

Geometry of Quantum States

An Introduction to Quantum Entanglement

2nd edition

Ingemar Bengtsson

Stockholms Universitet

Karol Życzkowski

Uniwersytet Jagiellonski, Poland

Quantum information theory is a branch of science at the frontier of physics, mathematics, and information science, and offers a variety of solutions that are impossible using classical theory. This book provides a detailed introduction to the key concepts used in processing quantum information and reveals that quantum mechanics is a generalisation of classical probability theory. The second edition contains new sections and entirely new chapters: the hot topic of multipartite entanglement; in-depth discussion of the discrete structures in finite dimensional Hilbert space, including unitary operator bases, mutually unbiased bases, symmetric informationally complete generalized measurements, discrete Wigner function, and unitary designs; the Gleason and Kochen–Specker theorems; the proof of the Lieb conjecture; the measure concentration phenomenon; and the Hastings' non-additivity theorem. This richly-illustrated book will be useful to a broad audience of graduates and researchers interested in quantum information theory. Exercises follow each chapter, with hints and answers supplied.

Preface; 1. Convexity, colours, and statistics; 2. Geometry of probability distributions; 3. Much ado about spheres; 4. Complex projective spaces; 5. Outline of quantum mechanics; 6. Coherent states and group actions; 7. The stellar representation; 8. The space of density matrices; 9. Purification of mixed quantum states; 10. Quantum operations; 11. Duality: maps versus states; 12. Discrete structures in Hilbert space; 13. Density matrices and entropies; 14. Distinguishability measures; 15. Monotone metrics and measures; 16. Quantum entanglement; 17. Multipartite entanglement; Appendix 1. Basic notions of differential geometry; Appendix 2. Basic notions of group theory; Appendix 3. Geometry – do it yourself; Appendix 4. Hints and answers to the exercises; Bibliography; Index.

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'True story: A few years ago my daughter took a break from her usual question, 'Dad, what is your favourite colour?' and asked instead, 'What is your favourite shape?' I was floored! 'What a wonderful question; my favourite shape is Hilbert space!' 'What does it look like?' she asked. My answer: 'I don't know! But every day when I go to work, that's what I think about.' What I was speaking of, of course, is the geometry of quantum-state space. It is as much a mystery today as it was those years ago, and maybe more so as we learn to focus on its most key and mysterious features. This book, the worn first-edition of which I've had on my shelf for 11 years, is the indispensable companion for anyone's journey into that exotic terrain. Beyond all else, I am thrilled about the inclusion of two new chapters in the new edition, one of which I believe goes to the very heart of the meaning of quantum theory.'

Christopher A. Fuchs
University of Massachusetts, Boston



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