

- [1] P. W. Anderson, Absence of diffusion in certain random lattices, *Phys. Rev.* **109**, 1492 (1958).
- [2] N. F. Mott, Impurity band conduction. Experiment and theory the metal-insulator transition in an impurity band, *J. Phys. Colloques* **37**, C4-301 (1976).
- [3] S. Kettemann, Towards a comprehensive theory of metal-insulator transitions in doped semiconductors, *Ann. Phys.* **456**, 169306 (2023).
- [4] L. D. Cesare, K. Lukierska-Walasek, I. Rabuffo, and K. Walasek, Two-spin cluster approach to the infinite-range quantum transverse XY spin-glass model, *Phys. Lett. A* **145**, 291 (1990).
- [5] L. De Cesare, K. Lukierska-Walasek, I. Rabuffo, and K. Walasek, Cavity-fields approach to quantum XY spin-glass models in a transverse field, *Phys. Rev. B* **45**, 1041 (1992).
- [6] A. de Paz, A. Sharma, A. Chotia, E. Maréchal, J. H. Huckans, P. Pedri, L. Santos, O. Gorceix, L. Vernac, and B. Laburthe-Tolra, Nonequilibrium quantum magnetism in a dipolar lattice gas, *Phys. Rev. Lett.* **111**, 185305 (2013).
- [7] B. Yan, S. A. Moses, B. Gadway, J. P. Covey, K. R. A. Hazzard, A. M. Rey, D. S. Jin, and J. Ye, Observation of dipolar spin-exchange interactions with lattice-confined polar molecules, *Nature (London)* **501**, 521 (2013).
- [8] P. Fersterer, A. Safavi-Naini, B. Zhu, L. Gabardos, S. Lepoutre, L. Vernac, B. Laburthe-Tolra, P. B. Blakie, and A. M. Rey, Dynamics of an itinerant spin-3 atomic dipolar gas in an optical lattice, *Phys. Rev. A* **100**, 033609 (2019).
- [9] J. Zeiher, J.-y. Choi, A. Rubio-Abadal, T. Pohl, R. van Bijnen, I. Bloch, and C. Gross, Coherent many-body spin dynamics in a long-range interacting Ising chain, *Phys. Rev. X* **7**, 041063 (2017).
- [10] H. Bernien, S. Schwartz, A. Keesling, H. Levine, A. Omran, H. Pichler, S. Choi, A. S. Zibrov, M. Endres, M. Greiner, V. Vuletić, and M. D. Lukin, Probing many-body dynamics on a 51-atom quantum simulator, *Nature (London)* **551**, 579 (2017).
- [11] A. Keesling, A. Omran, H. Levine, H. Bernien, H. Pichler, S. Choi, R. Samajdar, S. Schwartz, P. Silvi, S. Sachdev, P. Zoller, M. Endres, M. Greiner, V. Vuletić, and M. D. Lukin, Quantum Kibble–Zurek mechanism and critical dynamics on a programmable Rydberg simulator, *Nature (London)* **568**, 207 (2019).
- [12] R. Islam, C. Senko, W. C. Campbell, S. Korenblit, J. Smith, A. Lee, E. E. Edwards, C.-C. J. Wang, J. K. Freericks, and C. Monroe, Emergence and frustration of magnetism with variable-range interactions in a quantum simulator, *Science* **340**, 583 (2013).
- [13] P. Jurcevic, B. P. Lanyon, P. Hauke, C. Hempel, P. Zoller, R. Blatt, and C. F. Roos, Quasiparticle engineering and entanglement propagation in a quantum many-body system, *Nature (London)* **511**, 202 (2014).
- [14] P. Richerme, Z.-X. Gong, A. Lee, C. Senko, J. Smith, M. Foss-Feig, S. Michalakakis, A. V. Gorshkov, and C. Monroe, Non-local propagation of correlations in quantum systems with long-range interactions, *Nature (London)* **511**, 198 (2014).
- [15] M. Gärtner, J. G. Bohnet, A. Safavi-Naini, M. L. Wall, J. J. Bollinger, and A. M. Rey, Measuring out-of-time-order correlations and multiple quantum spectra in a trapped-ion quantum magnet, *Nat. Phys.* **13**, 781 (2017).
- [16] A. Signoles, T. Franz, R. F. Alves, M. Gärtner, S. Whitlock, G. Zürn, and M. Weidemüller, Glassy dynamics in a disordered Heisenberg quantum spin system, *Phys. Rev. X* **11**, 011011 (2021).
- [17] A. Nauts and R. E. Wyatt, New approach to many-state quantum dynamics: The recursive-residue-generation method, *Phys. Rev. Lett.* **51**, 2238 (1983).
- [18] T. J. Park and J. C. Light, Unitary quantum time evolution by iterative Lanczos reduction, *J. Chem. Phys.* **85**, 5870 (1986).
- [19] L. Colmenarez and D. J. Luitz, Lieb-Robinson bounds and out-of-time order correlators in a long-range spin chain, *Phys. Rev. Res.* **2**, 043047 (2020).
- [20] J. Vahedi, Asymmetric transport in long-range interacting chiral spin chains, *SciPost Phys. Core* **5**, 021 (2022).
- [21] M. Faridfar and J. Vahedi, Thermodynamic behavior of spin-1 Heisenberg chain: A comparative study, *J. Supercond. Novel Magn.* **35**, 519 (2022).
- [22] U. Schollwoeck, The density-matrix renormalization group in the age of matrix product states, *Ann. Phys.* **326**, 96 (2011).
- [23] G. Vidal, Efficient classical simulation of slightly entangled quantum computations, *Phys. Rev. Lett.* **91**, 147902 (2003).
- [24] S. R. White and A. E. Feiguin, Real-time evolution using the density matrix renormalization group, *Phys. Rev. Lett.* **93**, 076401 (2004).
- [25] M. P. Zaletel, R. S. K. Mong, C. Karrasch, J. E. Moore, and F. Pollmann, Time-evolving a matrix product state with long-ranged interactions, *Phys. Rev. B* **91**, 165112 (2015).
- [26] S. Paeckel, T. Köhler, A. Swoboda, S. R. Manmana, U. Schollwöck, and C. Hubig, Time-evolution methods for matrix-product states, *Ann. Phys.* **411**, 167998 (2019).
- [27] P. B. Blakie, A. Bradley, M. Davis, R. Ballagh, and C. Gardiner, Dynamics and statistical mechanics of ultra-cold Bose gases using c-field techniques, *Adv. Phys.* **57**, 363 (2008).
- [28] A. Polkovnikov, Phase space representation of quantum dynamics, *Ann. Phys.* **325**, 1790 (2010).
- [29] A. K. Tuchman, C. Orzel, A. Polkovnikov, and M. A. Kasevich, Nonequilibrium coherence dynamics of a soft boson lattice, *Phys. Rev. A* **74**, 051601(R) (2006).
- [30] S. M. Davidson, D. Sels, and A. Polkovnikov, Semiclassical approach to dynamics of interacting fermions, *Ann. Phys.* **384**, 128 (2017).
- [31] K. Nagao, M. Kunimi, Y. Takasu, Y. Takahashi, and I. Danshita, Semiclassical quench dynamics of Bose gases in optical lattices, *Phys. Rev. A* **99**, 023622 (2019).
- [32] S. R. Muleady, M. Yang, S. R. White, and A. M. Rey, Validating phase-space methods with tensor networks in two-dimensional spin models with power-law interactions, *Phys. Rev. Lett.* **131**, 150401 (2023).
- [33] C. D. Mink, D. Petrosyan, and M. Fleischhauer, Hybrid discrete-continuous truncated Wigner approximation for driven, dissipative spin systems, *Phys. Rev. Res.* **4**, 043136 (2022).
- [34] W. K. Wootters, A Wigner-function formulation of finite-state quantum mechanics, *Ann. Phys.* **176**, 1 (1987).
- [35] J. Schachenmayer, A. Pikovski, and A. M. Rey, Many-body quantum spin dynamics with Monte Carlo trajectories on a discrete phase space, *Phys. Rev. X* **5**, 011022 (2015).
- [36] J. Schachenmayer, A. Pikovski, and A. M. Rey, Dynamics of correlations in two-dimensional quantum spin models with long-range interactions: A phase-space Monte-Carlo study, *New J. Phys.* **17**, 065009 (2015).