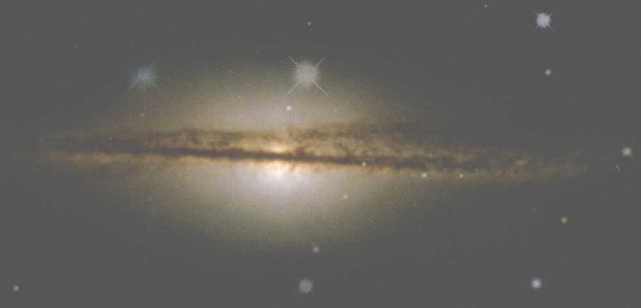
回顾与展望丛书（影印版）

AFTER THE BEGINNING

A COSMIC JOURNEY THROUGH SPACE AND TIME

大爆炸后的宇宙之旅

Norman K. Glendenning



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内 容 简 介

大约 140 亿年前，随着一次眩目的闪光，时间和物质刹那间诞生了。高温致密的宇宙，每一处都开始膨胀，从虚无中产生着空间和时间。从宇宙起初的致密火球中，首先诞生了最轻的那些元素，接着产生了原初云，后者最终演化成了星系、恒星和行星。本书在讲述宇宙学的同时，穿插讲述了为我们揭示这些奥秘的先行者的轶事，妙趣横生，引人入胜。

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About the Author

Norman K. Glendenning was born in Ontario, Canada and took his bachelor's and master's degrees at McMaster University in Hamilton, Ontario. He was awarded a Ph.D. in Theoretical Physics in 1958 by Indiana University. He was promoted to Fellow of the American Physical Society in 1968 and won the Prestigious Alexander von Humboldt Prize in 1994. He has spent his entire academic career at the University of California's Lawrence Berkeley National Laboratory. Besides publishing more than 200 research papers in scientific journals, Dr Glendenning has written two previous books concerning his research: *Direct Nuclear Reactions* and *Compact Stars.*

Ptolemy of Alexandria charting the constellations. *Reproduced with permission from Bibliotheque National de France.*

To my dear children:

Nathan, Elke, Alan

Preface

> I know not what I appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell, whilst the great ocean of truth lay all undiscovered before me.
>
> — Isaac Newton, *Memoirs*

The heavens are a wonder to us all. So it has been throughout the ages. When we look at the night sky we see what seems a timeless panorama of stars. The slow procession of the planets and an occasional shooting star suggest a sedate motion in an otherwise eternal and unchanging universe.

It isn't so. It has long been known that stars are constantly being born in great gaseous clouds, that they develop in complexity over millions of years and then eventually die. Indeed, in the early years of the last century, the famed British astronomer Sir Arthur Eddington described the Sun as a great furnace that had enough fuel to burn for 12 billion years before it would fade away. His estimate is sound, according to all the developments in the understanding of stellar processes since then. This much is commonly known, if not the details.

What is less well known, which was only recently confirmed by the many different ways in which the heavens can be viewed by modern instruments, many of them based on satellites or carried aloft by balloons, is that from the earliest moments the universe has been a cauldron of fiery activity.

At the beginning, the fire was so intense that nothing in the universe now resembles what it was made of then. The entire *part* of the universe that astronomers can possibly see — limited as it is, not by their instruments alone, but by the distance that light can travel since the beginning — was contained in a very small space. From such a beginning, how did the universe evolve to make stars and the elements out of which planets could be made and from which life could emerge? This is the story I wish to tell. Still more, I include brief stories of some of the men and women who have revealed the cosmos to us. As David Knight wrote in his preface to Rupert Hall's *Isaac Newton*, "Science is a fully human activity; the personalities of

those who practice it are important in its progress and often interesting to us. Looking at the lives of scientists is a way of bringing science to life."

I write especially with the layman in mind; for the more technically inclined I have placed interesting derivations and calculations in boxes at the end of chapters. In this way I think I have written a story of our universe that will be satisfying to the lay reader as well as to the scientist who would like to become more familiar with a subject — the cosmos — that, beginning in childhood, fills us all with wonder.

The universe we live in is as beautiful as it is awesome — more so to me, having with great pleasure learned enough to write these pages. I hope they will give pleasure to the reader. These are wonderful times in the history of science *on this planet* to be a cosmologist.

Norman K. Glendenning
Lawrence Berkeley National Laboratory
November 2001

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Many thanks to Laura Glen Louis for encouraging me to write this book for the children and especially for the proofing and the many valuable suggestions, and to Jean-Pierre Luminet, whose many publications have been an inspiration.

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Hierarchy of Cosmic Structures

Object	Size	Mass
Sun	7×10^5 km	2×10^{33} g $\equiv M_\odot$
Galaxy	45×10^{16} km	$10^{11} M_\odot$
Galaxy cluster	15×10^{19} km	$10^{13} M_\odot$
Supercluster	150×10^{19} km	$10^{15} M_\odot$
Universe	$10\,000 \times 10^{19} = 10^{23}$ km	$10^{21} M_\odot$

Timeline of Particle Appearances

Cosmic Content	Temperature (K)	Time (seconds)
Quantum foam	4×10^{32}	10^{-43}
Horizon < nucleon size	6×10^{21}	3×10^{-24}
$\gamma, \nu\bar{\nu}, e\bar{e}, q\bar{q}$, Z^0, W	10^{15}	10^{-11}
$\gamma, \nu\bar{\nu}, e\bar{e}, q\bar{q}$,	10^{14}	10^{-8}
$\gamma, \nu\bar{\nu}, e\bar{e}$, p, n, hyperons	10^{12}	10^{-5}
$\gamma, \nu\bar{\nu}, e\bar{e}$, p, n	10^{10}	1
$\gamma, \nu\bar{\nu}$, H, D, He, Li (ions)	10^9	100
Atoms of the above (recombination)	3000	300 000 yr
$\gamma, \nu\bar{\nu}$, H, D, He, Li $\cdots$ Pb	180	10^8 yr
Galaxies, stars, planets, life	2.73	15×10^9 yr

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