HEP World's Classics

Mathematical Principles of Natural Philosophy

Volume Two

自然哲学的数学原理

第二卷

ISAAC NEWTON

TRANSLATED INTO ENGLISH BY
ANDREW MOTTE IN 1729
THE TRANSLATIONS REVISED, AND SUPPLIED WITH AN HISTORICAL
AND EXPLANATORY APPENDIX BY FLORIAN CAJORI

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HEP World's Classics

There is a Chinese saying: "It is beneficial to open any book." It is even more fruitful to open and read classic books. The world is keeping on changing, but really fundamental and essential things stay the same since there is nothing new under the sun. Great ideas have been discovered and re-discovered, and they should be learnt and re-learnt. Classic books are our inheritance from all the previous generations and contain the best of knowledge and wisdom of all the people before us. They are timeless and universal. We cannot travel back in time, but we can converse with the originators of current theories through reading their books. Classic books have withstood the test of time. They are reliable and contain a wealth of original ideas. More importantly, they are also books which have not finished what they wanted or hoped to say. Consequently, they contain unearthed treasures and hidden seeds of new theories, which are waiting to be discovered. As it is often said: history is today. Proper understanding of the past work of giants is necessary to carry out properly the current and future researches and to make them to be a part of the history of science and mathematics. Reading classics books is not easy, but it is rewarding. Some modern interpretations and beautiful reformulations of the classics often miss the subtle and crucial points. Reading classics is also more than only accumulating knowledge, and the reader can learn from masters on how they asked questions, how they struggled to come up with new notions and theories to overcome problems, and answers to questions. Above all, probably the best reason to open classic books is the curiosity: what did people know, how did they express and communicate them, why did they do what they did? It can simply be fun!

This series of classic books by Higher Education Press contains a selection of best classic books in natural history, mathematics, physics, chemistry, information technology, geography, etc. from the past two thousand years. They contain masterpieces by the great people such Archimedes, Newton, Lavoisier, Dalton, Gauss, Darwin, Maxwell, and hence give a panorama of science and mathematics. They have been typeset in modern fonts for easier and more enjoyable reading. To help the reader understand difficult classics better, some volumes contain introductions and commentaries by experts. Though each classic book can stand in its own, reading them together will help the reader gain a bigger perspective of science and mathematics and understand better interconnection between seemingly unrelated topics and subjects.

Higher Education Press has been the largest publisher in China. Besides the long tradition of providing high quality books for proper education and training of university and graduate students, she has also set out to provide research monographs and references books to people at all levels around the world. Higher Education Press considers it her duty to keep the world science and mathematics community informed of what has been achieved in their subjects in easy and accessible formats. This series of classic books is an integral part of this effort.

内容简介

《自然哲学的数学原理》是牛顿一生中最重要的科学著作, 对物理学、数学、天文学和哲学等领域的研究和发展产生了巨大影响。

牛顿在世时共发表了 3 个版本的《自然哲学的数学原理》, 分别于 1687 年、1713 年及 1726 年出版, 均为拉丁文版本。第一个英文译本由莫特 (Andrew Motte) 根据该书的第三版翻译而来, 出版于 1729 年; 1802 年又出现了根据《自然哲学的数学原理》第一版翻译的英文译本。1930 年, 美国学者、科学史家卡约里 (Florian Cajori) 在莫特的英译本基础上用现代英文对《自然哲学的数学原理》进行了校订出版, 从而成为 20 世纪读者群最大的版本。本书也采用此版本重排而成。

《自然哲学的数学原理》共五部分, 分为两卷。第一卷内容主要包括: 物质的量、时间、空间、向心力等的定义; 包括著名的运动三定律在内的公理或运动的定律; 第一、二编 (BOOK I、BOOK II) 的标题均为论物体的运动, 第一编研究在无阻力的自由空间中物体的运动, 第二编研究在阻力给定的情况下物体的运动、流体力学以及波动理论。本书为第二卷, 主要内容包括: 第三编 (BOOK III) 宇宙的系统 (使用数学的论述)、宇宙体系以及附录, 附录中的内容是卡约里对牛顿《自然哲学的数学原理》进行的历史和解释性注释。

《自然哲学的数学原理》提出了经典力学的三个基本定律和万有引力定律, 在科学史上, 它是经典力学的第一部经典著作, 是人类掌握的第一个完整的科学的宇宙论和科学理论体系, 影响力遍及经典自然科学的所有领域。

SIR ISAAC NEWTON

(See Appendix, Note 1, page 627)

艾萨克 · 牛顿爵士 (Sir Isaac Newton, 1643—1727), 英国著名物理学家、数学家、自然哲学家和天文学家, 经典物理学理论体系的建立者。牛顿是剑桥大学三一学院硕士和院士, 卢卡斯数学讲座教授, 英国皇家学会会员, 法国科学院外籍院士, 英国皇家学会主席, 被册封为英国历史上第一个自然哲学家爵士。

牛顿对代数学、数论、古典几何学与分析几何学、曲线分类、计算方法与近似求解以及概率论等都有重要贡献, 他最重要的贡献是微积分和无限级数理论, 特别是二项式展开式。

牛顿曾致力于颜色的现象和光的本性的研究, 他的重要发现成为光谱分析的基础。牛顿的最高科学成就体现在运动学和天体力学中, 1684 年, 牛顿的论文《论轨道上物体的运动》证明了天上与地上的物体服从完全相同的运动规律, 引力的存在使得行星及其卫星必定沿椭圆轨道运动, 展示出一种全新的力学理论框架, 这篇论文成为写作名著《自然哲学的数学原理》的必要准备。1687 年,《自然哲学的数学原理》的出版震动了整个英国和欧洲学术界, 使牛顿一跃成为当时欧洲最负盛名的数学家、天文学家和自然哲学家。

牛顿是经典力学基础的牛顿运动定律的建立者。他发现的运动三定律和万有引力定律为近代物理学和力学奠定了基础, 他的万有引力定律和哥白尼的日心说奠定了现代天文学的理论基础, 实现了人类对自然认识的巨大飞跃。直到今天, 人造地球卫星、火箭、宇宙飞船的发射升空和运行轨道的计算, 仍以牛顿运动定律作为理论根据。

PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *J S. NEWTON, Trin. Coll. Cantab. Soc.* Matheſeos Profeſſore *Lucaſiano,* & Societatis Regalis Sodali.

IMPRIMATUR.
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TITLE PAGE OF THE FIRST EDITION OF THE PRINCIPIA

(See Appendix, Note 2, page 627)

Editor's Note to the Present Revision

Professor FLORIAN CAJORI died August 15, 1930. In May of the following year I was invited by the University of California Press to edit this work. After much delay, due in part to unavoidable circumstances and in part to the time consumed in the extraordinary care taken in reading, checking, and rereading the proofs, this edition of Newton's *Principia* is now ready to be run off the press.

The manuscript as presented to the Press contained no Preface. Much of the material that would be included in the usual Preface is contained in the first few notes of the Appendix, pages 627 ff. Professor Cajori probably intended to prepare a Preface while the book was in the process of manufacture. There being none, the customary acknowledgment of thanks to various persons who assisted him in one way or another is lacking. Lest I unknowingly omit some to whom thanks are due, I refrain from attempting any such acknowledgment on behalf of the author.

As the title page states, this is a revision of Motte's translation of the *Principia*. From many conversations with Professor Cajori, I know that he had long cherished the idea of revising Newton's immortal work by rendering certain parts into modern phraseology (e.g., to change the reading of "reciprocally in the subduplicate ratio of" to "inversely as the square root of") and to append historical and critical notes which would provide instruction to some readers and interest to all. This is his last work; one most fitting to crown a life devoted to investigation and to writing the history of the sciences in his chosen field.

R. T. CRAWFORD

Berkeley, California,
March 31, 1934.

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APPENDIX

BOOK III
SYSTEM OF THE WORLD
(IN MATHEMATICAL TREATMENT)

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*The page numbers in square brackets in the margin of this book refer to the page numbers of the 1974 edition by University of California Press.

IN THE PRECEDING BOOKS I have laid down the principles of philosophy; principles not philosophical but mathematical: such, namely, as we may build our reasonings upon in philosophical inquiries. These principles are the laws and conditions of certain motions, and powers or forces, which chiefly have respect to philosophy; but, lest they should have appeared of themselves dry and barren, I have illustrated them here and there with some philosophical scholiums, giving an account of such things as are of more general nature, and which philosophy seems chiefly to be founded on; such as the density and the resistance of bodies, spaces void of all bodies, and the motion of light and sounds. It remains that, from the same principles, I now demonstrate the frame of the System of the World. Upon this subject I had, indeed, composed the third Book in a popular method, that it might be read by many; but afterwards, considering that such as had not sufficiently entered into the principles could not easily discern the strength of the consequences, nor lay aside the prejudices to which they had been many years accustomed, therefore, to prevent the disputes which might be raised upon such accounts, I chose to reduce the substance of this Book into the form of Propositions (in the mathematical way), which should be read by those only who had first made themselves masters of the principles established in the preceding Books: not that I would advise anyone to the previous study of every Proposition of those Books; for they abound with such as might cost too much time, even to readers of good mathematical learning. It is enough if one carefully reads the Definitions, the Laws of Motion, and the first three sections of the first Book. He may then pass on to this Book, and consult such of the remaining Propositions of the first two Books, as the references in this, and his occasions, shall require.

RULES OF REASONING IN PHILOSOPHY [398]

RULE I

We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.

To this purpose the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes.

RULE II

Therefore to the same natural effects we must, as far as possible, assign the same causes.

As to respiration in a man and in a beast; the descent of stones in *Europe* and in *America*; the light of our culinary fire and of the sun; the reflection of light in the earth, and in the planets.

RULE III

The qualities of bodies, which admit neither intensification nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.

For since the qualities of bodies are only known to us by experiments, we are to hold for universal all such as universally agree with experiments; and such as are not liable to diminution can never be quite taken away. We are certainly not to relinquish the evidence of experiments for the sake of dreams and vain fictions of our own devising; nor are we to recede from the analogy of Nature, which is wont to be simple, and always consonant to itself. We no other way know [399] the extension of bodies than by our senses, nor do these reach it in all bodies; but because we perceive extension in all that are sensible, therefore we ascribe it universally to all others also. That abundance of bodies are hard, we learn by experience; and because the hardness of the whole arises from the hardness