on the magnitude of doublet splitting. On the other hand, my earlier doubts as well as the cautious expression, "classically nondescribable two-valuedness," experienced a certain verification during later developments, as Bohr was able to show on the basis of wave mechanics that the electron spin cannot be measured by classically describable experiments (as, for instance, deflection of molecular beams in external electromagnetic fields) and must therefore be considered as an essentially quantum mechanical property of the electron.[1]

This is not the place to go into the details of the subsequent developments. On the one hand, the validity of the exclusion principle for all elementary particles of spin ½ was shown (for example, not only for electrons but also for neutrons and protons). This gave the principle a more general and universal meaning, and it found application to the problem, still not completely solved, of nuclear structure. On the other hand, the exclusion principle could not be deduced from the new quantum mechanics and wave mechanics, but remains an independent principle which excludes a class of mathematically possible solutions of the wave equation. This excess of mathematical possibilities of the present-day theory, as compared with reality, is in my opinion one of several indications that in the region where it touches on relativity theory, quantum theory has not yet found its final form.

The history of the exclusion principle is thus already an old one, but its conclusion has not yet been written. The essential advance of physics rests on the creative imagination of the experimental as well as the theoretical investigator, and, contrary to expensive applications of known principles, cannot be forced by planning on a grand scale. Therefore it is not possible to say beforehand where and when one can expect the further development of the basic principles of present-day physics, of which the problem of the exclusion principle is a part. We know, however, that this further development can take place only in the same atmosphere of free investigation and unhampered exchange of scientific results between nations that existed at the time of the disclosure of the exclusion principle. I am therefore very glad to be able to give this short historical survey here in Princeton's Institute for Advanced Study, which in the difficult years of the war, by support of pure and free research irrespective of applications, made it possible for me and others to continue our scientific work.

[1] See Rapport du Sixieme Conseil Solvey de Physique, Paris, 1932, pp. 217–225.

Introductory Remarks

Frank Aydelotte, *Director*

Institute for Advanced Study, Princeton, New Jersey

IT GIVES ME GREAT PLEASURE, ladies and gentlemen, to welcome you on behalf of the Trustees and Faculty of the Institute for Advanced Study on this happy occasion. The awarding of a Nobel Prize to a newly appointed member of our Faculty is just the kind of endorsement of our choice that we value and that we ought to expect. In one sense Pauli's is our fourth Nobel Prize: one member of our Faculty, Einstein; one former member of our Board of Trustees, Carrel; and one former member of the Institute, Rabi, have already received Nobel Prizes. That, however, is a little like the statement in the Believe-It-or-Not cartoon that Lindberg was the sixty-fourth person to fly across the Atlantic ocean. In a real sense Pauli is our first, just as Lindberg was the first to succeed in the design which he attempted.

About one-seventh of the 215 Nobel Prizes so far awarded have gone to citizens of the United States. In view of the size of our educational organization, that is not too many—indeed, it is not enough. We cannot yet claim Pauli's as an American achievement; the exclusion principle was formulated by him twenty years ago while he was still an Austrian. We hope that in a few weeks we shall have the pleasure of welcoming Dr. and Mrs. Pauli to American citizenship.

It is fitting that Pauli should become an American citizen and a member of the Faculty of the Institute for Advanced Study. American civilization, American scholarship, American art and letters, are products of the great European tradition. Our task is not to separate ourselves from that tradition but to support it and to enrich it by the productive work of American scholars. In these days when all men's minds in every field of endeavor are disturbed by the conflict between individualism and collectivism, we may be thankful for the fact that our scholarly tradition is one of individualism. The Nobel Prizes are one evidence of that philosophy. The organization of the Institute for Advanced Study is another. The fundamental plan of this institution is to provide opportunity for individual effort, not for what is called planned research. Our newspapers and magazines,

even some scientific periodicals, are filled today with vast and nebulous schemes for the regimentation of scholars in the great war against chaos and ignorance. Useful work, like the production of the atomic bomb (if you call that useful), may be done by such organization. But the great advances of knowledge are not made by such means. They are, rather, the product of individual effort, free, unpredictable in their nature and in their consequences. They are the products of minds like Newton, Einstein and Pauli: "Voyaging through strange seas of thought alone."

Such a plan or, rather, lack of plan for the advancement of knowledge violates all the instincts and preconceptions of the adminstrative type of mind. It is not orderly, but, rather, haphazard. I can only say that the whole process of evolution on this planet has, so far as we can see, been an unexpected one. It may conform to some divine plan, but it does not follow any plan of human devising. There is nothing in the *Bible* about the exclusion principle or the atomic bomb, though the author of "Revelations" would doubtless have equipped the Four Horsemen of the Apocalypse with the latter device had he known about it.

Robert Louis Stevenson was once asked what was the moral to one of his stories. "My moral?" he replied, "I have no moral: it is God's moral that I am trying to understand." So with our scientists. It is nothing less than the mind of God they are seeking to penetrate.

All educational institutions, all societies of scholars, are devoted to this high quest. It is with this in mind that we have tried to make conditions here such that they can devote themselves to it in the single-minded way that is not always possible elsewhere. It is in line with our fundamental purpose that we have chosen Pauli to be a member of our Faculty. We hope that he will make his career here and that the exclusion principle will not be the last or the greatest of his contributions to physics.

Encomium

Hermann Weyl
Institute for Advanced Study, Princeton, New Jersey

IT IS DIFFICULT TO IMAGINE what the history of physics would have been without the influence of Pauli during the last twenty-odd years. As another Nobel laureate recently expressed it, "Pauli for many years has been the conscience and criterion of truth for a large part of the community of theoretical physicists." Thus, there is complete unanimity the world over that Pauli has amply deserved the recognition now accorded his work by the Royal Swedish Academy, to whose hands, by Nobel's will, the distribution of the Nobel Prize for Physics is entrusted. . . .

I think it is very fortunate that through the accident of Nobel's birth the lot to bestow this highest international honor for scientific achievement fell to Sweden, one of the Scandinavian countries. Indeed, these countries march in the vanguard of civilization; nowhere on this planet has man come nearer to the fulfillment of his dream of a happy and free life, with justice and equal opportunity for all, where good prevails over evil, and beauty and truth can shine and are loved. In physics and mathematics in particular the Scandinavian countries have, during the last decades, contributed more than their share to the advancement of our knowledge. It is enough to mention one name, that of Niels Bohr, who has exerted the most extraordinary influence upon the development of physics and on the whole generation of younger physicists in the last thirty years. Pauli himself is his disciple.

The impression prevails that it has been harder for a theoretical than for an experimental physicist to win the Nobel laurels. One obvious reason is that it is more difficult to assess at an early stage the importance of a theoretical discovery. When modern quantum physics came into being around 1925, one often spoke of it as boys' physics—"Knabenphysik." Indeed, at the time neither Heisenberg, nor Dirac, nor Pauli were over twenty-five (de Broglie and Schrödinger were somewhat older). It is gratifying that now all the boys who enacted this great scientific drama have been crowned by the Swedish Academy.

Born and educated in Vienna, Wolfgang Pauli started his scientific career in Munich under Arnold Sommerfeld. Perhaps I am among the first with whom he established scientific contacts, for the first papers he published dealt with a unified field theory of gravitation and electromagnetism which I had propounded in 1918. He dealt with it in a truly Paulinean fashion—namely, he dealt it a pernicious blow. Pauli's article on relativity theory, written in these years for the *Mathematical Encyclopaedia,* is a mature and masterly work which shows the author in full command of both the mathematical and physi-