LECTURE NOTES IN PHYSICS

Pratip Bhattacharyya
Bikas K. Chakrabarti
(Eds.)

Modelling Critical and Catastrophic Phenomena in Geoscience

A Statistical Physics Approach

Springer

2005

Pratip Bhattacharyya Bikas K. Chakrabarti

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P. Bhattacharyya and B.K. Chakrabarti et al., *Modelling Critical and Catastrophic Phenomena in Geoscience*, Lect. Notes Phys. 705 (Springer, Berlin Heidelberg 2006), DOI 10.1007/b11766995

Library of Congress Control Number: 2006928276

ISSN 0075-8450
ISBN-10 3-540-35373-9 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-35373-7 Springer Berlin Heidelberg New York

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Typesetting: by the authors and techbooks using a Springer LaTeX macro package
Cover design: *design & production* GmbH, Heidelberg

Printed on acid-free paper SPIN: 11766995 54/techbooks 5 4 3 2 1 0

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Preface

Geophysics, or physics modelling of geological phenomena, is as old and as established as geoscience itself. The statistical physics modelling of various geophysical phenomena, earthquake in particular, is comparatively recent. This book intends to cover these recent developments in modelling various geophysical phenomena, including the imposing classic phenomenon of earthquakes, employing various statistical physical ideas and techniques. This first book on statistical physics modelling of geophysical phenomena contains extensive reviews by almost all the leading experts in the field and should be widely useful to the graduate students and researchers in geoscience and statistical physics. It grew out of the lecture notes from a workshop on "Models of Earthquakes: Physics Approaches", held in Saha Institute of Nuclear Physics, Kolkata, under the auspices of its Centre for Applied Mathematics and Computational Science in December 2005.

The book is divided in four parts. In the first part, tutorial materials are introduced. Chakrabarti introduces the fracture nucleation processes, their (extreme) statistics in disordered solids, in fibre bundle models and in the two fractal overlap models of earthquakes. In the next two chapters, Hemmer et al. and Kun et al. review the avalanche or quake statistics and the breaking dynamics in simple (mean-field like) fibre bundle models and in their extended versions, respectively. Hansen and Mathiesen discuss the scale invariance properties of the random and fractured surfaces.

In part II, physics models of earthquake and their statistical analysis are discussed in detail. Burridge recounts some of the early and very successful attempts like the spring-block models. Bhattacharyya discusses the recently introduced geometric models of earthquakes and their successes in capturing the statistics. The solid–solid friction and stick-slip models of earthquakes are discussed next by Matsukawa and Saito. Corral puts forward an intriguing analysis of the statistical correlations in various observed catalogue data for earthquakes. Similar spatio-temporal correlations in data and their analysis in the context of spring-block models are discussed by Kawamura. Spatio-temporal correlations between earthquakes and aftershocks are examined in

detail by de Rubeis et al. In view of such correlations, the possibilities of short-term predictions for relatively stronger earthquakes are then examined by Tabar et al. Finally, following a detailed survey of the inadequacies of our knowledge of faults, fracture, etc., and of their dynamics and statistics, Kagan argues why physics may still fail in making precise long-term predictions of earthquakes.

In the third part, some related modelling efforts are reviewed. Herrmann discusses the sand-dune formations and their physics models. Mehta reviews the dynamics of sand-piles and of ripple formation in the same, in the next chapter. Dynamics of plastic flow, the Portevin-Le Châtelier effect in particular, of stick-slips as in the peeling of adhesive tapes, etc., are discussed by Ananthakrishna and De. Next, Pradhan and Chakrabarti reviewed the statistical nature of various possible precursors in some established models of catastrophic failures in sand-piles or of fractures in composites.

In the final part, we include some short notes on some interesting and occasionally speculative analysis of phenomena or models in all these related fields.

As mentioned already, these up-to-date, detailed and penetrating reviews by the leading experts are expected to make this volume a profound guide book for the graduate students and researchers in the related fields. We are extremely thankful to these contributors for their intensive work and pleasant cooperations. We are also very much indebted to Arnab Das for his help in compiling and editing this book. Finally, we express our gratitude to Johannes Zittartz, Series Editor, LNP, and Christian Caron of Physics Editorial Department of Springer for their encouragement and support.

Kolkata
April 2006

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