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(*b*. Hannover, Germany, 18 October 1902; *d*. Hamburg. Federal Republic of Germany, 31 July 1980

theoretical physics.

Jordan's father, Ernst Pascual Jordan, the descendant of a Spaniard, was a painter of portraits, landscapes, and buildings. His interest in perspective drawings and his acquaintance with the elements of projective geometry seem to have influenced the inclinations of his son. Jordan's mother, Eva (née Fischer), was responsible for his permanent concern with biological problems and his early dedication to numerical computations. Through readings of the popular science literature of his time, such as the influential works of Wilhelm Bölsche, Ernst Haeckel, Ernst Mach, and Friedrich Lange, Jordan became interested in the discussion of the problem of neovitalism. As a result he was later an ardent defender of positivism.[1]

At the age of sixteen, when he attended the socalled reformed gymnasium at Hannover. Jordan became acquainted with higher mathematics through Walther Nernst and Arthur Schönflies *Einführungin Modern and Ancient Geosynclinal Sedimention*. Against the wishes of his father, who wanted him to study architecture, Jordan decided to study physics and mathematics. In the spring of 1921 he matriculated at the Technische Hochschule of his hometown, Hannover, where he attended the mathematical lectures of Heinrich Muller and Georg Prange. The only lectures on physical topics he found of interest were courses on electrical engineering by Friedrich Kohlrausch and on physical chemistry by Max Bodenstein. The low level of the other lectures on physics led him to study by himself. He learned atomic physics through Arnold Sommerfeld's *Atomhau and Spektrallinien and relativity* through Moritz Schlick's *Raum and Zeit in der gegenwärtigen Physik*.

After two semesters Jordan moved to the University of Göttingen, one of the most prominent centers of theoretical physics in postwar Germany. Two weeks after his arrival, he attended Niels Bohr's celebrated Wolfskehl lectures on atomic physics, an event of great importance for the future development of the field in German-speaking countries.

In Göttingen, Jordan soon was introduced to Richard Courant and Max Born. Having recently taken the chair for theoretical physics vacated by Peter Debye, Born was initiating his research program for a more rational foundation of quantum theory. So he welcomed Jordan, whose exceptional talents—despite a speech defect that plagued him all his life—soon became apparent.

During the course of his lectures and seminars Born applied the perturbation methods developed in celestial mechanics to problems in atomic physics. Born had worked out these procedures with the help of Jordan's predecessors, Wolfgang Pauli and Werner Heisenberg. Jordan was quickly introduced into the most pressing problems of quantum physics. He increasingly participated in the research as Born's closest collaborator. In Göttingen, Jordan also attended Alfred Kühn's lectures on biology, a subject that continued to hold his interest all his life.

During his student years Jordan assisted his teachers in the writing of an article on lattice dynamics for the famous *Encyklopädie der mathematischen Wissenschafte n*. He helped Richard Courant in the editing of the first volume of Courant and Hilbert's *Methods of Mathematical Physics* (1924), a volume written to a great extent as a response to the mathematical demands of the rapidly developing quantum mechanics.

In October 1924 Jordan was officially employed as Born's assistant. Among his other duties was assisting James Franck in the preparation of his handbook article *Anregungen von Quantensprüngen durch Stösse* (1926); it was eventually coauthored by Jordan and Franck.

After finishing his regular courses in physics, mathematics, and zoology, the twenty-two-year-old Jordan presented a highly original doctoral thesis on the light-quantum problem,[2] which aroused considerable interest in view of the discovery of the Compton effect. But Jordan's suggestion that the momentum distribution of scattered light quanta may also be continuous—in opposition to Einstein's original idea of needlelike radiation—was immediately disproved by the latter.[3] The attention that Einstein had paid to his first publication, however, made a strong impression on the young man.

Jordan now began to participate in Born's research program on a new formulation of quantum theory based on correspondence arguments and the use of observable magnitudes only. These and similar procedures developed independently by John van Vleck showed clearly that Einstein's earlier probabilistic treatment of the radiation phenomena could be brought into line with Bohr's work. In a joint publication Born and Jordan[4] emphasized the importance of the concept of "transition amplitudes," which later proved to be decisive for the emergence of matrix mechanics.

After pursuing extensions of Pauli's investigations on the Zeeman effect and studies of the thermal equilibrium between atoms and radiation,[5] Jordan became involved in the formal development of matrix mechanics advanced by Heisenberg at the end of July 1925. Jordan's familiarity with the methods of matrix calculus from his collaboration with Courant made him an invaluable collaborator for Born, and together they developed the general foundations of the new theory. Only two months after the submission of Heisenberg's fundamental paper the two authors submitted their results for publication to the *Zeitschrift für Physik*[6] Whereas Heisenberg had supplied the basic idea of how the new formalism could be obtained from classical theory by means of correspondencelike arguments, Born and Jordan worked out in detail a proof of this procedure and its mathematical framework. They found that quantum physics could be formulated adequately in matrix language and discovered that the fundamental basis of the new quantum mechanics could be expressed by the famous commutation relation $pq - qp = (h/2\pi i)1$. Because of Born's ill health, Jordan carried out most of the detailed elaborations and calculations, as well as the writing of this important paper.[7]

A thorough study of quantum mechanics, including the extension of the formalism to systems with many degrees of freedom and the inclusion of angular momentum. Was the subject of Jordan's next paper, the famous "three-man paper," elaborated in collaboration with Max Born and Werner Heisenberg.[8] An improvement in the definition of matrix differentiation in accordance with the product rule allowed an especially simple formulation of the equations of motion of quantum mechanics. The authors also generalized the concept of canonical transformation in order to preserve the commutation relation in such an operation. One of the most important insights of their joint work was the recognition that the solution of a quantum mechanical problem was equivalent to a canonical transformation of a matrix into its diagonal form. After treating the consequences of the spinning-electron hypothesis in matrix theory in a paper together with Werner Heisenberg,[9] Jordan turned to the more fundamental questions of the new theory.

By the middle of 1926 four different formulations of quantum mechanics existed: Heisenberg's matrix mechanics, Dirac's *q*-number formalism. Schrödinger's wave mechanics, and the operator formalism of Born and Norbert Wiener. Thenecessity to clear up the relations between them came to the fore. The all-embracing formulation finally was supplied in December 1926 independently by Dirac and Jordan with the so-called statistical transformation theory, which also paved the way for comprehending the physical content of the new formalism.[10] In general there are infinitely many different possibilities for representing the quantum mechanical magnitudes by operators connected by canonical transformations, Heisenberg's and Schrödinger's representations being only special cases. Whereas Dirac started incorporating Schrödinger's theory into his *q*-number formalism. Jordan was guided by Pauli's suggestion that according to the statistical interpretation of quantum theory.quantum theory, interference between probabilities must also occur. In spite of their different methods of attack, both authors solved the fundamental problem of determining the probability amplitude of two arbitrary mechanical magnitudes, concluding that Schrödinger's eigenvalue functions constitute just those elements of the canonical transformation matrix that render the Hamiltonian diagonal.

As Born's collaborator, Jordan soon became one of the strongest adherents of the new indeterministic world picture based on Born's statistical interpretation of Schrödinger's wave function. Rejecting Schrödinger's attempts to return to a classical description of atomic processes in terms of continuous changes, Jordan participated in the debates concerning the fundamental question of the meaning of the new quantum magnitudes, relying on his transformation theory.[11]In his *Habilitationsvortrag*,[12] delivered in February 1927. Jordan could state simultaneously with Heisenberg the following implicit formulation of the principle of indeterminacy "If certain coordinates of a quantum mechanical system are empirically observable magnitudes…then the corresponding momenta to these coordinates are in principle nonobservable magnitudes." A visit to Copenhagen made him especially apt to accept Bohr's complementarity principle.

The application of the new formalism to the radiation field contained in the last section of the Born-Heisenberg-Jordan paper was considered by Jordan one of his most important contributions to physics because it served as the beginning of quantum field theory. It was especially satisfying to Jordan that the quantization of the vibrations of an elastic continuum according to the quantum-rules supplied from first principles the energy fluctuations derived thirty years earlier by Einstein using thermodynamical arguments from Planck's radiation law. In Einstein's second fluctuation law the mean square fluctuation of the cavity radiation energy E in the frequency interval $v, v + dv$ is given by $(E - \bar{E})^2 = h\,v\,E + (c^3 8\pi v^2 \Delta v)\,E^2/V$, V being the volume of the cavity. This expression was the most elegant early formulation of the wave-particle dualism of light quanta. The striking fact that all the particle aspects of light could in 1925 be obtained directly by quantization of the electromagnetic field made Jordan consider the possibility of applying the same procedure to matter waves in order to obtain, by "second quantization," the material particles in a natural way.[13]

Convinced that the many-body problem in quantum mechanics can be stated correctly only in the context of quantized matter waves ("repeated" or "second" quantization. as it was called later by Léon Rosenfeld), Jordan started working out his ideas together with Wolfgang Pauli. Oskar Klein, and Eugene Wigner. During his stay in Copenhagen in the summer 1927 Jordan established, together with Klein, the first nonrelativistic formalism of second quantization for a system of interacting Bose particles.[14] The more complicated case of particles obeying the Pauli exclusion principle could be solved only in collaboration with his colleague Eugene Wigner when Jordan returned in October 1927 to Göttingen. Their work led to the commutation rules for Fermi-Dirac particles.[15] Because in Dirac's theory (second) quantization was applied only to the components of the electromagnetic field and not to the matter waves associated with the material particles. the Jordan-Wigner theory accounts only for the creation and destruction of photons, but not for the material particles.

To incorporate transformations between matter and radiation, Jordan devised a theory with waves and corpuscles treated in a more symmetrical fashion. As a first indication of the appropriateness of his view, Jordan used this method to offer a derivation of Einstein's first fluctuation theorem. Which states that the probability W to encounter all the radiation energy E of frequency *v* in a subvolume *V'* of *V* is equal to $W = (V' / V)^{E/hv}$, where $E/hv = n$ is interpreted as the number of light quanta in the radiation field. Jordan claimed that, although he had proposed in the winter of 1925–1926 a full program to develop these ideas, it was only after Dirac's success with the radiation problem early in 1927 that his ideas gained the acceptance of the scientific community.[16]

According to Jordan's conception, interactions between light and matter should be described by interacting three-dimensional quantized wave fields. the occurrence of discrete electrified particles and of the light quanta merely being manifestations of the quantum laws. As a counter part of Heisenberg's and Dirac's treatment of the many-body problem, Jordan had first formulated the same problem in the context of wave quantizations, before going on to solve the general case. Since, as in Dirac's radiation theory, space and time coordinates are not given in their covartiant form, the relativistic invariance of Jordan's theory was not obvious. On the other hand, the method of second quantization revealed its practical usefulness, partricularly in the relativistic domain, where creation and annihilation of particles take place. At that time no method was known to handle the change of particle number in the configuration-space approach. Furthre, it was expected that the feared retardation problem, present when moving particles interact, would automatically vanish as soon as the theory was expressed in a relativistically convariant formulation. Such a relativistically invariant formalism for the charge-free radiation field was developed first by Jordan and Pauli with the introduction of relativistically invariant commutation relations as well for the field variables at different space-time points.[17]

The more ambitious program of a general relativistic field theory of interacting spinorial and electromagnetic fields was accomplished finally in 1929 and 1930 by Heisenberg and Pauli. This difficult task had been made possible only by utilizinf the more sophisticated mathematical tools of functional analysis, required for the treatment of the nonlinear field equations. But the basic difficulties of quantum field theory, such as the infinite self-energy of elementary particles and transitions to the negative energy states first noted in Dirac's theory of the electron, also were present in the new formalism. So the final goal of Jordan's program never could be achieved.[18]

In the meantime Jordan had become *Privatdozent* in Göttingen. In 1928 he succeeded Pauli as Wilhelm Lenz's assistant in Hamburg, before attaining in 1929 a more permanent position as extraordinary professor at the University of Rostock. Soon after his appointment he married Hertha Stahn in 1930: they had two sons. In 1935 he was promoted to ordinary professor, a position he held until 1944, when he was called to take the directorship of the Institute of The oretical Physics at the University of Berlin as Max von Laue's successor.

During those years, Jordan continued to do research in fundamental problems. But his different attempts to change the foundations of quantum physics in order to get a more consistent relativistic theory[19] never obtained general acceptance. In this context he developed new non associative algebraic forms[20] that instead founded a new branch of mathematical investigation, the so-called Jordan algebras.[21]

When, at the beginning of the thirtles, progress in physics became slower. many physicists tried to extend the applicability of the quantum theory beyond their own disciplines. After Niels Bohr's famous lecture "Light and Life" in the summer of 1932, Jordan was one of the first to search for further manifestations of the complementarity principle in biology, color vision, and psychology.[22] In a series of controversial articles, disapproved by Bohr, Jordan put forward the idea that the background of biological phenomena are individual quantum processes messes (Quantum jumps), adequately amplified by the biological organism to produce in deterministic effects at the macroscopic level. He also paid much attention to genetics and especially to the problem of radiation-induced gene-mutation (topics then of great interest in Germany) as studied by the Russianborn scientist Nikolai Timoféeff-Ressovsky. k.G. Zimmer, and Max Delbruck. For many years in the late 1930's quantum biology became Jordan's main field of research.[23] But his intention after the war to found a large institute devoted to pure research in quantum biology was never realized.[24]

In spite of his sympathies for the National Socialist movement, Jordan never broke with the tenets of modern theoretical physics, which were then under attack by a group of physicists sympathetic to the Nazi leaders.[25]During the war he served on the meteorological staff of the Luftwaffe in HamburgFulsbüttel.

Jordan had an unfortunate disposition to put science at the service of political rulers. In June 1936. attending the Copenhagen conference on theoretical physics and philosophy, he informed the Nazi authorities in a secret report about the activities of various participants. In spite of the scientific character of the meeting, he claimed, there was often a definitely materialistic and political worldview involved in many of the reports presented to the philosophical section.[26]

In his popular writings Jordan liked to use strange political analogies, comparing a cell to the state and the nucleus to the Führer, thereby offending many of his foreign colleagues. The enthusiastic disquisitions on military power and armaments he frequently gave in his scientific and philosophical explanations were often almost comic. This behavior even if interpreted as a sign of opportunism—and in spite of his outstanding scientific contributions—prevented his being reistalled in full academic professorship right after the war. But after some inquiries by foreign authorities, Jordan was reinstated as a visiting professor in 1947 and as full professor in 1953 in Hamburg—a position he held until his retirement in 1971. It would be incorrect, Pauli commented at the time, "if West Germany chooses to ignore a person like P. Jordan."[27]

During the Adenauer era Jordan again became involved in politics. He was a supporter of the notion that only Western atomic armaments could guarantee a peaceful world order.[28] From 1957to 1961 Jordan was member of the German Bundestag, contributing to the elaboration of the laws regulating the peaceful use of atomic power. In this last period. Jordan's scientific activities centered on general relativity, astrophysics, cosmology, and pure mathematics.

Motivated by Stanley Eddington's number speculations about the connection of fundamental physical constants and Dirac's conjectures on a slowly decreasing gravitational constant on a cosmological scale, Jordan and his collaborators attempted after 1944 to incorporate these ideas into the framework of Einstein's general relativity theory using the fivedimensional formalism as developed earlier by Theodor Kaluza, Oskar, Klein, and Oswald Veblen. As one of the practical conclusions of this generalized relativity theory, Jordan suggested explaining Wegener's continental drift phenomenon as a result of an expansion of the earth.[29] Even more unconven-tional were Jordan's cosmological speculations. including a theory of the formation and evolution of stars.[30]

Jordan's books on scientific and philosophical subjects addressed to lay audiences[31] as well as his textbooks on physics[32] found wide readerships. Many of them were translated into several foreign languages and appeared in many editions. In 1942 Jordan was awarded the Max Planck Medal and in 1955 the Gauss Medal.

NOTES

1. P. Jordan, "Über den positivistischen Begriff der Wirklichkeit," in *Naturwissenschaften*. **22** (1934). 485–490, and "Positivismus in der Naturwissenschaft," in *Glaube und Forschung*, II (Gütersloh, 1950), 93–112.

2. P. Jordan. "Zur Theorie der Quantenstrahlung," in *Zeitschrift für Physik*, **30** (1924), 297–319.

3. A. Einstein, "Bemerkungen zu P.Jordans Abhandlung 'Zur Theorie der Quantenstrahlung.'" *ibid*., **31** (1925), 784–785.

4. M.Born and P.Jordan, "Zur Quantentheorie aperiodischer Vorgänge," *ibid*., **33** (1925), 479–505.

5. P.Jordan. "Über das thermische Gleichgewicht zwischen Quantenatomen und Hohlraumstrahlung."*ibid*., 649–655.

6. M. Born and P.Jordan. "Zur Quantermechanik, I" *ibid*., **34** (1925). 858–888.

7. In response to an inquiry from B. L. van der Waerden, Jordan recalled in October 1964, "During Born's stay at Silvaplana I was in Hannover, in my parents' house, thinking about a part of the material, which was then explained in the paper by Born and myself. I was in correspondence with Born, to whom I naturally reported my progress. I remember that he suggested after some time to stop our exchange of letters, because the double demands of the exhausting treatment in the sanatorium and our conversations by letter about this exciting theme had a bad effect on him. So it could in fact have been as you suppose. that I had already written most of the work in a first draft when we met again in Göttingen."

8. M. Born. W. Heisenberg. and P. Jordan, "Zur Quantenmechanik, II," in *Zeitschrift für Physik*, **35** (1925). 557–615.

9. W. Heisenberg and P.Jordan. "Anwendung der Quantenmechanik auf das Problem der anomalen Zeemaneffekte." *ibid*., **37** (1926), 263–277.

10. P. Jordan, "Über Kanonische Transformationen in der Quantenmechanik. I. II." *ibid*., **37** (1926). 383–386, and **38** (1926). 513–517. and "Über eine neue Begründung der Quantenmechanik," *ibid*., **40** (1927). 809–838.

11. P. Jordan. "Anmerkung zur statistischen Deutung der Quantenmechanik." *ibid*., **41** (1927), 797–800, "Philosophical Foundations of Quantum Theory." in *Nature*. **119** (1927), 566–569, and "Reply to N. C. Campbell," *ibid*., 779. See also M. Beller. "Pascual Jordan's Influence on the Discovery of Heisenberg's Indeterminacy Principle." in *Archive for History of Exact Science*, **33** (1985). 337–349.

12. P. Jordan, "Kausalität und Statistik in der modernen Physik," in *Naturwissenschaften*, **15** (1927)105–110.

13. P. Jordan. "Zur Quantenmechanik der Gasentartung," in *Zeitschrift für Physik*. **44** (1927). 473–480, and "Über Wellen und Korpuskeln in der Quantenmechanik," *ibid*., **45** (1927). 766–775. See also J.Bromberg."The Concept of Particle Creation Before and After Quantum Mechanics." in *Historical Studies in the Physical Sciences*. 7 (1977). 161–191.

14. P. Jordan and O. Klein, "Zum Mehrköperproblem der Quantentheorie," in *Zeitschrift für physik*. **45** (1927). 751–765.

15. P. Jordan land E. Wigner."Über das Paulische Äquivalenzverbot." *ibid*., **47** (1928). 631–651.

16. P. Jordan, “Die Lichtquantenhypothese, Entwicklung und gegenwärtiger Stand,” in *Ergebnisse der exakten Naturwissenschaften*, **7** (1928), 158–208.

17. P. Jordan and W. Pauli, “Zur Quantenelektrodynamik ladungsfreier Felder,” in *Zietschrift für Physik*, **47** (1928), 151–173.

18. The equivalence of both methods later was cleared up by different authors, particularly by V. Fock, “Konfigurationsraum und Zweite Quantelung,” *ibid*., **75** (1932), 622–647. See also P. Jordan, “Zur Methode der zweiten Quantelung,” *ibid*., 648–653.

19. P. Jordan, “Über die Multiplikation quantenmerchanischer Grössen, I, II,” *ibid*., **80** (1933), 285–291, and **87** (1934), 505–512.

20. P. Jordan, “Eine Klasse nichtassoziativer hyperkomplexer Algebren,” in *Nachrichten aus der Gesellschaft der Wissenschaften zu Göttingen*, **33** (1932), 569–575; and P. Jordan, J. von Neumann, and E. Wigner, “On an Algebraic Generalization of the Quantum Mechanical Formalism,” in *Annals of Mathematics*, **35** (1934), 29–64.

21. H. Braun and M. Koecher, *Jordan-Algebren* (Berlin 1966); and N. Jacobson, *Structure and Representations of Jordan Algebras* (Providence, 1968).

22. P. Jordan, “Die Quantenmechanik und die Grundprobleme der Biologie und Psychologie,” in *Naturwissenschaften*, **20** (1932), 815–821, “Quantenphysikalische Bemerkungen zur Biologie und Psychologie,” in *Erkenntnis*, **4** (1934), 215– 252. “Positivistische Bemerkungen über die parapsychologischen Erscheinungen,” in *Zentralblatt für Psychotherapic*, **9** (1936), 3–17, “Quantenphysick und Biologie,” in *Naturwissenschaften*, **32** (1944), 309–316. “Theorie des Farbensehens,” in *Physikalische Zeitschrift*, **45** (1944), 327, and “Zur Biophysik des Farbensehens,” in *Optik*, **2** (1947), 169–189.

23. An exposition of quantum biology is also in his book *Die Physik und das Geheimnis des organischen Lebens* (Braunschweig, 1941).

24. P. Jordan, “Zukunftsaufgaben quantenbiologischer Forschung,” in P. Jordan, A. Meyer-Abich, and H. Petersen, eds., *Physis* (Stuttgart, 1942).

25. P. Jordan, “Naturwissenschaft im Umbruch,” in *Deutschlands Erneuerung*, **25** (1941), 452–458. Compare also S. Balke, “Laudatio auf Prof. Dr. Pascual Jordan,” unreferenced printed booklet (after 1969) in the Jordan-Nachlass at the Staatsbibliothek Preussischer Kulturbesitz in Berlin.

26. D. Hoffman, “Zur Teilnahme deutscher Physiker an den Kopenhagener Physiker Konferenzen nach 1933,” in *Schriftenreihe für Geschichte der Naturwissenschaften, Technik, und Medizin*, **25** (1988), 49–55.

27. In a letter of 8 May 1952 to the dean of the Faculty of Mathematics and Science of the University of Hamburg. Later, in 1979, Jordan was also proposed by Wigner for the Nobel Prize.

28. P. Jordan, *Der gescheiterte Aufstand, Betrachtungen zur Gegenwart* (Frankfurt am Main, 1956). See also the critical remarks by W. Kliefoth, “Forschung in veränderer Umwelt,” in *Physikalische Blätter*, **13** (1957), 23–32.

29. P. Jordan, “Zum Problem der Erdexpansion,” in *Naturwissenschaften*, **48** (1961), 417–425, “Geophysical Consequences of Dirac’s Hypothesis,” in *Reviews of Modern Physics*, **34** (1962), 596–600, and *The Expanding Earth*, Arthur Beer, trans, and ed. (Oxford. 1971).

30. P. Jordan, “Entstehung der Sterne, I. II,” in *Physikalische Zeitschrift*, **45** (1944), 183–190, 233–244. “Zur Theorie der Sternentstehung,” in *Physikalische Blätter*, **3** (1947), 97–106, and *Die Herkunft der Sterne* (Stuttgart, 1947). See also J. Singh, *Great Ideas and Theories of Modern Cosmology* (New York, 1961).

31. P. Jordan, *Physics of the 20th Century*, Eleanor Oshry, trans. (New York, 1944), *Die Physik und das Geheimnis des organischen Lebens* (Braunschweig, 1941), *Der Naturwissenschaftler vor der religiösen Frage* (Oldenburg, 1963). *Albert Einstein* (Frauenfeld und Stuttgart, 1969). *Begegnungen* (Oldenburg and Hamburg, 1971). and *Erkenntnis und Besinnung* (Oldenburg and Hamburg, 1972).

32. J. Franck and P. Jordan, *Anregung von Quantensprüngen durch Stösse* (Berlin, 1926): M. Born and P. Jordan, *Elementare Quantenmechanik* (Berlin, 1930); and P. Jordan, *Statistische Mechanik auf quantentheoretischer Grundlage* (Braunschweig, 1933).*Anschauliche Quantentheorie* (Berlin 1936), and *Schwerkraft and Weltall* (Braunschweig, 1952).

BIBLIOGRAPHY

I. Original Works. There is no complete bibiography of Jordan's writings. but his most important scientific publications can be found in the corresponding volumes of Poggendorff. Most of his early scientific work is published in the *Zeitschrift für Physik* and in the *Nachrichten aus der Gesellschaft der Wissenschaften zu Göttingen*. Jordan's review articles and a great number of book reviews are contained in *Naturwissenschaften*. Beginning in the 1930's he published also in journals of a more general nature, such as *Erkenntnis, Forschungen und Fortschritte, Radiologica*, and. after 1945, *Universitas, Optik, Zeitschrift für Naturforschung, and Physikalische Blätter*. As vice president (1950–1963) and president (1963– 1967) of the Akademie der Wissenschaften und der Literatur in Mainz, he contributed more than twenty-five papers on mathematics and on general relativity to the *Abhandhungen* of the academy.

Jordan's unpublished papers and literary remains, which include twenty-one boxes and twenty-two files, are deposited at the Staatsibliothek Preussischer Kulturbesitz in Berlin. More than eighty letters from his correspondence with physicists during the 1920's are cited by T. S. Kuhn, *et al., Sources for History of Quantum Physics: An Inventory and Report* (Philadelphia, 1967). Two hundred twenty-four letters from the correspondence with his main publisher are preserved in the archives of the ViewegVerlag in Wiesbaden. Thirty-three letters from Jordan's correspondence with Wolfgang Pauli are kept in the Pauli letter collection at the Centre Européen Pour la Recherche Nucléaire in Geneva and will be published in the forthcoming edition of Wolfgang Pauli's *Wissenschaftlicher Briefwechsel mit Bohr, Einstein, Heisenberg, u.a*., edited by Karl von Meyenn. A more complete list containing also Jordan's later scientific correspondence is provided by the "Inventory of Sources for History of TwentiethCentury Physics" (ISHTCP), available to researchers at the Office for History of Science and Technology of the University of California, Berkeley. The transcripts (101 pages) of four interviews conducted by T. S. Kuhn on 17–20 June 1963 in Hamburg are available at the repositories of the material listed in the above-cited *Sources for History of Quantum Physics*.

II. Secondary Literature. There are no major biographical studies of Jordan. E. Brüche provided a short notice on the occasion of Jordan's sixtieth birthday in *Physikalische Bl¨tter*, **18** (1962), 513; and J. Ehlers, Jordan's collaborator during the 1960's wrote an appreciation on his seventieth birthday, *ibid*., **28** (1972), 468–469. Jordan's philosophical convictions are discussed by H. Laitko, "Zur philosophischen Konzeption des Physikers Pascual Jordan. Versuch einer kritischen Analyse" (Ph.D. diss., Berlin. 1964). Jordan's neopositivistic views in the 1930's aroused muchopposition from members of the Vienna circle. such as O. Neurath, "Jordan, Quantentheorie and Willensfreiheit," in *Erkenntnis***5** (1935), 179– 181; H. Reichenbach, "Metaphysik bei Jordan?" ibid., 178–179; M. Schlick, "Ergänzende Bemerkungen über P. Jordans Versuch einer quantentheoretischen Deutung der Lebenserscheinungen," *ibid*., 181–183; and E. Zilsel, "P. Jordans Versuch, den Vitalismus quantenmechanisch zu retten," *ibid*., 56–65

Since Jordan was an active member of the Bundestag from 1957 until 1961, his political actions were also discussed throughly in the press. See S. Nowak, "Der Anti-Göttinger," in *Rheinischer Merkur*, **12** , no. 35 (1957), 6, Concerning Jordan's collaboration with Max Born, see Born, *My Life* (New York, 1978). and The Born-Einstein Letters, Irene Born, trans. (New York, 1971). Jordan's contributions to quantum mechanics are described in E. Bagge, "Pascual Jordan und die Quantenphysik," in *Physikalische Blätter*, **34** (1978). 224–228; M. Jammer. "Pascual Jordan und die Entwicklung der Quantenphysik," in *Naturwissenschaftliche Rundschau***37** (1984), 1–9; J. Mehra and H. Rechenberg, *The Historical Development of Quantum Theory*, III (New York, Heidelberg, and Berlin, 1982); and in the introduction to B. L. van der Waerden's *Sources of Quantum Mechanics* (Amsterdam, 1967)

More detailed historical studies have been carried out on Jordan's work on quantum field theory by J. Bromberg, "The Concept of Particle Creation Before and After Quantum Mechanics," in *Historical Studies in the Physical Sciences*, **7** (1976), 161–191; and by O. Darrigol, "The Origin of Quantized Matter Waves," *ibid*., **16** (1986), 197–253

Karl Von Meyenn