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978-0-521-88794-6 - Bayesian Methods in Cosmology
Michael P. Hobson, Andrew H. Jaffe, Andrew R. Liddle, Pia Mukherjee and David Parkinson
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BAYESIAN METHODS IN COSMOLOGY

In recent years, cosmologists have advanced from largely qualitative models of the Universe to precision modelling using Bayesian methods in order to determine the properties of the Universe to high accuracy. This timely book is the only comprehensive introduction to the use of Bayesian methods in cosmological studies, and is an essential reference for graduate students and researchers in cosmology, astrophysics and applied statistics.

The first part of the book focuses on methodology, setting the basic foundations and giving a detailed description of techniques. It covers topics including the estimation of parameters, Bayesian model comparison, and separation of signals. The second part explores a diverse range of applications, from the detection of astronomical sources (including through gravitational waves), to cosmic microwave background analysis and the quantification and classification of galaxy properties. Contributions from 24 highly regarded cosmologists and statisticians make this an authoritative guide to the subject.

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Preface

A revolution is underway in cosmology, with largely qualitative models of the Universe being replaced with precision modelling and the determination of Universe's properties to high accuracy. The revolution is driven by three distinct elements – the development of sophisticated cosmological models and the ability to extract accurate predictions from them, the acquisition of large and precise observational datasets constraining those models, and the deployment of advanced statistical techniques to extract the best possible constraints from those data.

This book focuses on the last of these. In their approach to analyzing datasets, cosmologists for the most part lie resolutely within the Bayesian methodology for scientific inference. This approach is characterized by the assignment of probabilities to all quantities of interest, which are then manipulated by a set of rules, amongst which Bayes' theorem plays a central role. Those probabilities are constantly updated in response to new observational data, and at any given instant provide a snapshot of the best current understanding. Full deployment of Bayesian inference has only recently come within the abilities of high-performance computing.

Despite the prevalence of Bayesian methods in the cosmology literature, there is no single source which collects together both a description of the main Bayesian methods and a range of illustrative applications to cosmological problems. That, of course, is the aim of this volume. Its seeds grew from a small conference 'Bayesian Methods in Cosmology', held at the University of Sussex in June 2006 and attended by around 60 people, at which many cosmological applications of Bayesian methods were discussed. CUP editor Vince Higgs, who attended the conference, saw the need for a comprehensive volume covering these topics, and suggested that we put together an edited volume of articles. And here it is!

The book is divided into two part. The first part, 'Methods', concentrates on the formalism, methods and algorithms, with only limited illustrative examples. The focus is very much on those aspects that have proven valuable in cosmological

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studies, complementing the much more complete treatments of Bayesian inference given in the excellent books by MacKay (2003; see page 35), Gregory (2005; see page 97), and Sivia and Skilling (2006; see page 35), all of which we recommend to the interested reader. The second part, 'Applications', studies a wide range of cosmological applications in detail. Many of the codes used in these applications are publicly available.

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