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Autore	Wall Michael L
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Nota di contenuto	Part I: Introduction -- General Introduction -- Models for Strongly Correlated Lattice Physics -- Part II: The Molecular Hubbard Hamiltonian -- Emergent Timescales in Entangled Quantum Dynamics of Ultracold Molecules in Optical Lattices -- Hyperfine Molecular Hubbard Hamiltonian -- Part III: The Fermi Resonance Hamiltonian -- Microscopic Model for Feshbach Interacting Fermions in an Optical Lattice with Arbitrary Scattering Length and Resonance Width -- Part IV: Matrix Product States -- Matrix Product States: Foundations -- Out-of-Equilibrium Dynamics with Matrix Product States -- The Infinite Size Variational Matrix Product State Algorithm -- Finite Temperature Matrix Product State Algorithms and Applications -- Part V: Open Source Code and Educational Materials -- Open Source Code Development -- Educational Materials -- Part VI: Conclusions and Appendices -- Conclusions and Suggestions for Future Research -- Appendix A: Documentation for ALPS V2.0 TEBD Code -- Appendix B: Educational

	Materials: A Gentle Introduction to Time Evolving Block Decimation (TEBD) -- Appendix C: Educational Materials: Introduction to MPS Algorithms.
Sommario/riassunto	This thesis investigates ultracold molecules as a resource for novel quantum many-body physics, in particular by utilizing their rich internal structure and strong, long-range dipole-dipole interactions. In addition, numerical methods based on matrix product states are analyzed in detail, and general algorithms for investigating the static and dynamic properties of essentially arbitrary one-dimensional quantum many-body systems are put forth. Finally, this thesis covers open-source implementations of matrix product state algorithms, as well as educational material designed to aid in the use of understanding such methods.