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Nota di contenuto	Disordered Topological Insulators: A Brief Introduction -- Homogeneous Materials -- Homogeneous Disordered Crystals -- Classification of Homogenous Disordered Crystals -- Electron Dynamics: Concrete Physical Models -- Notations and Conventions -- Physical Models -- Disorder Regimes -- Topological Invariants -- The Non-Commutative Brillouin Torus -- Disorder Configurations and Associated Dynamical Systems -- The Algebra of Covariant Physical Observables -- Fourier Calculus -- Differential Calculus -- Smooth Sub-Algebra -- Sobolev Spaces -- Magnetic Derivations -- Physics Formulas -- The Auxiliary C*-Algebras -- Periodic Disorder Configurations -- The Periodic Approximating Algebra -- Finite-Volume Disorder Configurations -- The Finite-Volume Approximating Algebra -- Approximate Differential Calculus -- Bloch Algebras --

Canonical Finite-Volume Algorithm -- General Picture -- Explicit Computer Implementation -- Error Bounds for Smooth Correlations -- Assumptions -- First Round of Approximations -- Second Round of Approximations -- Overall Error Bounds -- Applications: Transport Coefficients at Finite Temperature -- The Non-Commutative Kubo Formula -- The Integer Quantum Hall Effect -- Chern Insulators -- Error Bounds for Non-Smooth Correlations -- The Aizenman-Molchanov Bound -- Assumptions -- Derivation of Error Bounds -- Applications II: Topological Invariants -- Class AIII in d = 1 -- Class A in d = 2 -- Class AIII in d = 3 -- References.

Sommario/riassunto

This work presents a computational program based on the principles of non-commutative geometry and showcases several applications to topological insulators. Noncommutative geometry has been originally proposed by Jean Bellissard as a theoretical framework for the investigation of homogeneous condensed matter systems. Recently, this approach has been successfully applied to topological insulators, where it facilitated many rigorous results concerning the stability of the topological invariants against disorder. In the first part of the book the notion of a homogeneous material is introduced and the class of disordered crystals defined together with the classification table, which conjectures all topological phases from this class. The manuscript continues with a discussion of electrons’ dynamics in disordered crystals and the theory of topological invariants in the presence of strong disorder is briefly reviewed. It is shown how all this can be captured in the language of noncommutative geometry using the concept of non-commutative Brillouin torus, and a list of known formulas for various physical response functions is presented. In the second part, auxiliary algebras are introduced and a canonical finite-volume approximation of the non-commutative Brillouin torus is developed. Explicit numerical algorithms for computing generic correlation functions are discussed. In the third part upper bounds on the numerical errors are derived and it is proved that the canonical-finite volume approximation converges extremely fast to the thermodynamic limit. Convergence tests and various applications concludes the presentation. The book is intended for graduate students and researchers in numerical and mathematical physics.