THE DARK MATTER PROBLEM

A Historical Perspective

Most astronomers and physicists now believe that the matter content of the Universe is dominated by dark matter: hypothetical particles which interact with normal matter primarily through the force of gravity. Though invisible to current direct detection methods, dark matter can explain a variety of astronomical observations. This book describes how this theory has developed over the past 75 years, and why it is now a central feature of extragalactic astronomy and cosmology.

Current attempts to directly detect dark matter locally are discussed, together with the implications for particle physics. The author comments on the sociology of these developments, demonstrating how and why scientists work and interact. Modified Newtonian Dynamics (MOND), the leading alternative to this theory, is also presented.

This fascinating overview will interest cosmologists, astronomers, and particle physicists. Mathematics is kept to a minimum, so the book can be understood by non-specialists.

ROBERT H. SANDERS is Professor Emeritus at the Kapteyn Astronomical Institute, Groningen, the Netherlands. He has worked in the field of dark matter for many years.

THE DARK MATTER PROBLEM

A Historical Perspective

ROBERT H. SANDERS
Kapteyn Astronomical Institute, Groningen

CAMBRIDGE
UNIVERSITY PRESS

Shaftesbury Road, Cambridge CB2 8EA, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India

103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of Cambridge University Press & Assessment,
a department of the University of Cambridge.

We share the University's mission to contribute to society through the pursuit of
education, learning and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9780521113014

First published 2010
First paperback edition 2013

A catalogue record for this publication is available from the British Library

Library of Congress Cataloging-in-Publication data
Sanders, Robert H.
The dark matter problem : a historical perspective / Robert H. Sanders.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-521-11301-4
1. Dark matter (Astronomy)–History. I. Title.
QB791.3.S25 2010
523.1´126–dc22
2010004532

ISBN 978-0-521-11301-4 Hardback
ISBN 978-1-107-67718-0 Paperback

Contents

Acknowledgements

The task of describing the historical development of the dark matter problem would have been much more difficult without the assistance of a number of colleagues and old friends. In the first place I thank Mort Roberts for numerous conversations and emails on the events surrounding the early observations of spiral-galaxy rotation curves. The insights of such a major participant in these developments have been a treasure house, although I hasten to add that the conclusions drawn here from these insights (particularly concerning matters of priority) have been entirely my own.

Throughout the years I have benefited from uncountable conversations with my Groningen colleagues, Renzo Sancisi and Tjeerd van Albada, on the interpretation of the observations of rotation curves. I deeply value this contact, and their numerous useful suggestions contributed both to the content and presentation of this book. I have also benefited enormously from collaborations with generations of Groningen students: Kor Begeman, Adrick Broeils, Marc Verheijen, Edo Noordermeer, and Rob Swaters. We have spent many hours together looking at and discussing rotation curves of galaxies ranging from faint dwarfs (barely a smudge on the photographic plate) to those of giant luminous spiral systems. Altogether, in their objective and critical way, they have formed my view of the phenomenology.

There is nothing like a discussion with a critical but well-meaning colleague and friend to clarify ideas and sharpen arguments. In this regard I am very grateful to Jacqueline van Gorkom for chats about the sociology of rotation-curve observers and the philosophy of science. I also thank Rien van de Weygaert and Saleem Zaroubi for attempting to fill in the many gaps in my knowledge of cosmology and structure formation, particularly with respect to the historical developments in this field.

Moti Milgrom and Stacy McGaugh have commented on several of the chapters here, and, as always, their remarks are perceptive and helpful. For me it

has been a special privilege to have known and worked with Moti, Stacy and Jacob Bekenstein during the past quarter-century; they are creative and bold scientists.

I would like to thank Vince Higgs and his colleagues at Cambridge University Press for their constant help and many useful suggestions.

Further I am very grateful to Stefano Casertano, Jacob Bekenstein, and especially the French translator, Benoit Clenet, for pointing out embarrassingly many omissions, ambiguities and errors in the first printing of this book.

Finally, I thank my wife, Christine, for her patience and for coming to terms with our different dreams of retirement.