's original paper on the foundations of the general theory of relativity is perfectly clear on this point. However obscure and indefinite that paper may be in regard to the law of gravitation and the supposed relativity motion of Mercury, it is definite as to the actual mathematical formulas by which the light calculation was made. These formulas are printed in full, and the mathematical symbols, in which they are expressed, are explained and defined. There cannot be the slightest question as to how Einstein made his actual computation, or as to the assumption, or hypothesis upon which that calculation rests. And these formulas and this calculation show that there is no basis whatsoever for the fantastic claims of the popular expounders of relativity, show that Einstein's own popular "half and half" explanation is utterly at variance with his mathematical work.

The mathematical formula, by which Einstein calculated his predicted deflection of light, is a well-known and simple formula of physical optics. In it there is not the faintest trace of tensor analysis, of warped space, of the relativity of motion, or of any one of the many perplexing concepts of relativity. It is a formula of the old-fashioned, simple wave theory of light, which is in constant, almost daily, use by astronomers, by physicists, and by the makers of optical instruments. In this simple, every-day formula Einstein substitutes an hypothetical "retardation" of light in its passage by the sun; and this purely theoretical retardation is the sole new concept, or hypothesis involved in the prediction of bent-light. Now this supposed, or hypothetical effect of gravitation upon light is the direct reverse of the known effect of gravitation upon matter. Gravitation accelerates matter: according to this hypothesis of Einstein it retards light. A particle of matter falling to-

ward the sun falls faster and faster; a ray of light moving directly toward the sun, travels, according to relativity, more and more slowly. At the centre of the sun, the speed of the falling body would be infinite; the speed of light, zero. The gravitational attraction of the earth for bodies at its surface produces the effect we call "weight"; if Einstein's hypothesis in regard to light be right, the gravitational effect is reversed. Light would have "anti-weight," it would weigh less than nothing. How can one who has ever looked at Einstein's formulas spin fancy tales of "Weighing Light?"

Thus the many and elaborate eclipse expeditions have been given fictitious importance. Their results can neither prove nor disprove the relativity theory, for not a single one of the many concepts of that theory is involved in Einstein's calculation. Nor can these results prove anything in regard to the supposed "new" law of gravitation, for the truth or falsity of the Newtonian law is not involved in the formula, from and by which Einstein calculated his celebrated 1.75″ of arc. The sole new concept that can be tested by the eclipse expeditions is that of an hypothetical retardation of light in its passage through the gravitational field of the sun. At the best these eclipse observations might prove the fact that light suffers a retardation as it passes the sun, and might prove that such retardation is of a certain definite amount. But such observations cannot show anything as to the cause or causes of such retardation; they cannot distinguish between a purely theoretical retardation, such as claimed by Einstein, and an actual retardation caused by the passage of the ray through refracting materials near the solar surface.

But the actual published results of the many eclipse expeditions do not show even this. There is no evidence of any kind to show that light-rays are bent, in any degree whatsoever, as they pass the edge of the sun. The observations are extremely difficult and are beset by all sorts of complications and disturbing influences. The instrumental difficulties alone are almost insurmountable, and before the ray reaches the plate of the astronomer it must pass through the many miles of the earth's atmosphere. In this passage through the air, the ray is always bent, and sometimes twisted out of its direct course. All stars appear higher in the heavens than they really are, and this effect of atmospheric refraction is one of the most troublesome corrections to allow for. Based upon many years of astronomical observations, tables have been made which give the average amount of such refraction for normal night conditions of the atmosphere. The amount of this atmospheric bending of the light rays changes quite rapidly with the varying temperatures of the air, and is materially affected by layers and currents of air of different temperatures. Such effects are often noticeable at the seashore and in desert lands, and cause the well-known mirages in which ships are seen upside down, and desert lands are turned into lakes and seas.

Now the eclipse observations must be made under very abnormal conditions of the atmosphere. As the eclipse becomes total, the sun's light and heat are suddenly withdrawn, and the temperature falls very rapidly. Disturbances and air currents are set up, and the refraction will not be the same as in the case of ordinary observations made on quiet, clear nights. Yet there is no way of estimating the effects of these abnormal conditions, and the astronomer must apply the corrections from the tables made

to represent night observations. These corrections to the observed positions of the stars on the eclipse plates are larger than the predicted Einstein displacements, and many times larger than most of the deflections reported to have been found. In fact an error of only a few degrees in estimating the temperature of the column of air through which the ray passes, would give a fictitious and entirely erroneous deflection for each star. And the various expeditions took no precautions to determine actually the temperature at the time each plate was exposed. During the five or six minutes of the eclipse while the temperature was rapidly changing, only one reading of the thermometer seems to have been made; for all the various calculations were made with one standard temperature.

Fully as serious are the instrumental difficulties. A photograph of a group of stars may give a more or less accurate map of the group, but it gives nothing as to the scale of the map. From an eclipse photograph one cannot tell whether a given star is at its normal distance from the sun's centre, or whether it has been displaced inward, or outward. To determine this one must know the photographic scale: the scale on which the map was made. An astronomical camera is extremely sensitive to changes in temperature. A difference of 3° between the temperatures of the outside tube of the camera and the photographic plate encased in the plate holder is sufficient to so change the scale of the map as to give the stars an apparent outward, or inward, displacement larger than the 1.75″ of the relativity prediction. This scale, upon which the whole question of whether or not the stars were actually displaced outward, should be determined by some unquestioned, independent method. Yet not a single eclipse party has ever yet so determined the scale. Each and every party has found this scale from the star images on the eclipse plates by assuming that these images were displaced just as Einstein predicted. Campbell reduced his photographic plates and determined the scale by "adopting Einstein's prediction": Trumpler finds the scale of his map by "assuming with Einstein" the presence of the predicted displacement and the way in which Einstein said the stellar deflections would decrease with the distance of the star from the sun.

Even though the astronomers thus assume the existence of the very stellar displacements that their elaborate and costly expeditions were supposed to hunt for, they could not even then bring their observations into accord with Einstein without utilizing to the full the artistic power of selection. In the South American eclipse of 1919 less than 15 per cent of the actual measured data was used by the British astronomers in obtaining their announced results: in the Australian eclipse of 1922 slightly less than 50 per cent of the data was used by Campbell and Trumpler. The Einstein prediction requires a deflection for each star not only of a certain definite amount, but also in a certain definite direction. The observed deflection might agree exactly with the predicted amount, but if it were in the wrong direction, it would disprove, not prove the relativity prediction. You cannot reach Washington from New York by travelling west, even if you do go the requisite number of miles. The astronomers got over this difficulty by the simple means of calling all nonradial portions of their actual measures "accidental errors," while that portion of each observed deflection, which happened to be in the direction predicted by Einstein, was taken to be a reality. Such

selection was most artistically done, and, in looking at the picture of proof presented, one takes in the general effect, but fails to notice the artistic license by which the effect was produced.

When the star displacements are freed from all these assumptions and the actual measured deflections are taken, they are found to be very discordant, to be in all sorts of directions, and to have not the slightest resemblance to those predicted by Einstein. And further the size and direction of these minute deflections are different on different plates: they show distinctive changes, both in direction and in size, as the eclipse progresses. The photographs taken at the beginning of an eclipse are quite different from those taken near the end of totality. This is just the effect that one would expect, if these deflections are due to temperature changes in the air over the eclipse station. Thus the actual results of the many eclipse expeditions do not furnish the slightest evidence in favor of Einstein's prediction of "retarded" light. The discordant and often illusive measured displacements, if real, can best be explained by some refractive effect in the earth's atmosphere; by possible temperature effects, on air and instruments, caused by the passage of the eclipse shadow.

Thus two of the crucial tests of relativity are found to be illusions. What of the third test, the displacement of spectral lines toward the red end of the spectrum? Einstein, himself, states that if this displacement does not exist, "then the general theory of relativity will be untenable." Yet a simple inspection of Einstein's own mathematical work shows that this predicted displacement does not involve a single one of the basic tenets of relativity. The formulas by which he calculated this hypothetical shift do not contain the slightest trace of "curved space," of a "space-time continuum," or of non-Euclidean geometry. The so-called Einstein shift is due to a single concept grafted onto the relativity theory:—namely, the assumption that all atoms situated near the surface of the sun, or other gravitational body, vibrate more slowly than do similar atoms situated in free space. This merely means that an atom of sodium, of zinc, or of hydrogen will vibrate at a given rate in a laboratory on the earth, at another and slower rate near the surface of the sun, and at a still slower rate in the vicinity of a large and more ponderous star. Now there is nothing impossible, or even improbable in this new assumption. The time of vibration of a pendulum changes with its location on the surface of the earth; the Moon would rotate about the earth much slower if it and the earth were brought nearer the sun. These are well-known effects of gravitation. But Einstein does not base either his new assumption or his calculations upon any of these well-known and thoroughly tested principles of gravitation. On the contrary, the sole basis for his formula is a revamped and modernized version of Jules Verne's story of an imaginary trip to the Moon. Thus while there may be some plausibility in the general conception that the vibrating atom is affected by gravitation, there is neither rhyme nor reason in Einstein's specific formula, nor in his prediction of a specific shift in the spectral lines.

Further there is no valid observational evidence to support his claims and predictions. In the early years of relativity, Einstein, Eddington, and dozens of lesser lights claimed that spectroscopic observations of the sun had placed "the existence of the effect almost beyond doubt." The observations, however, are of extreme difficulty, and there are many

factors which may displace a line in the solar spectrum. Motion in the line of sight, toward or away from the observer, will cause very marked shifts (the Doppler effect); changes in the pressure of the light emitting gases will seriously affect the positions of the spectral lines. And these purely physical shifts may be much larger than the hypothetical Einstein effect. No one knows the exact conditions of the solar atmosphere, knows whether, at a particular moment, the light giving atom is rising or falling, or whether the pressure is negligibly small or many times that of the atmosphere at the surface of the earth. This is now clearly recognized and even such an ardent relativist as Henry Norris Russell admits that "in the case of the sun the shift is small and its effects are confused with other small displacements not yet fully understood." Abandoning thus the original claims of proof, the relativists now turn to a small star, the companion of Sirius, and assert that observations on this minute body "conclusively prove" the existence of the Einstein shift. But the measurements are based upon only two or three selected photographic plates of small scale, which were taken under most difficult conditions. While these measures indicate a shift toward the red end of the spectrum, yet the most recent independent analysis of all this evidence shows that the shift may rather be due to simple physical causes, and that these measures made upon this abnormal selected star fail to prove the presence of the definite shift predicted by Einstein.

Thus the claim of Einstein to have found a new law of gravitation and the many assertions that the theory of relativity has worked in accounting for the motions of Mercury and has been conclusively proved by the eclipse observations and by the displacement of spectral lines are all merely unproved, and, so far, really unsupported illusions. Einstein and his followers have been dwelling in the "pleasing land of drowsyshed —"; in the land

"Of dreams that wave before the half shut eye."

Requiem

By Margaret Emerson Bailey

No man wishes
Body and soul
Of a woman. Either
Outweighs the whole.

For both together
Well may be
Less than he bargained for
Separately.

One gives to the other
Till there is
Left from neither
What he'd call his.

And he shows wisdom
When all's said and done,
Of her body or soul
To have martyred one.

But while he wishes
A half, not the whole,
God rest her body—
God save her soul.

SCRIBNER'S MAGAZINE

November 1930

VOL. LXXXVIII NO. 5