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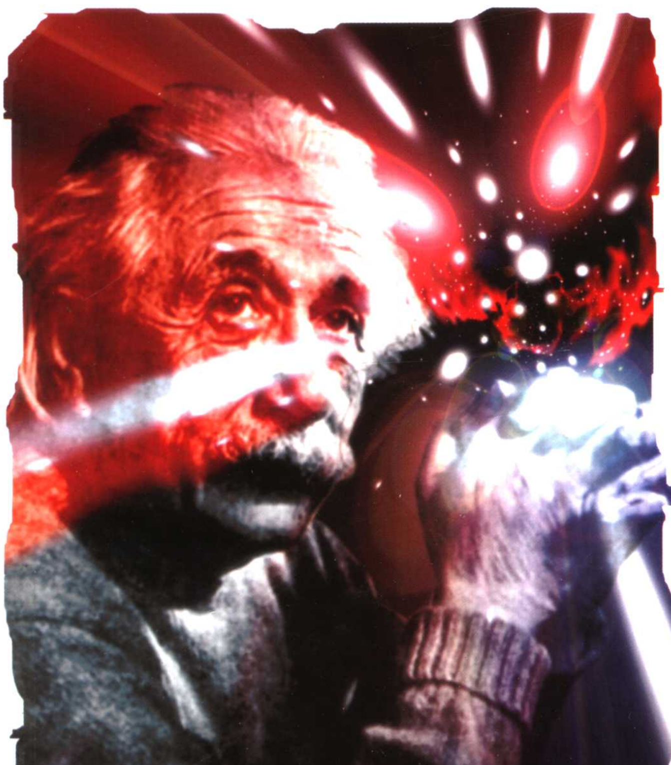
The Universe and Dr. Einstein

宇宙与爱因斯坦博士



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魏洪钟 注释

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出 版 说 明

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该系列中每本书均出自原文，英语纯正，内容丰富，深入浅出，经过详细的注释，有助于读者把握原文的精髓。

相信在二十一世纪，这套经过精心策划的英语文库必将成为我国大学生及广大英语爱好者书架中亮丽的点缀，成为他们英语学习的得力助手。

二〇〇〇年一月

Foreword By Albert Einstein

ANYONE who has ever tried to present a rather abstract scientific subject in a popular manner knows the great difficulties of such an attempt. Either he succeeds in being intelligible by concealing the core of the problem and by offering to the reader only superficial aspects or vague allusions, thus deceiving the reader by arousing in him the deceptive illusion of comprehension; or else he gives an expert account of the problem, but in such a fashion that the untrained reader is unable to follow the exposition and becomes discouraged from reading any further.

If these two categories are omitted from today's popular scientific literature, surprisingly little remains. But the little that is left is very valuable indeed. It is of great importance that the general public be given an opportunity to experience — consciously and intelligently — the efforts and results of scientific research. It is not sufficient that each result be taken up, elaborated, and applied by a few specialists in the field. Restricting the body of knowledge to a small group deadens the philosophical spirit of a people and leads to spiritual poverty.

Lincoln Barnett's book represents a valuable contribution to popular scientific writing. The main ideas of the theory of relativity are extremely well presented. Moreover, the present state of our knowledge in physics is aptly characterized. The author shows how the growth of our factual knowledge, together with the striving for a unified theoretical conception comprising all empirical data, has led to the present situation which is characterized — notwithstanding all successes — by an uncertainty concerning the choice of the basic theoretical concepts.

Princeton, New Jersey
September 10, 1948

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1. Einstein, a Great Physicist

CARVED in the white walls of the riverside Church in New York, the figures of six hundred great men of the ages — saints, philosophers, kings — stand in limestone immortality[1], surveying space and time with blank imperishable[2] eyes. One panel[3] enshrines[4] the geniuses of science, fourteen of them, spanning[5] the centuries from Hippocrates, who died around 370 B.C., to Albert Einstein, who died in 1955. In this whole sculptured gallery of the illustrious[6] dead, Einstein is the only one who shook the world within the memory of most living men.[7]

It is equally noteworthy that of the thousands of people who worship weekly at Manhattan's most spectacular Protestant[8] church, probably 99 per cent would be hard pressed[9] to explain why Einstein's images is there. It is there because a generation ago, when the iconography[10] of the church was being planned, Dr. Harry Emerson Fosdick wrote letters to a group of the nation's leading scientists asking them to submit lists of the fourteen greatest names in scientific history. Their ballots[11] varied.

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〔1〕 stand in limestone immortality 永存于石灰岩上

〔2〕 imperishable 不朽的

〔3〕 panel 墙面

〔4〕 enshrines 珍藏

〔5〕 spanning 跨越

〔6〕 illustrious 杰出的

〔7〕 Einstein is ... living men. 译文:爱因斯坦是绝大多数在世者记忆当中唯一令世界感到震撼的人物。

〔8〕 Protestant 新教的

〔9〕 be hard pressed 很难迫使

〔10〕 iconography 名人录

〔11〕 ballots 选择结果

Most of them included Archimedes, Euclid, Galileo, and Newton. But on every list appeared the name of Albert Einstein.

The vast gap that has persisted for more than fifty years — since 1905, when the Theory of Special Relativity[1] was first published — between Einstein's scientific eminence and public understanding of it is the measure of a gap in American education.[2] Today most newspaper readers know vaguely that Einstein had something to do with the atomic bomb; beyond that his name is simply a synonym for the abstruse[3]. While his theories form part of the body of modern science, many of them are not yet part of the modern curriculum. It is not surprising therefore that many a college graduate still thinks of Einstein as a kind of mathematical surrealist[4] rather than as the discoverer of certain cosmic laws of immense importance in man's slow struggle to understand physical reality. He may not realize that Relativity, over and above its scientific import, comprises a major philosophical system which augments and illumines the reflections of the great epistemologists[5] — Locke[6], Berkeley[7], and Hume[8]. Consequently he has very little notion of the vast, arcane[9], and mysteriously ordered universe in which he dwells.

Dr. Einstein, long professor emeritus at the Institute for Advanced Study in Princeton[10], spent the last years of his life

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[1] the Theory of Special Relativity 狭义相对论

[2] The vast ... American education. 译文：爱因斯坦的杰出的科学成就同公众对它的理解之间存在着巨大的差距，这一差距自狭义相对论首次发表以来已持续了五十年，它也是对美国教育尚存在差距的衡量。

[3] a synonym for the abstruse 深奥的同义词

[4] surrealist 超现实主义者

[5] epistemologists 认识论者

[6] Locke 洛克(1632－1704)，英国哲学家

[7] Berkeley 贝克莱(1684－1753)，英国神学家、哲学家

[8] Hume 休谟(1711－1776)，英国哲学家

[9] arcane 深藏的

[10] the Institute ... in Princeton 普林斯顿高级学术研究所

working on a problem which had baffled him for more than a quarter of a century. This was his Unified Field Theory[1], which attempted to set forth in one series of mutually consistent equations the physical laws governing two of the fundamental forces of the universe, gravitation and electromagnetism.[2] The significance of this task can be appreciated only when one realizes that most of the phenomena of our external world seem to be produced by these two primordial[3] forces. Until a hundred years ago electricity and magnetism — while known and studied since early Greek times — were regarded as separate quantities. But the experiments of Oersted[4] and Faraday[5] in the nineteenth century showed that a current of electricity is always surrounded by a magnetic field, and conversely that under certain conditions magnetic forces can induce electrical currents. From these experiments came the discovery of the electromagnetic field through which light waves, radio waves, and all other electromagnetic disturbances[6] are propagated[7] in space.

Thus electricity and magnetism may be considered as aspects of a single force. Save for gravitation and the newly discovered, little understood meson[8] forces which appear to hold the various parts of the atomic nucleus together, nearly all other forces in the material universe — frictional forces, chemical forces which hold atoms together in molecules, cohesive forces which bind larger particles of matter, elastic forces which cause bodies to maintain

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〔1〕 Unified Field Theory 统一场论

〔2〕 Which attempted ... and electromagnetism. 它试图在一系列相互一致的方程中建立起物理定律来规范宇宙基本力中的两种：引力和电磁力。

〔3〕 primordial 基本的

〔4〕 Oersted 奥斯特(1777－1851)，丹麦物理学家

〔5〕 Faraday 法拉第(1791－1867)，英国物理学家

〔6〕 electromagnetic disturbances 电磁干扰

〔7〕 propagated 产生

〔8〕 meson 介子

their shape — are of electromagnetic origin[1]; for all of these involve the interplay[2] of matter, and all matter is composed of atoms which in turn are composed of electrical particles. Yet the similarities between gravitational and electromagnetic phenomena are very striking. The planets spin in the gravitational field of the sun; electrons swirl in the electromagnetic field of the atomic nucleus. The earth, moreover, is a big magnet — a peculiar fact which is apparent to anyone who has ever used a compass. The sun also has a magnetic field. And so have all the stars.

Although many attempts have been made to identify gravitational attraction as an electromagnetic effect, all have failed. Einstein thought he had succeeded in 1929 and published a unified field theory which he later rejected as inadequate. His new theory, completed in the final days of 1949, was far more ambitious; for it promulgated a set of universal laws designed to encompass not only the boundless gravitational and electromagnetic fields of interstellar[3] space but also the tiny, terrible field inside the atom. Whether the whole grand objective of a Unified Field Theory will be realized only many more months or years of mathematical and experimental work can determine. But in its vast cosmic picture, when fully revealed, the abyss between macrocosmos and microcosmos[4]— the very big and the very little — will surely be bridged[5], and the whole complex of the universe will resolve into[6] a homogeneous fabric[7] in which matter and energy are indistinguishable and all forms of motion from the slow wheeling of the galaxies to the wild flight of electrons become

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〔1〕 are of electromagnetic origin 来源于电磁的力

〔2〕 interplay 相互作用

〔3〕 interstellar 星际的

〔4〕 macrocosmos and microcosmos 宏观世界和微观世界

〔5〕 bridged 沟通

〔6〕 resolve into ... 转化成……

〔7〕 homogeneous fabric 相同的框架

simply changes in the structure and concentration of the primordial field[1].

Since the aim of science is to describe and explain the world we live in, such a theory would, by thus defining the manifold of nature within the terms of a single harmonious theory, attain its loftiest goal. The meaning of the word "explain," however, suffers a contraction with man's every step in quest of reality. Science cannot yet really "explain" electricity, magnetism, and gravitation; their effects can be measured and predicted, but of their ultimate nature no more is known to the modern scientist than to Thales of Miletus[2], who first speculated on the electrification of amber around 585 B.C. Most contemporary physicists reject the notion that man can ever discover what these mysterious forces "really" are. Electricity, Bertrand Russell[3] says, "is not a thing, like St. Paul's Cathedral; it is a way in which things behave. When we have told how things behave when they are electrified, and under what circumstances they are electrified, we have told all there is to tell.[4]" Until recently scientists would have scorned such a thesis. Aristotle, whose natural science dominated Western thought for two thousand years, believed that man could arrive at an understanding of ultimate reality[5] by reasoning from *self-evident principles*[6]. It is, for example, a self-evident principle that everything in the universe has its proper place, hence one can deduce that objects fall to the ground because that's where they belong, and smoke goes up because that's where *it* belongs. The goal of Aristotelian science was to explain *why* things happen. Modern science was born when Galileo began

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〔1〕 primordial field 基本场

〔2〕 Thales of Miletus 古希腊米利都学派的泰勒斯，古希腊哲学家

〔3〕 Bertrand Russell 伯特兰·罗素(1872－1972)，英国数学家、哲学家

〔4〕 we have ... to tell 我们已经说出了所有一切

〔5〕 ultimate reality 至真

〔6〕 self-evident principles 公理

trying to explain *how* things happen and thus originated the method of controlled experiment[1] which now forms the basis of scientific investigation.

Out of Galileo's discoveries and those of Newton in the next generation there evolved a mechanical universe of forces, pressures, tensions[2], oscillations[3], and waves.[4] There seemed to be no process of nature which could not be described in terms of ordinary experience, illustrated by a concrete model or predicted by Newton's amazingly accurate laws of mechanics.[5] But before the turn of the past century certain deviations from[6] these laws became apparent; and though these deviations were slight, they were of such a fundamental nature[7] that the whole edifice of Newton's machine-like universe began to topple. The certainty that science can explain *how* things happen began to dim about twenty years ago. And right now it is a question whether scientific man is in touch with "reality" at all — or can ever hope to be.

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〔1〕 controlled experiment 控制实验

〔2〕 tensions 张力

〔3〕 oscillations 振动

〔4〕 out of ... and waves 从伽利略的发现和随后牛顿的发现中，发展出了一个力、压力、张力、振动和波(组成)的机械宇宙。

〔5〕 There seemed ... of mechanics. 似乎没有一个自然过程不能用普通的经验来描述，用具体模型来说明，或者用牛顿惊人的精确的力学定律来预测。

〔6〕 deviations from ... 偏离……

〔7〕 of such ... fundamental nature 具有如此基本的性质

2. Theory and Reality

THE factors that first led physicists to distrust their faith in a smoothly functioning mechanical universe loomed on the inner and outer horizons of knowledge — in the unseen realm of the atom and in the fathomless depths of intergalactic[1] space. To describe these phenomena quantitatively, two great theoretical systems were developed between 1900 and 1927. One was the Quantum Theory, dealing with the fundamental units of matter and energy. The other was Relativity, dealing with space, time, and the structure of the universe as a whole.[2]

Both are now accepted pillars of modern physical thought. Both describe phenomena in their fields in terms of consistent, mathematical relationships. They do not answer the Newtonian "how" any more than Newton's laws answered the Aristotelian "why."[3] They provide equations[4], for example, that define with great accuracy the laws governing the radiation and propagation of light. But the actual mechanism[5] by which the atom radiates light and by which light is propagated through space remains one of nature's supreme mysteries. Similarly the laws governing the phenomenon of radioactivity enable scientists to predict that in a given quantity of uranium[6] a certain number of atoms will disintegrate in a certain length of time. But just which

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[1] intergalactic 星系间的

[2] one was ... a whole 一个是研究物质和能量的基本单位的量子理论，另一个是研究空间、时间和宇宙总体结构的相对论。

[3] They do ... Aristotelian "why." 正如牛顿不回答亚里士多德的"为什么"问题，他们也不回答牛顿力学的"怎么样"问题。

[4] equations 方程

[5] mechanism 机制

[6] uranium 铀

atoms will decay and how they are selected for doom are questions that man cannot yet answer.

In accepting a mathematical description of nature, physicists have been forced to abandon the ordinary world of our experience, the world of sense perceptions[1]. To understand the significance of this retreat it is necessary to step across the thin line that divides physics from metaphysics.[2] Questions involving the relationship between observer and reality, subject and object, have haunted philosophical thinkers since the dawn of reason[3]. Twenty-three centuries ago the Greek philosopher Democritus[4] wrote: "Sweet and bitter, cold and warm as well as all the colors, all these things exist but in opinion and not in reality;[5] what really exists are unchangeable particles, atoms, and their motions in empty space." Galileo also was aware of the purely subjective character[6] of sense qualities like color, taste, smell, and sound and pointed out that "they can no more be ascribed to the external objects than can the tickling or the pain caused sometimes by touching such objects."[7]

The English philosopher John Locke tried to penetrate to[8] the "real essence of substances"[9] by drawing a distinction between[10] what he termed the primary and secondary qualities of

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〔1〕 sense perceptions 感觉

〔2〕 To understand ... from metaphysics 要理解这种倒退，就必须跨越区分物理学和形而上学的细微的界线。

〔3〕 the dawn of reason 理性的破晓时代

〔4〕 Democritus 德谟克利特(公元前 460—前 370?)，古希腊哲学家

〔5〕 Sweet and ... in reality 甜和苦、冷与热以及所有颜色，所有这些都只是存在于观念之中，而不是存在于现实之中。

〔6〕 purely subjective character 纯粹主观特性

〔7〕 "they can ... the tickling" 正如有时触摸这些物体所引起的发痒和疼痛一样，它们也不能归结于外部物体。

〔8〕 penetrate to ... 深入……

〔9〕 "real essence of substances" 物质的真正本质

〔10〕 drawing a distinction between ... 在……之间作出区分

matter. Thus he considered that shape, motion, solidity, and all geometrical properties[1] were real or primary qualities, inherent in[2] the object itself; while secondary qualities, like colors, sounds, tastes, were simply projections upon the organs of sense. The artificiality[3] of this distinction was obvious to later thinkers.

"I am able to prove," wrote the great German mathematician, Leibniz[4], "that not only light, color, heat, and the like, but motion, shape, and extension[5] too are mere apparent qualities." Just as our visual sense, for example, tells us that a golf ball is white, so vision abetted by our sense of touch tells us that it is also round, smooth, and small — qualities that have no more reality, independent of our senses, than the quality which we define by convention as white.

Thus gradually philosophers and scientists arrived at the startling conclusion that since every object is simply the sum of its qualities, and since qualities exist only in the mind, the whole objective universe of matter and energy, atoms and stars, does not exist except as a construction of the consciousness, an edifice of conventional symbols shaped by the senses of man. As Berkeley, the archenemy[6] of materialism, phrased it: "All the choir of heaven and furniture of earth, in a word all those bodies which compose the mighty frame of the world, have not any substance without the mind ... So long as they are not actually perceived by me, or do not exist in my mind, or that of any other created spirit, they must either have no existence at all, or else subsist in the mind of some Eternal Spirit." Einstein carried this train of logic

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[1] geometrical properties 几何性质

[2] inherent in ... 内在于……

[3] artificiality 人为性

[4] Leibniz 莱布尼茨(1646－1716),德国数学家、哲学家

[5] extension 广延性

[6] archenemy 主要敌人

to its ultimate limits by showing that even space and time are forms of intuition, which can no more be divorced from consciousness than can our concepts of color, shape, or size.[1] Space has no objective reality except as an order or arrangement of the objects we perceive in it, and time has no independent existence apart from the order of events by which we measure it.

These philosophical subtleties have a profound bearing on modern science. For along with the philosophers' reduction of all objective reality to a shadow-world of perceptions[2], scientists became aware of the alarming limitations of man's senses. Anyone who has ever thrust a glass prism[3] into a sunbeam and seen the rainbow colors of the solar spectrum[4] refracted on a screen has looked upon the whole range of visible light[5]. For the human eye is sensitive only to the narrow band of radiation that falls between the red and the violet. A difference of a few one hundred thousandths of a centimeter in wave length[6] makes the difference between visibility and invisibility. The wave length of red light is .00007 cm. and that of violet light .00004 cm.

But the sun also emits other kinds of radiation. Infrared rays[7], for example, with a wave length of .00008 to .032 cm. are just a little too long to excite the retina[8] to an impression of light, though the skin detects their impact as heat. Similarly

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〔1〕 which can ... or size 正如我们关于颜色、形状和大小的概念，它们也不能脱离意识。

〔2〕 reduction of ... of perceptions 把所有客观现实都还原到感觉的影子世界中去。

〔3〕 a glass prism 三棱镜

〔4〕 spectrum 光谱

〔5〕 the whole ... visible light 整个可见光范围

〔6〕 wave length 波长

〔7〕 infrared rays 红外线

〔8〕 retina 视网膜