you will, and Professor Einstein's position as the leading mind in the development of our modern physics would still remain unchallenged. It is a very high honor to be able to introduce him to the associates to-night.

DR. EINSTEIN (*Translated by Professor 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 marvelous 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 to-day 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 nebulae 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 a definite period of 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.

ADDRESS AT THE LUNCHEON[1]

THE presence here of hundreds of people to greet a distinguished man of science is a part of something without parallel in our American life. When newspapers everywhere continue, day after day, to give front page space to a man whose work does not directly touch the lives of the people, it signifies something unusual. The public itself would first catch the humor of a suggestion that it knows anything about relativity; and yet the warm interest in the man who has given us relativity continues.

Part of this interest is our spontaneous response to a gracious personality, full of modesty and kindness and humanity. For the rest, it means, I think, that our imagination has in some way been touched. We realize that Professor Einstein has done things on the remote frontiers of science where man seems to approach the mystery of his existence; we know that he has changed the space and time we thought a safe framework to which we might tie all our activities; that he has dared to think about the bounds of the universe itself. Those who have seen his work at first hand feel the beauty of its logical structure; others marvel that there could be any new way of thinking about stubborn old realities. And why shouldn't these things stir the imagination?

Nevertheless, Einstein himself would insist on the purely intellectual character of what he has done. He has remarked, "Relativity has nothing to do with the soul; it is a matter only for the head." But what intellectual achievement ever remained wholly detached from human feeling? The work of Copernicus was such an achievement. Yet it precipitated the bitterest of controversies because it tumbled man out from the place of honor in the center of the universe and suggested that he was of less importance than he thought. Again, the painstaking inductions of Darwin put life into the long-dormant doctrine of evolution; and you well know the emotional reactions to that intellectual effort. These are extreme instances; but even the work of Newton, which held no threat for man's cherished beliefs, profoundly influenced his outlook on life as well as his views of the physical world. And so, before such an achievement as relativity, we can not remain passive. Even though we know none of its details, we feel the freshening wind of new thought and find ourselves stirred; and we feel that it is good to be so stirred.

No one at this moment would dare predict how the

[1] Remarks on behalf of the Mount Wilson Observatory at a luncheon in honor of Professor Einstein, given by the Chamber of Commerce at Pasadena, California, February 24, 1931.

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-