PHYSICS

Einstein Discusses Revolution He Caused In Scientific Thought

Feasted by Pasadena Colleagues, He Hears Drs. Millikan, Michelson and Campbell Explain His Achievements

Prof. and Mrs. Albert Einstein were welcomed to comradeship in the scientific circles of Pasadena by a banquet given Jan. 15 by two hundred members of the California Institute Associates, held in the new and beautiful Athenaeum (see SCIENCE NEWS LETTER, Jan. 3, 1931). A nationwide radio audience of the Columbia Broadcasting System heard the speeches, excerpts from which are given here.

By DR. ALBERT EINSTEIN

Translated by Prof. William B. Munro

FROM far away I have come to you; but not to strangers. I have come among men who for many years have been true comrades with me in my labors. You, my honored Dr. Michelson, began with this work when I was only a little youngster, hardly three feet high. It was you who led the physicists into new paths, and through your marvellous experimental work paved the way for the development of the theory of relativity. You uncovered an insidious defect in the ether theory of light, as it then existed, and stimulated the ideas of H. A. Lorentz and Fitz Gerald, out of which the special theory of relativity developed. These in turn pointed the way to the general theory of relativity, and to the theory of gravitation. Without your work this theory would today be scarcely more than an interesting speculation; it was your verifications which first set the theory on a real basis.

Campbell's determination of the bending of rays of light coming past the sun; St. John's determination of the red shift of spectral lines due to the gravitational potential existing at the surface of the sun; Adams' determination of the red shift in the light which comes to us from the companion of Sirius—these provide the best support for the general theory of relativity.

Going beyond all this, the work of your wonderful observatory, through the recent discoveries of Hubble concerning the dependence of the red shift in the spectral lines of the spiral nebulæ on their distance, has led to a dynamic conception of the spatial structure of the universe, to which Tolman's work has given an original and especially illuminating theoretical expression.

Likewise in the realm of the quantum theory I am grateful to you for important assistance because of your fundamental experimental investigations. Here I acknowledge gratefully Millikan's researches concerning the photo-electric effect which first proved conclusively that the emission of electrons from solid bodies under the influence of light is associated with definite period vibration of the light itself, which result of the quantum theory is especially characteristic for the corpuscular structure of radiation.

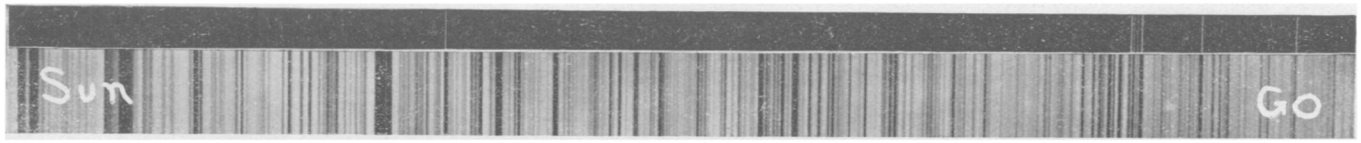
While I let my spirit reflect upon all this, I account myself exceedingly fortunate to be able to break bread with you here in joyous mood, full of the happy conviction that your researches will continue through the future to broaden and deepen without let or hindrance, our knowledge of Nature's mysterious forces. From my heart I thank you all.

By DR. R. A. MILLIKAN

THE distinguishing feature of modern scientific thought lies in the fact that it begins by discarding all *a priori* conceptions about the nature of reality—or about the ultimate nature of the universe—such as had characterized practically all of Greek philosophy and all of medieval thinking as well, and takes instead, as its starting point, well authenticated, carefully tested experimental facts, no matter whether these facts seem at the moment to fit into any general philosophical scheme or not—that is, no matter whether they seem at the moment to be reasonable or not. In a word, modern science is essentially empirical, and no one has done more to make it so than the theoretical physicist, Albert Einstein. That, in a sentence, is, I take it, his greatest contribution to modern thought.

I wish to dispel a very common misconception, for the average man, who only knows science from afar, labors, I suspect, under the misunderstanding that we honor Einstein only because he was the author of the theory of relativity.

Now, every physicist knows that the Nobel prize committee, which awarded him that honor in 1921, did not have to consider the theory of relativity at all in making that award. They might have given it on any one of at least four grounds, and the scientific world would have been unanimous in applauding the award on any one of them. I myself have the best of reasons for knowing which one of these four they actually chose, the late Professor Gullstrand, the chairman of the Nobel committee in making the 1923 award, stated that it was the experimental verification of the Einstein photo-electric equation that removed all doubt as to its validity in the minds of the committee, so that they chose the first theoretical statement of that equation in 1905 by Professor Einstein as the basis of the award to him in 1921 and the experimental verification thereof as the half basis of the 1923 award. Now, this equation has nothing whatever to do with relativity, but I think that all students of modern physics will agree that it is of quite as far reaching significance as is relativity, or, indeed, as is anything that has appeared in modern physics, for it necessitated, as soon as it was firmly established, our return to at least a semi-corpuscular theory of the nature of radiant energy.



SUN'S SPECTRUM GIVES ONE PROOF OF THE THEORY OF RELATIVITY

"If the positions of the thousands of dark lines . . . . be measured very accurately, it should be found, Einstein said, that the lines are displaced by an exceedingly small but definite amount toward the red end of the spectrum."

The extraordinary penetration and boldness which Einstein showed in 1905 in accepting a new group of experimental facts and following them to what seemed to him to be their inevitable consequences, whether they were reasonable or not as gauged by the conceptions prevalent at the time, has never been more strikingly demonstrated.

Any small contributions that I myself may have made to the progress of physics have been largely in the nature of experimental verification of predictions contained in three theoretical equations first set up by Einstein and but one of these has had anything to do with relativity.

The first of these was the Brownian movement equation (1905) whose verification by a number of observers removed the last doubts as to the atomic theory of matter; the second was the aforementioned photo-electric equation (1905) which changed radically our conception as to the nature of radiation; the third was the equation expressing the interconvertibility of mass and energy. This grew out of special relativity (also 1905) and it has recently predicted for me verifiable relations in the radio-active field, and it also constitutes the most important basis for the cosmic ray conclusions that I am now wishing to draw. All these three are of equal significance, I think, with the predictions from general theory of relativity, the experimental verification of which Dr. Campbell has just described.

You can throw (*Turn to page* 61)

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Relativity Passes Three Tests Declared Crucial by Einstein

Motion of Mercury, Bending of Light and Red Shift of Spectrum Described by One of Theory's Judges

By DR. W. W. CAMPBELL

WHEN Professor Einstein published his immortal theory of relativity, a theory evolved within the four walls of his study room, he in effect advised his colleagues in the physical sciences not to accept it until it had been subjected to certain observational tests of an astronomical nature. He described three such tests by which his theory must stand or fall.

Test No. 1.—The theory of relativity, he said, must explain and remove the discrepancy between the predicted and the observed motions of the planet Mercury. This little brother of the earth, revolving around the sun at an average distance about one-third as great as the earth's distance from the sun, refused to follow the path assigned to it by Sir Isaac Newton's law of gravitation. For more than half a century before Einstein, astronomers had sought diligently but in vain for the explanation. Promptly following the publication of Einstein's work, astronomer De Sitter of Holland applied the test to Mercury, and the theory of relativity accounted in full for the discrepancies referred to.

Test No. 2.—The theory of relativity, he said, required that a ray of light, say from a distant star, when passing close to the surface of our sun, should be bent slightly from its straight-line course by the gravitation pull of the sun upon it as an addition as an effect of the curvature of the space in which the sun is immersed. That a ray or pulse of light should be subject to gravitational attractions and that space should be curved were results or hypotheses new to the world. Einstein urged that astronomers endeavor to observe the phenomenon at times of total solar eclipse, the only times when the test can be applied by photographing the eclipsed sun's surroundings in order to record on the photographic plates the images of the stars in the neighborhood of the sun,—though of course these stars would be millions of times as far away as the sun. The star images should be slightly displaced from their normal positions, he said, and those nearest the sun displaced the most. In 1919, there occurred a total eclipse extremely favorable as to the astronomical elements, and the British Eclipse Committee, represented by Eddington and Davidson, sought to observe the Einstein phenomenon. Unfortunately, the programs of observations were sorely afflicted with clouds, and the images of only a few stars, seven as a maximum, were recorded, faintly and otherwise, on only a part of the plates exposed. Nevertheless, the measurements of the plates showed that the rays were bent from their straight-line courses in passing the sun and through angles approximately of the minute dimensions predicted by Einstein.

The William H. Crocker expedition from the Lick Observatory, University of California, represented by astronomers Campbell and Trumpler, observed the total solar eclipse of 1922 on the northwest coast of Australia, using four photo- (*Turn to page* 60)

EINSTEIN COLLABORATORS

In order of seniority, the scientists working with Einstein at Pasadena are:

Albert A. Michelson, Emeritus Director of the Ryerson Physical Laboratory of the Univerity of Chicago, now a permanent resident of Pasadena and an Associate of both the California Institute and the Mount Wilson Observatory;

Charles E. St. John, astrophysicist of the Mount Wilson Observatory.

William Wallace Campbell, President Emeritus of the University of California and formerly Director of the Lick Observatory.

Robert A. Millikan, Director of the Norman Bridge Laboratory of Physics of the California Institute.

Walter A. Adams, Director of the Mount Wilson Observatory.

Richard C. Tolman, Professor of Physical Chemistry and Theoretical Physics of the California Institute.

Edwin P. Hubble, astrophysicist of the Mount Wilson Observatory.

possible, reached conclusions in substantial agreement with the Einstein prediction.

A few years ago, through the work of Eddington and others, it became evident that the fainter star in the well-known double star Sirius, though about as massive as our sun, is a surprisingly small and exceedingly dense body. A cubic inch of it, on the average, it is confidently believed, would weigh as much as 50,000 cubic inches of water. That is, on the earth a cubic inch of the star would weigh almost a ton. It was pointed out that the Einstein displacement of the lines in this star's spectrum should therefore be about twenty-seven times as great as for the lines in the sun's spectrum. Director Adams of the Mount Wilson Observatory, using the 100-inch reflecting telescope, and demanding the full power of that great instrument, succeeded in observing this displacement and he found it to be of the dimensions required by the Einstein theory.

And thus has the theory of relativity met and passed the three astronomical tests set for it by its distinguished author.

Science News Letter, January 24, 1931

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Einstein Discusses Revolution in Thought

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general relativity into the waste basket if you will, and Professor Einstein's position as the leading mind in the development of our modern physics would still remain unchallenged.

By DR. A. A. MICHELSON

I CONSIDER it particularly fortunate for myself to be able to express to Dr. Einstein my appreciation of the honor and distinction he has conferred upon me for the result which he so generously attributes to the experiments made half a century ago in connection with Professor Morley, and which he is so generous as to acknowledge as being a contribution on the experimental side which led to his famous theory of relativity. I may recall the fact that in making this experiment there was no conception of the tremendous consequences brought about by the great revolution which Dr. Einstein's theory of relativity has caused—a revolution in scientific thought unprecedented in the history of science.

Science News Letter, January 24, 1931