

Akihiro Kanamori

# The Higher Infinite

Large Cardinals in Set Theory  
from Their Beginnings

Second Edition

 Springer

Akihiro Kanamori  
Department of Mathematics  
111 Cummington Street  
Boston, MA 02215  
USA  
aki@math.bu.edu

---

The first edition was published in 1994 by Springer-Verlag under the same title in the series  
*Perspectives in Mathematical Logic*

---

First softcover printing 2009

ISBN 978-3-540-88866-6

e-ISBN 978-3-540-88867-3

DOI 10.1007/978-3-540-88867-3

Springer Monographs in Mathematics ISSN 1439-7382

Library of Congress Control Number: 2008940025

Mathematics Subject Classification (2000): 03E05, 03E15, 03E35, 03E55, 03E60

© 2009, 2003, 1994 Springer-Verlag Berlin Heidelberg

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

*Coverdesign:* WMXDesign GmbH, Heidelberg

Printed on acid-free paper

9 8 7 6 5 4 3 2 1

springer.com

# Table of Contents

Introduction . . . . .	XI
§0. Preliminaries . . . . .	1
Chapter 1. Beginnings	
§1. Inaccessibility . . . . .	16
§2. Measurability . . . . .	22
§3. Constructibility . . . . .	28
§4. Compactness . . . . .	36
§5. Elementary Embeddings . . . . .	44
§6. Indescribability . . . . .	57
Chapter 2. Partition Properties	
§7. Partitions and Trees . . . . .	70
§8. Partitions and Structures . . . . .	85
§9. Indiscernibles and $0^\#$ . . . . .	99
Chapter 3. Forcing and Sets of Reals	
§10. Development of Forcing . . . . .	114
§11. Lebesgue Measurability . . . . .	132
§12. Descriptive Set Theory . . . . .	145
§13. $\Pi_1^1$ Sets and $\Sigma_2^1$ Sets . . . . .	162
§14. $\Sigma_2^1$ Sets and Sharps . . . . .	178
§15. Sharps and $\Sigma_3^1$ Sets . . . . .	192
Chapter 4. Aspects of Measurability	
§16. Saturated Ideals I . . . . .	210
§17. Saturated Ideals II . . . . .	220
§18. Prikry Forcing . . . . .	234
§19. Iterated Ultrapowers . . . . .	244

§20. Inner Models of Measurability . . . . . 261

§21. Embeddings,  $0^\#$ , and  $0^\dagger$  . . . . . 277

Chapter 5. Strong Hypotheses

§22. Supercompactness . . . . . 298

§23. Extendibility to Inconsistency . . . . . 311

§24. The Strongest Hypotheses . . . . . 325

§25. Combinatorics of  $\mathcal{P}_\kappa\gamma$  . . . . . 340

§26. Extenders . . . . . 352

Chapter 6. Determinacy

§27. Infinite Games . . . . . 368

§28. AD and Combinatorics . . . . . 383

§29. Prewellorderings . . . . . 403

§30. Scales and Projective Ordinals . . . . . 417

§31.  $\text{Det}(\alpha\text{-}\mathbf{\Pi}_1^1)$  . . . . . 437

§32. Consistency of AD . . . . . 450

Chart of Cardinals . . . . . 472

Appendix . . . . . 473

Indexed References . . . . . 483

Subject Index . . . . . 531