Remarkable Physicists

From Galileo to Yukawa

The 250 years from the second half of the seventeenth century saw the birth of modern physics and its growth into one of the most successful of the sciences. The reader will find here the lives of fifty of the most remarkable physicists from that era described in brief biographies. All the characters profiled have made important contributions to physics, through their ideas, through their teaching, or in other ways. The emphasis is on their varied life-stories, not on the details of their achievements, but, when read in sequence, the biographies, which are organized chronologically, convey in human terms something of the way in which physics was created. Scientific and mathematical detail is kept to a minimum, so the reader who is interested in physics, but perhaps lacks the background to follow technical accounts, will find this collection an inviting and easy path through the subject's modern development.

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From Galileo to Yukawa

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The author regrets that, due to an oversight, text from J. Mehra, Satyendra Nath Bose. 1 January 1894 – 4 February 1974, in: Biographical Memoirs of Fellows of the Royal Society, Nov. 1975, Vol. 21, was included on pages 314–316 and 318–319 in early printings of this work without permission from the Royal Society and without reference to the original work. Permission to reproduce this text in the present edition of this work has now been granted by the Royal Society, and an apology has been made by the author.

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Preface

This book is intended for those who would like to read something, but not too much, about the life-stories of some of the most remarkable physicists born between the middle of the sixteenth century and the first decade of the twentieth, a period of just over 350 years. There are five subjects in each of the ten chapters, making fifty profiles altogether. The subjects have all made an important contribution to physics, through their ideas, through their teaching, or in other ways. The emphasis is mainly on their varied life-stories, not on the details of their achievements. By minimizing technical detail, I have been able to concentrate on a representative selection of physicists whose lives seem to me of special interest. The reader who wishes for more detail about the technicalities can so easily find it elsewhere that only the briefest of indications are given here.

In writing this book I have had in mind the reader who is interested in physics but is not necessarily familiar with the history of the subject. The biographies are arranged chronologically by date of birth, so that when read in sequence they convey in human terms something of the way in which physics developed. Each of the profiles is illustrated by a portrait of the subject, except for one case where none is known. As we shall see, the remarkable physicists of our period were a surprisingly diverse collection of people. One thing that emerges clearly is that there is no such thing as a typical physicist. Any student of physics who might be looking for a role model will find some interesting possibilities. At the end I have tried to draw some general conclusions. I have also provided some suggestions for further reading.

My thanks are due to the many people who have helped me either by reading parts of the text in draft and commenting or by dealing with particular questions. Among them are Blemis Bleaney, David Brink, Sir Roger Elliott, Dominic Flament, Robert Fox, John Roche, Paolo Salvatore, Rosemary Stewart, David Thomson, David Tranah, and John Tyrer. As far as possible the sources of the illustrations and longer quotations are given at the end of the book.

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Prologue

All of us, as children, have a strong desire to learn about the natural world. What we are taught about it, at home and at school, is the result of centuries of enquiry and thought. To make it easy for us we are not taken through all the stages of the historical process of discovery, and may not realize the epic struggle which went on in order to establish the basic facts of physics. What we are taught about heat, light and sound may seem rather obvious, but it was not always so. We may be knowledgeable about the universe but much of what we know was discovered within living memory. If we are at all scientifically inclined we will be fascinated by electricity and magnetism and by many other mysterious phenomena that were poorly understood until recently and perhaps are not fully understood even now.

I have chosen to begin with Galileo and Kepler, key figures in the Renaissance of science. The scientific revolution which followed fifty years later is associated primarily with the ideas of Newton but of course others were involved, notably Huygens. In the eighteenth and nineteenth centuries there were enormous advances in the understanding of heat, light, sound, electricity and magnetism, to name just a few of the fundamental concepts. At the end of the nineteenth century it was possible to find scientists who believed that there were no more major discoveries in physics to be made. However, the twentieth century saw the birth of quantum theory and the theory of relativity. Although modern physics arose out of classical physics, there was such a profound and far-reaching discontinuity that use of the term revolution is again justified. Although its implications are still being worked out, a natural place to finish my story seems to be with the period sometimes referred to as the golden age. I begin, therefore, with physicists born in the middle of the eighteenth century, and end with some of those born in the early twentieth. To have included subjects born later in the twentieth century, when the invisible college of physics was growing so rapidly in size, would have unduly extended a book that is already long enough.

Although the subjects of these profiles are of many different nationalities, I would have preferred to have achieved a wider geographical spread. Including Russia, ten different European countries are represented; Britain, France and Germany are particularly strongly represented, with justification, I believe. However, only four countries outside Europe are represented, the USA, New Zealand, India and Japan. To a large extent this is a reflection

of the way physics has developed. In many countries it is only relatively recently that remarkable physicists have begun to appear. I would also have liked to include more women, but until quite recently it was so difficult for a woman to become a physicist that it is surprising that so many succeeded, rather than so few. Even today it is quite normal for a woman to abandon a promising career on marriage, in order to concentrate on raising a family.

Biographies of the men and women who contributed something important to physics in this period do not all make interesting reading; careful selection is necessary. With an eye to variety I have chosen those which seemed to me the most remarkable. There were many other subjects I should like to have included, but not enough is on record to allow a satisfactory profile to be written. It is not sufficient just to rely on an obituary notice or eulogistic memorial address. All too often personal papers have been lost and no biography has been written because not much survives for a biographer to work on. For example, take the case of Rudolf Clausius, one of the greatest German physicists of the nineteenth century. We know that he was severely wounded during service as a non-combatant in the Franco-Prussian war. We know that he was married and had six children, that his wife died in childbirth and that he married again. However, the only aspect of his personality that can be inferred from comments of his contemporaries is his contentious nature. We read in letters of 'that grouch Clausius'; in portraits we see a strong, unforgiving face. That is about all there is on record about his life, apart from listing the successive stages in his career.

The period from the birth of Galileo Galilei in 1564 to the death of Louis de Broglie in 1987 spans over four centuries, during which there were substantial changes in scientific terminology. The term physics, in anything like the sense we use it today, had not come into use at the start of our period; the term natural philosophy was often used instead, and physicists were referred to as philosophers. Of course men like Descartes, Leibniz and Kant were philosophers in the modern sense, but they were deeply interested in physics as well and so the former usage is not inappropriate. In the eighteenth century the Paris Academy distinguished between the mathematical sciences, which included physics, and the physical sciences, which did not. In fact experimental physics was in its infancy, and it was natural to group theoretical physics with mathematics. University students who later became physicists normally started out as mathematicians. Nowadays mathematical physics is usually regarded as part of mathematics and theoretical physics as part of physics but in many respects the distinction is an artificial one and serves no purpose in what follows.

Mediaeval universities had much in common, with curricula based on the *quadrivium* and *trivium*. After the Reformation, however, they developed in different ways in different parts of Europe, although Latin remained the academic language. Throughout the eighteenth century and even later, they were almost exclusively concerned with education, especially preparation for entry into the professions. Divinity, law and medicine were taught, but the physical sciences were largely ignored. Until relatively recently universities did not regard research as part of their mission. That was left to academies, especially those of Berlin, Paris and St Petersburg. Such academies were in the nature of research institutes, under control of the state.

British scientists, above all Newton, played a leading role in the scientific revolution of the seventeenth century, but the ascendancy of Britain did not last. Towards the end of the eighteenth century Britain was being left far behind in the field of scientific research after more than a century of steady progress on the continent, particularly in France. 'It is a source of wonder and regret to many that this island, having astonished Europe by the most glorious display of talents in mathematics and the sciences dependent upon them, should have suddenly suffered its ardour to cool and almost entirely to neglect those studies in which it infinitely excelled other nations', wrote one of the few British scientists who tried to do something about it. In France science was becoming increasingly professionalized; in other countries this process occurred much later. As a result France came to dominate most aspects of early-nineteenth-century science. The foundations of theoretical physics were laid in Paris and transmitted in various ways to other countries. Laplace's physical astronomy was followed by Poisson's theory of electricity, Ampère's theory of electromagnetism, Fresnel's theory of light and Fourier's theory of heat.

In Britain, the Royal Society of London did not function like the continental academies but nevertheless served as a focus for research activity. 'Men of science', to use the phrase in vogue, might well become fellows of the Royal Society but were not usually attached to any other institution. Apart from a few wealthy amateurs, scientific training was still largely an apprenticeship entered into for love of the subject. Only a few scientists made a living through teaching or other scholarly professions; a few scattered practitioners found posts at the Royal Institution, the British Museum or similar establishments, but no-one embraced science as he might the church or law or medicine to support himself and a family. In the informal apprenticeship that produced a scientific practitioner, a master guided the

novice into full participation in his speciality through advice or example. Discussion of scientific principles and findings, observation of scientific activities and criticism of scientific efforts were the chief tools of instruction. The master directed the reading of his apprentice, showed him how to use apparatus and how to design experiments and instruments, and introduced him to the scientific community.

Although Britain had no precise equivalent of the continental academies, the combination of the Royal Society and the Royal Institution served just as well, if not better. Moreover, there was hardly a town of any consequence that could not boast a Philosophical Society, where the progress of science could be reported upon, and the annual meetings of the British Association for the Advancement of Science performed a similar function at a national level. In nineteenth-century Britain, as we shall see, it was the north, rather than the south, which took the lead in scientific education and research, partly because the Scottish universities had always been strong in science. In the second half of the century reform of the ancient universities of Oxford and Cambridge, and the foundation of a number of new institutions of higher education, began to transform the situation in England.

Thus a distinctive school of physics developed in Britain, and the same was true in other countries, although at all times the subject tended to transcend national boundaries. While the international character of the subject was maintained, a particularly strong rivalry developed between the French school and the German school of physics. From about 1830 science in Germany became increasingly strong; towards the end of the nineteenth century Germany's reputation in chemistry, physics, biology and medicine was rivalled only by Britain. In the twentieth century, if scientific success can be measured by the award of Nobel prizes, Germany's record far outshone that of any other country. Of all the 100 Nobel prizes in science awarded between 1901, when the awards were founded, and 1932, the year before Hitler came to power, no less than 33 were awarded to Germans or scientists working in Germany. Britain had 18 laureates; the USA had six. Of the German laureates about a quarter of the scientists were of Jewish extraction, although the Jewish population made up no more than one per cent of the German people at the time. It might be added that Austria-Hungary supplied a considerable proportion of the physicists who contributed most to German leadership in scientific research.

Until the nineteenth century scientific research was usually published in book form. This was the age of the treatise, of which Newton's

Principia is a prime example. However, correspondence between the leading researchers also played an important role, as we shall see. At the same time individuals moved around a surprising amount, considering how difficult travelling was until quite recently, and they disseminated new ideas in the process. The earliest scientific journals were *Le journal des sçavans* and the *Philosophical Transactions* of the Royal Society of London. Both first appeared in 1665, the French journal a few months before the British. The former was clearly intended to serve the interests of the European educated public generally; after the French Revolution it was renamed the *Journal des savants*, and became more of a literary and less of a scientific journal. The latter was always more focused on science but even so was originally designed to 'give some accompt of the present undertakings, studies and labours of the ingenious in many considerable parts of the world'. Similar publications soon began to appear in other countries. It has been estimated that, out of 755 titles of serials of some scientific interest that had appeared up to the end of the eighteenth century, 401 were published in Germany, 96 in France, 50 in Great Britain, 43 in the Netherlands and 37 in Switzerland. The first specialized journal in physics is generally considered to have been the *Journal der Physik*, issued at Halle and Leipzig from 1790. The *Philosophical Magazine* in England, which is still extant, began to appear in 1798.

In what follows, expressions in foreign languages will usually be translated into English, with or without the original as seems appropriate. Literal translation is sometimes unsatisfactory, for example solar system seems preferable to world system for the French *système du monde* and counsellor or excellency to privy councillor for the German title *Geheimrat*. Expressions such as *Lycée* and *Grande Ecole* in French and *Gymnasium* and *Technische Hochschule* in German seem better left untranslated. It is important to remember that the meaning of a term may vary a good deal according to time and place. The term professor might often be interpreted as lecturer, otherwise it might seem strange that almost all university posts were professorships and that they could be held in plurality: they were often ill-paid. It seems best to elucidate any other points that might cause difficulty, such as the special features of the educational systems in different countries, when they first arise. Regarding place-names, I prefer the old name Breslau rather than the new name Wrocław, for example, but Dubrovnik rather than Ragusa and Regensburg rather than Ratisbon, as being more likely to be familiar to the reader: at first I write Leyden, later Leiden – consistency in such matters seems unnecessary.