国家出版基金项目
NATIONAL PUBLICATION FOUNDATION

中外物理学精品书系

引进系列 · 53

Statistical Dynamics: A Stochastic Approach to Nonequilibrium Thermodynamics

2nd Edition

统计力学

——非平衡态热力学的随机方法

第二版

(影印版)

〔英〕斯特里特(R. F. Streater) 著

北京大学出版社
PEKING UNIVERSITY PRESS

Statistical Dynamics:

A Stochastic Approach to Nonequilibrium Thermodynamics

2nd Edition

国家出版基金项目
NATIONAL PUBLICATION FOUNDATION

中外物理学精品书系

引进系列 · 53

Statistical Dynamics: A Stochastic Approach to Nonequilibrium Thermodynamics

2nd Edition

统计力学

——非平衡态热力学的随机方法

第二版

（影印版）

〔英〕斯特里特（R. F. Streater） 著

北京大学出版社
PEKING UNIVERSITY PRESS

著作权合同登记号　图字:01-2014-5533
图书在版编目(CIP)数据

统计力学:非平衡态热力学的随机方法:第2版 = Statistical dynamics: a stochastic approach to nonequilibrium thermodynamics, 2nd Edition:英文/(英)斯特里特(Streater,R. F.)著. —影印本. —北京:北京大学出版社,2014.12
(中外物理学精品书系)
ISBN 978-7-301-25176-8

Ⅰ. ①统…　Ⅱ. ①斯…　Ⅲ. ①统计力学—研究—英文　Ⅳ. ①O414.2

中国版本图书馆 CIP 数据核字(2014)第 278902 号

书　　　名: **Statistical Dynamics: A Stochastic Approach to Nonequilibrium Thermodynamics 2nd Edition(统计力学——非平衡态热力学的随机方法　第二版)**(影印版)
著作责任者:〔英〕斯特里特(R. F. Streater)　著
责 任 编 辑:刘　啸
标 准 书 号:ISBN 978-7-301-25176-8/O·1052
出 版 发 行:北京大学出版社
地　　　址:北京市海淀区成府路205号　100871
网　　　址:http://www.pup.cn
新 浪 微 博:@北京大学出版社
电 子 信 箱:zpup@pup.cn
电　　　话:邮购部 62752015　发行部 62750672　编辑部 62752038　出版部 62754962
印　刷　者:北京中科印刷有限公司
经　销　者:新华书店
730毫米×980毫米　16开本　24.75印张　395千字
2014年12月第1版　2014年12月第1次印刷
定　　　价:67.00元

序　言

物理学是研究物质、能量以及它们之间相互作用的科学。她不仅是化学、生命、材料、信息、能源和环境等相关学科的基础，同时还是许多新兴学科和交叉学科的前沿。在科技发展日新月异和国际竞争日趋激烈的今天，物理学不仅囿于基础科学和技术应用研究的范畴，而且在社会发展与人类进步的历史进程中发挥着越来越关键的作用。

我们欣喜地看到，改革开放三十多年来，随着中国政治、经济、教育、文化等领域各项事业的持续稳定发展，我国物理学取得了跨越式的进步，做出了很多为世界瞩目的研究成果。今日的中国物理正在经历一个历史上少有的黄金时代。

在我国物理学科快速发展的背景下，近年来物理学相关书籍也呈现百花齐放的良好态势，在知识传承、学术交流、人才培养等方面发挥着无可替代的作用。从另一方面看，尽管国内各出版社相继推出了一些质量很高的物理教材和图书，但系统总结物理学各门类知识和发展，深入浅出地介绍其与现代科学技术之间的渊源，并针对不同层次的读者提供有价值的教材和研究参考，仍是我国科学传播与出版界面临的一个极富挑战性的课题。

为有力推动我国物理学研究、加快相关学科的建设与发展，特别是展现近年来中国物理学者的研究水平和成果，北京大学出版社在国家出版基金的支持下推出了“中外物理学精品书系”，试图对以上难题进行大胆的尝试和探索。该书系编委会集结了数十位来自内地和香港顶尖高校及科研院所的知名专家学者。他们都是目前该领域十分活跃的专家，确保了整套丛书的权威性和前瞻性。

这套书系内容丰富，涵盖面广，可读性强，其中既有对我国传统物理学发展的梳理和总结，也有对正在蓬勃发展的物理学前沿的全面展示；既引进和介绍了世界物理学研究的发展动态，也面向国际主流领域传播中国物理的优秀专著。可以说，“中外物理学精品书系”力图完整呈现近现代世界和中国物理

科学发展的全貌，是一部目前国内为数不多的兼具学术价值和阅读乐趣的经典物理丛书。

“中外物理学精品书系”另一个突出特点是，在把西方物理的精华要义“请进来”的同时，也将我国近现代物理的优秀成果“送出去”。物理学科在世界范围内的重要性不言而喻，引进和翻译世界物理的经典著作和前沿动态，可以满足当前国内物理教学和科研工作的迫切需求。另一方面，改革开放几十年来，我国的物理学研究取得了长足发展，一大批具有较高学术价值的著作相继问世。这套丛书首次将一些中国物理学者的优秀论著以英文版的形式直接推向国际相关研究的主流领域，使世界对中国物理学的过去和现状有更多的深入了解，不仅充分展示出中国物理学研究和积累的“硬实力”，也向世界主动传播我国科技文化领域不断创新的“软实力”，对全面提升中国科学、教育和文化领域的国际形象起到重要的促进作用。

值得一提的是，“中外物理学精品书系”还对中国近现代物理学科的经典著作进行了全面收录。20 世纪以来，中国物理界诞生了很多经典作品，但当时大都分散出版，如今很多代表性的作品已经淹没在浩瀚的图书海洋中，读者们对这些论著也都是“只闻其声，未见其真”。该书系的编者们在这方面下了很大工夫，对中国物理学科不同时期、不同分支的经典著作进行了系统的整理和收录。这项工作具有非常重要的学术意义和社会价值，不仅可以很好地保护和传承我国物理学的经典文献，充分发挥其应有的传世育人的作用，更能使广大物理学人和青年学子切身体会我国物理学研究的发展脉络和优良传统，真正领悟到老一辈科学家严谨求实、追求卓越、博大精深的治学之美。

温家宝总理在 2006 年中国科学技术大会上指出，“加强基础研究是提升国家创新能力、积累智力资本的重要途径，是我国跻身世界科技强国的必要条件”。中国的发展在于创新，而基础研究正是一切创新的根本和源泉。我相信，这套“中外物理学精品书系”的出版，不仅可以使所有热爱和研究物理学的人们从中获取思维的启迪、智力的挑战和阅读的乐趣，也将进一步推动其他相关基础科学更好更快地发展，为我国今后的科技创新和社会进步做出应有的贡献。

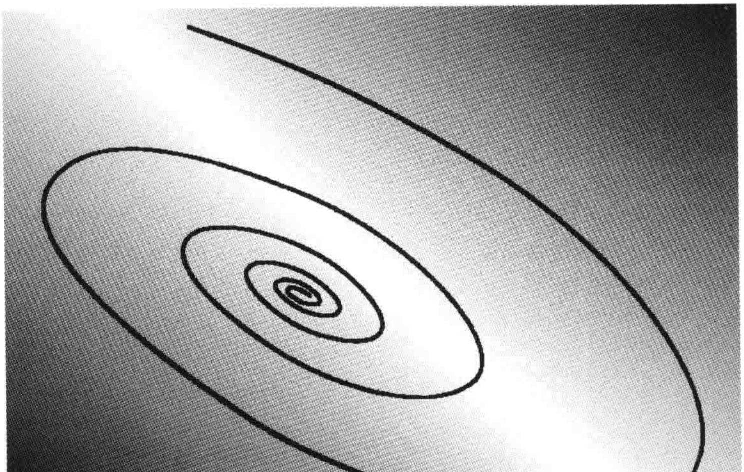
“中外物理学精品书系”编委会 主任
中国科学院院士，北京大学教授
王恩哥
2010 年 5 月于燕园

STATISTICAL DYNAMICS

A Stochastic Approach to Nonequilibrium Thermodynamics

Second Edition

R. F. Streater
King's College London, UK



Imperial College Press

ICP

Preface

This book grew out of lectures at Virginia Tech. in 1989-1991, and continued at King's College London. The first half is suitable as a text for a course of one semester, being part of a programme for students of mathematics or physics pursuing a degree at the level of the M. Sc., M. Sci., M. Phys. or M. Math. The second half, which is undoubtedly harder, might be used as a course-book for a more challenging course or as a source for project work at the M. Sc. level, or as a guide to research work leading to the M. Phil.

The author is indebted to many students and friends for help: E. B. Davies, A. Uhlmann, B. Crell, B. Luffman, L. Rondoni, S. Koseki, F. Behmardi and C. Connaughton have been particularly generous. He owes the idea of 13.3 to V. Jaksic. The author was introduced to cotransport by Prof. R. J. Naftalin, of the Department of Physiology, King's College, who also kindly drew the pictures using the Stella II 2.2.1 programme for differential equations, produced by High Performance Systems.

King's College London R. F. S. May 1995

Preface to the Second Edition

This edition is larger and, it is hoped, more accurate than the first edition. The notation has been simplified. The author thanks R. Balian for his remark that information can be lost to inaccessible parts of a large system, thus leading to entropy increase of the reduced dynamics. He thanks F. Leppington for the remark that any theory of fluid dynamics without a velocity field 'has not got off the ground'. He thanks M. R. Grasselli for a critical reading of the first edition, and comments. Thanks are also due to

H. Brenner for sending him his work on diffusion in the continuity equation. Thus, the new chapter on fluid dynamics has been added. Another new chapter reinterprets the work of W. De Roeck, T. Jacobs, C. Maes and K. Netočný, on their quantum Kac model, as the proof that the von Neumann entropy increases along the approximate dynamics. The extra pages on information dynamics were made possible by visits to the Science University of Tokyo, CNRS Luminy, the University of Madeira, the Erdos Institute Budapest, the University of Sao Paulo, Torino Politecnico, and MaPhySto Aarhus. The author is endebted to M. Ohya, S. Watanabe, H. Hasegawa, F. Combe, H. Nencka, D. Petz, W. Wrezsinski, G. Pistone, P. Gibilisco, and O. Barndorff-Nielson for help and discussions. The extra work on chemistry was done while the author was at the Polytechnic, Helsinki; he thanks Prof. Nieminen for the invitation, and for correcting his version of the Arrhenius law. Any remaining errors are the responsibility of the author.

King's College London R. F. S. Dec 2008

Contents

PART 1

Classical Statistical Dynamics

Chapter 1

Introduction

Probability theory has been used in physics since the work of Maxwell, Boltzmann and Gibbs, if not before. However, many-body theory was not very successful until Planck introduced the quantum of action. Then many puzzles about black-body radiation, specific heats, and the like, were resolved. Looking today at Planck's argument we see that he used classical probability theory, even though his energy was quantised, to get the famous Planck black-body law. The same can be said of Einstein's seminal paper on stimulated emission. Even Bose's paper on the derivation of Planck's law from radiation theory is a correct use of classical probability, if we admit that we are discussing the statistics of field configurations, rather than configurations of particles. It was Einstein who noticed that what Bose had done was to use a new counting rule for identical particles (assuming that photons were particles). At first, the new quantum mechanics was regarded as a modification of *mechanics*, not probability theory. Indeed, it was not until 1933 that Kolmogorov formally defined what a probability theory was. The upshot of Bell's notable work is that the Copenhagen interpretation of quantum theory, formulated between 1925 and 1930, is not actually a consistent set of rules within classical probability, but needs a generalization, which we call *quantum probability*. This was formalised by von Neumann in his book (von Neumann, 1932) before Kolmogorov [Neveu (1965)] set up the foundations of the classical theory.

There were two reasons for the lack of success of the statistical mechanics of classical particles; the first is the continuous nature of the phase space, with the result that the statistical entropy of a distribution is infinite. In statistical mechanics, we hope to identify the statistical entropy with the experimental entropy, which is finite if the system has finite volume. We may introduce a coarse-graining by replacing phase-space by a discrete set