This page intentionally left blank

DID TIME BEGIN?

WILL TIME END?

Paul H Frampton

University of North Carolina, USA

World Scientific

NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

DID TIME BEGIN? WILL TIME END?

Maybe the Big Bang Never Occurred

Copyright © 2010 by World Scientific Publishing Co. Pte. Ltd.

All rights reserved. This book, or parts thereof, may not be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording or any information storage and retrieval system now known or to be invented, without written permission from the Publisher.

For photocopying of material in this volume, please pay a copying fee through the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923, USA. In this case permission to photocopy is not required from the publisher.

ISBN-13 978-981-4280-58-7

ISBN-10 981-4280-58-5

Typeset by Stallion Press

Email: enquiries@stallionpress.com

Printed in Singapore.

Preface

Did time begin at a Big Bang? Will the present expansion of the universe last for a finite or infinite time? These questions sound philosophical but are now becoming in the twenty-first century central to the scientific study of cosmology. The answers, which should become clearer in the next decade or two, could have profound implications for how we see our own role in the universe. Since the publication of Stephen Hawking's *A Brief History of Time* in 1988, the answers to these questions have progressed as a result of research by a community of active theoretical physicists including myself. To present the underlying ideas requires a discussion of a wide range of topics in cosmology, especially the makeup of the energy content of the universe. A brief summary of my conclusions, that of three different possibilities concerning the history and future of time, the least likely being the conventional wisdom (time began and will never end) and most likely being a cyclic model (time never begins or ends), is in the short final chapter which could be read first. To understand the reasoning leading to those conclusions could encourage reading of the entire book. My hope in writing this, my first popular book, is that it

will engender reflection about time. Many nonscientists may already hold a philosophical opinion about whether time begins and ends. This book aims to present some recently discovered scientific facts which can focus the reader's consideration of the two brief questions in the book title.

Paul H. Frampton
University of North Carolina at Chapel Hill

Contents

Preface	v
Chapter 1 Why do Many Other Scientists Believe Time Began at a Big Bang?	1
Chapter 2 Smoothness of the Universe	18
Chapter 3 Structure in the Universe	32
Chapter 4 Dark Matter and Dark Energy	46
Chapter 5 Composition of the Universe's Energy	59
Chapter 6 Possible Futures of the Universe	72
Chapter 7 Advantages of Cyclic Cosmology	84
Chapter 8 Summary of Answers to the Questions: Did Time Begin? Will Time End?	99
Glossary	101