REVIEWS

O. P. Jaggi. *Scientist of Ancient India.* Atma Ram & Sons, Delhi 6, 1966, viii+266 pages. Price Rs.10.00

India is one of the few countries in the world where a spirit of scientific enquiry developed from early times. But unfortunately published books on the subject of Indian Sciences are few and far between. For this reason alone, Dr. Jaggi's book is praiseworthy and the author deserves our thanks.

The contents of the book are: I. Introduction; II. Medical men; III. Astronomers and Mathematicians; IV. Alchemists; V. Philosopher-Scientists; VI. Miscellaneous. Under Introduction, the author gives a short survey of the ancient sciences, starting from the Indus Valley civilization and ending with the eighteenth century A.D., touching on many topics in the process. He discusses in this context Vedic science, the role of religion, contact with the outside world, the spread of Indian sciences outside India and the reasons which led to the decline of the scientific spirit in India. In the remaining chapters, the author gives an account of thirty-one scientists and scientific writers, furnishing an adjective to each, for example: Āryabhaṭa, the mathematical colossus, Bhāskara, the great algebraist, etc.

The author's review in the Introduction is rather cursory and of doubtful merit, but his remarks on the causes that led to the decline of Indian sciences are penetrating and thought-provoking. In the chapter dealing with men of medicine, the author includes a number of names like Vṛnda, Dṛḍhabala, Bhāvamiśra and Ānandarāyamakhi whose claims to distinction are confined to editing, revising, compiling encyclopaedias and even writing plays. It is difficult to find any justification for including long passages on theories of divine origin of various persons, mythological episodes and classical dramatic works. In contrast, discussions on scientific approach and attainments are comparatively neglected. The author refers to nine mathematicians and astronomers, but his list does not include Bhāskara I, Śrīpati, Śrīdhara, Āryabhaṭa II and other important figures. Credit is given to individual scholars for great discoveries like those of zero, decimal system of value notations, indeterminate equations, etc. In actual practice these were the culminating points in the progressive and complementary works of a series of scholars.

The author has attached little value to the contributions of chemists in Indian science and makes the mistake of confusing between the two Nāgārjunas, the Buddhist theoretician of ancient times, and the alchemist of Albiruni's time (pp. 85 and 189).

The author's assessment of the philosopher-scientist Kaṇāda as the expounder of atomism in India on the strength of the *Vaiśeṣika Darśana* is partly true but the major credit is to be given to Praśastapāda (*c.* fifth century A.D.) who wrote a remarkable commentary known as *Praśastapāda-bhāṣya* (also known as *Padārthadharma Saṃgraha*). In later years, four commentaries (namely *Vyomavati* by Vyomācārya, *Kiraṇāvali* by Udayanācārya, *Kandalī* by Śrīdharācārya, *Setu* by Padmanābha Miśra) were written on the *Praśastapada-Bhāṣya,* itself a commentary of Kaṇāda's *Vaiśeṣika Darśana.* This shows that though Kaṇāda is the expounder, the major credit is due to Praśastapāda. But the author completely ignores the contribution of Praśastapāda who is not even mentioned in the book.

There is a great deal of doubt on the authenticity of Khanā, the woman astrologer of Bengal. Dr. Jaggi includes her as one of the thirty-one scientists and refers to Khanā as a man (p. 224).

The format, printing and get-up are satisfactory. Absence of specific references, diacritical marks and critical appraisal of available dates are other defects which detract from the value of the book. It is hoped that the author will favour us with a more critical study in his next edition and add references and diacritical marks.

H. N. GUPTA
A. K. BAG

Thomas S. Kuhn, John L. Heilbren, Paul E. Forman, Lini Allen. *Sources for History of Quantum Physics: An Inventory and Report.* Preface by John Archibald Wheeler. The American Philosophical Society, Philadelphia, 1967, pages ix+177. Price $5.00.

On the dust cover the object of the publication is stated as follows:

'Sources for History of Quantum Physics began as an archival project sponsored by the American Physical Society and the American Philosophical Society. Its aim was to assemble source materials from which historians and other scholars might describe and analyze the conceptual revolution in Physics which produced the quantum theory. This monograph is the staff's report on the projects's methods, experiences, and results. It constitutes an indispensable research aid both for those concerned with the development of twentieth century physics and for those wishing to conduct similar projects in other fields.'

Copies of much of the material described in the monograph are now deposited in the Archives for History of Quantum Physics, located at the libraries of the American Philosophical Society, Philadelphia, the University of California, Berkeley and the Niels Bohr Institute, Copenhagen. The monograph is first and foremost a guide to those collections. It also includes, however, a considerable list of materials held elsewhere, principally in European and American libraries.

As an introduction to the book Prof. John A. Wheeler has given a very illuminating study of the significance of the revolution in our scientific and philosophical thought which the development of Relativity and Quantum theory during the period 1898–1933 has brought about.

He begins his Preface with a quotation from Benedetto Croce:

> 'We are products of the past and we live immersed in the past which encompasses us. How can we move towards new life, create new activities without getting out of the past—without placing ourselves above it? There is no other way out except through thought which does not break off relations with the past but rises ideally above it and converts it into knowledge . . . Only historical judgement liberates the spirit from the pressure of the past; it maintains its neutrality and seeks only to furnish light—it makes possible the fixing of a practical purpose; opens a way to the development of action.'

Prof. Wheeler describes the nature of the three years' strenuous work by the Editor, Prof. Kuhn, and his colleagues during which 'Not only did they secure letters, manuscripts, notebooks and personal commentaries before loss or destruction; they also interviewed more than 90 men and women closely connected with the history of quantum physics and recorded and transcribed these interviews. Never in the history of science has so effective an effort been made to record decisive moments in the evolution of new ideas while key participants are still alive'.

Prof. Wheeler then indicates the importance of the project:

> 'Complementarity and indeterminism, the quantum principle and relativity, together constitute the major scientific innovation of our time. They are key concepts in a revolution in scientific theory without parallel in the last three hundred years. Of all the advances that the mind of man has ever made towards "a complete harmonious account of human experience", none is more revolutionary. None has penetrated more deeply into the inner working of the machinery of the universe. These new concepts have dramatically influenced that distinguishes the knowable from the unknowable. The discovery of the quantum principle and the discovery of the relativity principle both teach that man can learn . . . through his own investigations—to set a limit on what man can learn.
>
> 'Not only are physics and philosophy being transformed. Rare today is a new product of chemical industry which was not first formulated in terms of quantum orbitals. No one can telephone today without using devices based upon the quantum principle. Almost all the basic novelties in the field of metallurgy and magnetic materials originate in ideas that came from quantum theory. Atomic bombs and nuclear reactors could not have sprung in a single leap from pencil and paper to dramatic reality in the absence of relativity and quantum theory. Many of the deepest consideration about biochemistry and the nature of life could never have been mastered without the quantum idea.
>
> 'These features rank the revolution in theoretical physics as one of the greatest achievements of the human mind.
>
> 'Theoretical physics is a continuing and growing enterprise. However, the decisive developments of interest here—relativity and quantum theory—germinated in the decade-and-a-half, 1898–1913 and rose nearly to their present state and stature during the further two decades 1913–33.'

Wheeler points out that 90 per cent of the literatures on physics deals with work done by men who are now dead. There is a growing desire for a comprehensive account of the physics of the period 1898–1933 which will answer questions of the following nature. 'More is known about nature than about how man finds out about nature. The investigator. What brought him success? What determination? What force dragged him forward into the quantum present with his view fixed backward on the classical past? What did he count as the decisive issues? How was he led to new insights? What battles of ideas brought new enlightenment?'

> 'New bits of historical insight increase the wish to have the whole story. There comes to light a letter in which Planck writes of his determination to obtain a satisfactory account of blackbody radiation in one way or another, whatever the cost. Bohr, we learn, troubled year after year about the problem of atomic stability, made many an order-of-magnitude estimate of factors likely to be relevant to atomic stability; and reflected deeply about the effect of radiation upon stability—so that ten days after he saw Balmer's formula for the wavelengths in the hydrogen spectrum he had won his way through to the quantum theory of the atom. Of the controversy whether the spin of the electron can be measured, something has reached the published records. Less has come to print about the still greater debates that hammered out the concept of complementarity.'
>
> 'The student of physics loses by having no account of 20 major crises which actually occurred during the 1898–1933 period. How can one understand what quantum theory is today if he does not know how it developed? Many a young scientist lacks conviction about important points in workaday quantum theory, and is deprived of the deepest insights into the quantum principle itself, because he does not know the debates that settled these issues firmly for the fathers of the quantum theory. He troubles over the same old issues indecisively and ingloriously.'
>
> 'Neither physicist young nor physicist old, can serve society with full effectiveness until the past has sprung into intense and unfolding drama before his eyes. The great men, the great struggles, the great ideas. These historical insights are not for scientists alone, but also for analysts of the creative process, and for makers of government and university policy towards science.'

Having to convince the dollar-conscious American authorities, the makers of Government and University policy towards science, on the productivity of research in the new sciences, Wheeler proceeds to show how Physics has become the great factor in the economy of nations.

> 'Benefits to the economy and to defense, and to discovery, appeal to the mind. To the heart of the working scientist quantum history makes a still stronger appeal. The immortality of his heroes is at stake. With over increasing frequency the physicist in his middle years has asked his colleagues what can we do to capture the great dialogues and the great moments before they fade from memory? The bell has been telling; time is short. Einstein died in 1955, von Neumann in 1957, Pauli in 1959 and Schroedinger in 1961.'
>
> 'The published papers in which the elements of relativity and quantum mechanics were first announced to the scientific world are, of course, readily available. But proper history of scientific ideas can rarely, if ever, be written out of the original published papers by themselves. Though the historian starts with the papers, he cannot reconstruct the pattern of development without recourse to unpublished manuscripts such as notebooks, autobiographical reminiscences and letters. With respect to such personal materials, relativity and particularly quantum mechanics present the historian with problems of unprecedented magnitude. During the twentieth century, standards

of professional publication have become more and more impersonal and it is now harder than it has ever been to get from published sources hints about how ideas started and about how they developed. In addition, since World War I there seems to have been a marked decline in the role played by personal correspondence. Increasingly, conferences and the telephone have displaced the letter as the means of informal scientific communication. Finally, partly because of the speed of scientific advance, partly because of the esoteric nature of the emerging theories, certain segments of the physics community have been overwhelmed in recent times by the pace of the new developments. For a time they have turned away from the history of science. There is a notable lack of autobiographical lectures, articles, and books of the type that the eighteenth and nineteenth century make so familiar. The historian who wishes to examine the development of scientific ideas in the years after 1915 may well find fewer of the relevant research materials than the historian of science working on any other period since 1700.'

'To remedy this deficiency in source materials and to open the doors to a new understanding of how science operates, it was agreed that the project should seek to ensure the preservation of whatever manuscript materials remain; to record recollections and commentary by the living participants and their close associates; and to prepare for publication a catalogue of this material and otherwise to facilitate access to it, for example, by depositing originals or photoduplication of suitable parts of this material in the libraries of the American Philosophical Society and of the University of California, Berkeley.'

The book is divided into four chapters with two appendices

The reviewer finds the period covered by Sources for History (1898–1933) intensely interesting as he had had some first-hand experience of the men and of the discoveries of this period. As a boy he had witnessed in his uncle, Jagadish Chandra Bose's laboratory, Presidency College, Calcutta, the reproduction soon after the announcement of Roentgen's discovery, of penetrating rays produced outside a discharging cathode ray tube. On his return from Europe, Jagadish Chandra in 1902 brought with him one of the early spinthariscope by which scintillations produced by alpha particles from radium (or pitch blende) source on a fluorescent screen could be viewed through an eyepiece. His first shock that the Newtonian concept of constancy of mass was not valid came as early as in 1905-06, on reading J. J. Thomson's Elements of Electricity and Magnetism.

For a period of 3½ years (1908–1911), he was attached to the Cavendish laboratory as an advanced student. During this period Thomson was carrying on his research with a large number of research workers on discharges of electricity through gases. Investigations on positive rays had been commenced, and the presence of two isotopes in neon gas had been reported by J. J. Thomson. C. T. R. Wilson had just photographed ionization tracks of alpha particles in his cloud chamber. Rutherford had given his new model of the atom which later Bohr used for the interpretation on quantum basis the Balmer spectral series of hydrogen-like atoms.

According to Wheeler the second period of the development of relativity and quantum theories took place during 1913–33. The two decades could be divided into two periods (i) 1913–24 for the development of classical quantum theory of the atom which commenced with Bohr's model of the hydrogen atom and came to a climax with Bohr's formulation of the correspondence principle. The next period that of quantum mechanics may be said to begin with de Broglie's wave theory of mechanics (1925) and lasted according to Wheeler up to 1933.

The reviewer joined the Berlin University in 1914 and left the place in 1919, a few months after the declaration of an armistice ending the War. During this period most of the leading German physicists were to be found in Berlin permanently or for temporary periods. Planck in the course of his Berlin University lectures, 'On system of Physics', devoted the last semester to the theory of Irreversible Processes, in course of which he was continuously modifying the theoretical basis of his blackbody radiation formula. Einstein used to give two courses of lectures on Special and General Relativity and Statistical Thermodynamics.* In the weekly seminar arranged by Prof. Rubens the regular attendants besides Planck and Einstein were Nernst, Warburg, the Director of Reichs Anstalt and many others. Warburg reported on the Reichs Anstalt measurements on the spectral distribution of energy in blackbody radiation and the accuracy of its fit with the Planck formula. Nernst reported on measurements carried out by Lindemann and Eucken in his Institute on the variation with temperature of the atomic heat at low temperatures of metals, and on his suggested improvement of Einstein's Atomic heat formula by introducing a half frequency term $\nu/2$ in it. A considerable improvement was achieved when Debye introduced the concept of stationary acoustic waves in an elastic body as carriers of thermal energy. Max Born who was for some time extraordinary Professor of Physics in Berlin used to give a course of lectures on the dynamics of crystal lattice from which he derived a rather complicated formula for the atomic heat of a crystalline solid. We heard a report probably by Schaeffer on the variation of mass

* Pohl and Pringsheim, Frank and Hertz were dozents in the Physikalische Institut, Berlin. They were occasionally seen in the colloquia.

Geiger had recently joined the Reichs Anstalt; Chadwick was working with him. The writer saw the first working of Geiger's alpha particle counter here.

of an electron with velocity determined by Kaufmann which agreed better with Lorentz's calculation based upon the concept of deformable electron rather than with Abraham's model of a rigid electron.

In 1915-16 Sommerfeld published his generalization of Bohr's theory of hydrogen-like spectra taking into consideration the relativity variation in mass of the electron; the fine structure constant appears in it for the first time.

Sommerfeld was present at the 60th birth anniversary celebration of Planck, arranged by the Berlin Physical Society in 1918. We do not remember the subject of his address in which Sommerfeld introduced the 'ether' concept. When doing so Sommerfeld bowed and made his apologies to Einstein for using the concept of ether for which Einstein in his special Relativity Theory could not find any use. Einstein gave a very finely conceived sensitive address on: 'What motivates the scientist to take up the study of Theoretical Physics'.

The reviewer's next visit to Europe took place in September 1927 when along with M. N. Saha he attended the Volta Centenary celebration at Como and Rome. Nearly all the leading physicists of Europe and the U.S.A. were there with the exception of Einstein, who had conscientious objection to accepting an invitation from a dictatorially ruled State. Amongst those who attended were Lorentz, Planck, Bohr, Rutherford, Eddington, Millikan, Sommerfeld, Debye, A. Compton, Cotton, Gerlach and the younger generation of quantum physicists, Pauli, Heisenberg, Fermi, Amaldi and others.

The main topic of interest at the conference was the development of quantum theory following de Broglie's wave theory of mechanics (1925) and its subsequent experimental verification which had given rise to two incompatible developments of the quantum theory, the Matrix Mechanics (1926) of Heisenberg and the Wave Mechanics (1927) of Schroedinger; Bohr showed how the limitations of the particle concept as well as of the wave concept of matter could be subsumed within a Complementarity Principle. In 1928 before a Solvay Congress Bohr further elaborated this Principle.

Some developments and application of the new quantum theory were described by Heisenberg, Fermi, Sommerfeld and others. Rutherford described the recent work in the Cavendish laboratory on the artificial disintegration for the first time of light particles by protons using the Cockcroft Walton 600 kV D.C. generator. Compton gave an account of the sharing between a photon and an electron the energy $h\nu$ of a photon after collision with an electron.

During the rest of his study year, the reviewer visited different laboratories of Western Europe, Berlin, Tübingen, Leipzig, Vienna, Hamburg, Leyden, Amsterdam, Cambridge, etc., to observe the experimental investigations many of whose results had been reported at the Volta Centenary Congress. He met Kapitza in Cambridge in 1928 and again in 1933 when he spent a month there.

IN THE DUST cover of the book it is stated: 'It (the book) constitutes an indispensable research aid both for those concerned with the twentieth century physics and for those who wish to conduct similar projects in other fields'.

As the depository libraries of the records catalogued in the book are located mainly in the U.S.A. and certain centres in England and West Europe the author's Catalogue of Principal Sources will not be of much use to students of the subject in India; they would have preferred a complete bibliography of the subject.

Looking through the list of author's catalogues we find the names of three Indian physicists, C. V. Raman, M. N. Saha and B. B. Ray. It is rather disappointing not to find the name of S. N. Bose, joint author of the Bose-Einstein Statistics. It is known that there were some correspondences between Einstein and S. N. Bose when the latter sent a draft of his paper which was translated by Einstein and communicated to the Zeit f. Physik (**26**, 175, 1924) with the title 'Plancksche Gezetz und Licht Quantum Hypothese.' In 1924 S. N. Bose proceeded on a couple of years' deputation leave to Europe; he spent a part of this leave in Berlin and worked with Einstein. Subsequently in 1953 and later he contributed a couple of papers on Einstein's Unitary Field Theory.

The author's Catalogue has also provided some interesting information to the reviewer. We noticed that probably as a result of oversight while J. J. Thomson (p. 91) is stated correctly to have died in 1940, later it is mentioned that he was Master of Trinity College, Cambridge, from 1918–1949. In an obituary published in *Science and Culture* (**6**, 212, 1940) the reviewer had correctly noted that till his passing away in 1940 J. J. Thomson was still the Master of Trinity College, Cambridge. It was discovered that M. N. Saha and the reviewer had been responsible for publishing an inaccurate statement regarding P. Debye (*Science and Culture*, December 1936, p. 302). It was stated that Debye 'was a student of engineering about the year 1913 at Munich, but he chanced to come in contact with Sommerfeld under whose magnetic influence he began to study physics'. In the author's Catalogue (p. 31) it is stated that Debye after becoming a Diplom. Ingineer in Aachen in 1905 served as assistant to Sommerfeld and migrated to Munich with Sommerfeld when the latter received a call to fill up the chair of Theoretical Physics.

In conclusion we shall consider how, as suggested in the dust cover, this book may be used 'for those who conduct similar projects in other fields'. In this country from the end of the nineteenth century a small group of mathematicians, physicists, statisticians of international standing have come into prominence. It would be worth while if their contributions to their respective disciplines, their letters, unpublished manuscripts are catalogued and deposited in some repository institutions. For living scientists these could be supplemented by personal interviews by accredited persons who are scientists by training and have taken the trouble to read up the publications and other relevant literatures regarding the scientists they are going to interview; these could be tape-recorded and kept in these repositories. The book gives (on page 150) sample outlines of how such interviews are to be conducted. At the present stage of our scientific education we have few scientifically trained interviewers who could be entrusted with such work as is done, say, in the U.S.A. Still it is worth while undertaking it even at a lower technical level.

We give a preliminary list of scientists living or who have recently passed away about whose publications such collections could be made. J. C. Bose, Ramanujan, M. N. Saha, K. S. Krishnan, H. J. Bhabha, C. V. Raman, S. N. Bose, P. C. Mahalanobis and S. Chandrasekhar. Except the last four the others have passed away recently.

Many of the Institutes in which these scientists worked during the greater periods of their scientific career should it is suggested for the present function as repository of the publications, manuscripts, letters and, where possible, tape records of any interviews they have given.

The Bose Institute has a collection of Jagadish Chandra Bose's publications, manuscripts, some of the letters received by him. There are notebooks on some of his experimental researches. The published letters of Jagadish Chandra Bose to Rabindranath Tagore from London during the period 1900–02 contain a very valuable record of the controversies in which Jagadish Chandra Bose was involved when he was trying to establish the thesis of similarity of responses in the living and the non-living. We understand that the Madras University is the repository of Ramanujan's publications and other *memorabilia*. M. N. Saha's many-sided activities in scientific and allied fields should be collected and catalogued by the Saha Institute of Nuclear Physics.

Similarly H. J. Bhabha's letters, and other publications could be collected and stored either in the Tata Institute of Fundamental Research or in the Bhabha Atomic Energy Establishment. K. S. Krishnan had done some very valuable work both during his collaboration with C. V. Raman, which led to the discovery of modified scattering of light rays, as well as the new line of research he started subsequently. Probably the Indian Association for the Cultivation of Science may take the lead in this matter. It is hoped that the Research Institute at Bangalore under C. V. Raman will move in the matter of collecting and storing Raman's scientific records. The Indian Statistical Institute, Calcutta, probably has taken up documenting all the publications, letters and manuscripts of P. C. Mahalanobis.

S. N. Bose is not, we believe, a tidy collector of his publications, letters, etc. Some agency like the S. N. Bose 70th Birthday Celebration Committee which contain a number of his scholars and colleagues may be requested to take up the work. Since Chandrasekhar has published most of his important researches from the Yerkes Observatory, Chicago University, his papers and correspondence are likely to be stored there.

D. M. Bose