influences, direct and indirect, of Einstein's investigations are finally to be reckoned. Nevertheless, of their scientific aspect much may be said. We know that his contributions to physics in fields other than relativity would justify an award of the Nobel prize several times over, and we know the importance to both physics and astronomy of relativity itself. From these recognized accomplishments I turn to something that has received little comment.

In a sense scientific investigation is a game. The physicist must assemble his protons and electrons into a world—not any world, but one which has the properties of the physical world about us. As with all games, there are rules. Some of these are predetermined, for example, the fundamental rules of thinking. Others we choose for ourselves; and in this choice we have astonishing freedom. If I wish to arrange a shuffled pack of cards in sequences according to the four suits, you know a score of solitaire games, each with its own set of rules, by which this may be done. But it is not obvious that the game of world building may be played in more than one way. It remained for Einstein to show us that such is the case, and that if we judiciously change the rules we may still win fairly, with a greatly increased score. As a matter of fact, we have unconsciously been revising the rules of the game ever since men began to think in a scientific way; but we didn't realize it until Einstein drove it home in a way not to be ignored.

Thus with our notion of space. It may seem to you queer that space, which doubtless you think of as a great empty void, should have anything to do with rules. I don't know why it is that we so seldom point out to laymen that the space of physics and astronomy is not the void which separates objects from each other. The physicist never thinks of space apart from objects within it; in his mind is always the idea of distance—the distances of objects from each other. When he says that space has certain properties he is talking not about the empty void, but about how he makes measurements to find what these distances are. But you ask: Is he not obliged to measure distance in a definite way? The answer is, No. He may measure in any way he likes, along what we call a straight line for example; or, if he finds reason for so doing, he may measure along some curve connecting two objects and call that result the distance.

The physicist's space is therefore essentially a set of rules for measurement. Those used until Einstein suggested a change were unconsciously adopted by Euclid two thousand years ago. Until less than a century ago no one realized that by accepting one of Euclid's postulates we had committed ourselves to making measurements in a particular way, or that measurements could be made in any other way. Even then we looked upon the matter as a geometrical curiosity without practical significance; and by the time Einstein suggested the advantages of a change and we began to hear about curved space, our long-held ideas had become so fixed that readjustment was hard. For the layman it was even worse. He had in mind the empty void; and how could such a thing as a void be flat or curved? But if we say that curved space means only a new set of rules which require that measurements be made along curved lines, the idea at least makes sense, even though you may not be convinced that such a strange procedure is advantageous. But I assure you that it is, for it enables us to win the game with a score we could not otherwise attain. If that statement brings no illumination, let me ask you, What is the distance from here to New York? Your answer undoubtedly will be the miles measured over the curved surface of the earth, because that is the distance which every-day experience makes it useful to know.

As with our ideas of space, so with a dozen others. Each has been transformed and set before us in new light. Quite apart from the intrinsic importance of the results is the remarkable fact that such momentous changes of view-point could be made. By teaching us that, Einstein has put into our hands new power. The value of this service, it seems to me, can not be set too high.

And now, sir, that we must bid you farewell, let me thank you in the name of the Observatory for your friendly visit, for the companionship we have had with you, and for the inspiration your presence has brought us. We wish you Godspeed, and we hope that we may see you again soon.

FREDERICK H. SEARES
ASSISTANT DIRECTOR OF THE
MOUNT WILSON OBSERVATORY

THE REASON AND THE RESULTS OF DR. EINSTEIN'S VISIT TO THE CALIFORNIA INSTITUTE OF TECHNOLOGY

AT the time of the initiation of a strong department of physics at the California Institute in 1921 provision was made for bringing each year an outstanding European scientist to join the staff of the institute as foreign visiting professor on temporary appointment.

This professorship has been held twice by the late Dr. H. A. Lorentz, of Leiden, Holland, twice by Dr. Arnold Sommerfeld, of Munich, Germany, once by Dr. Bjerknes, of Oslo, Norway, once by Professor Raman, of India, twice by Professor Ehrenfest, of Holland; and as long as five years ago Professor Einstein, of Berlin, accepted appointment to come to Southern California to this same foreign professor-

ship but was prevented by a breakdown in his health from carrying out his plan at that time.

Three or four times since then, however, he has expressed a desire to come to the institute for purely scientific purposes, since the extensive experimental and theoretical researches being carried out both at the Norman Bridge Laboratory of Physics and the Mount Wilson Observatory were very intimately related to his own work, and a first-hand interchange of ideas was certain to be profitable to the men working in this center while an intimate view, especially of our experimental conditions and results, could scarcely fail to affect in some way Professor Einstein's own thinking.

After repeated interference, by untoward events, with the long-contemplated visit it has been made a reality this winter with results that are all that could be expected by the "Einstein collaborators" on the spot, namely, Eric T. Bell, Walter S. Adams, Richard C. Tolman, Charles E. St. John, Roy J. Kennedy, Paul S. Epstein, Harry Bateman, Edwin S. Hubble, Theodor von Karman, Albert A. Michelson, Fritz Zwicky, J. Robert Oppenheimer, Martin L. Humason, William V. Houston, Robert A. Millikan, Ira S. Bowen, Jesse W. DuMond, Linus C. Pauling, Francis G. Pease, Edward M. Thorndike, Ernest C. Watson, S. J. Barnett, Frederick H. Seares, Arthur S. King and Gustaf Stromberg. Every one of this considerable group of men who have made contributions either to some phases of the Einstein theories or to the experimental verification of these theories has been stimulated and inspired by Einstein's presence and the discussions with him that have been made possible by his stay here.

It is hoped, too, that Dr. Einstein himself has profited by the sight he has had of the extent and character of the new experimental results that have recently been brought to light by the aforementioned group of workers, and that he will feel the urge to repeat his visit, as Lorentz, Sommerfeld and Ehrenfest have done before him. His quite extraordinary human sympathy and insight, combined with his charming modesty, honesty, open-mindedness and objectivity, have made his visit an inspiration and a rich experience to all of us, whether we have been directly associated with Einstein's work or not.

ROBERT A. MILLIKAN

IT is quite impossible to estimate fully the influence of Professor Albert Einstein's visit to Pasadena and to the Mt. Wilson Observatory of the Carnegie Institution of Washington until many more years have passed.

The intangible results of the contact of this great master of science with the life and work of the observatory are likely to prove fully as important as will any of the notable lectures and discussions in which he has taken part so generously.

Among the specific problems of astronomy which Professor Einstein has considered during his visit there is none which makes so strong an appeal both to the mind and the imagination as that of the nature and structure of the universe.

In a clear and brilliant summary he has outlined the consequences of the different methods of treatment of the equations of generalized relativity and the aspects of cosmology to which they lead.

The recent discoveries of the large red-shifts in the spectra of the most distant nebulae and the enormous apparent velocities which they indicate, together with the direct relationship found to exist between distance and amount of red-shift, have modified greatly some of the earlier views.

Professor Einstein is now inclined to consider the most promising line of attack on this problem to be based on theories of a non-static universe, the general equations for which have been developed so ably by Dr. Richard Chace Tolman, of the California Institute of Technology. In the special solutions so far made involving an expanding universe the chief difficulty lies in the insufficiency of the time-scale which they require.

Of special interest to the members of the observatory staff have been Professor Einstein's outline of the method and development of the unified field theory; his suggestive discussion of the possible origin of circulatory movements in the solar atmosphere and their bearing on the rotation of the sun and the formation of sun-spots, and the valuable insight he has given us into his interpretation of some of the equations governing the probability of transitions within the atom, a field of vast importance in spectroscopy and one with which his name is associated most intimately.

His insistence upon the necessity and importance of the results of observation to control theoretical assumptions and developments has been a striking characteristic of his mode of thought.

Beyond any other consideration, however, has been the opportunity of observing his keen and brilliant mind at work, its instant grasp of the essentials of a problem and its extraordinary resourcefulness in its solution.

Finally, no one can meet Professor Einstein even for the first time without an immediate realization of extraordinary intellectual power combined with a natural simplicity and kindliness which so often characterize great genius.

WALTER S. ADAMS