Q 75: Quantum Systems between Bose and Fermi Statistics

Time: Friday 11:00–12:30 Location: P 11

Q 75.1 Fri 11:00 P 11

Encoding gauge theories in quantum systems — •Alessio Celi — Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain

In this talk, I will describe a quantum computation/simulation approach to gauge theories based on the encoding, the resolution of the local conservation law of the theory to reformulate it in terms of the physical states, the gauge invariant degrees of freedom. I will present successful applications of the encoding that ranges from the realization of topological gauge theories with ultracold atoms to the ab-initio continuum limit of 2D lattice gauge theories with tensor networks.

Q 75.2 Fri 11:15 P 11

Finite-Size Effect in Anyonic Schulz-Shastry Models — Borna Perkovic[1], •Martin Bonkhoff[2], and Thore Posske[2] — [1]Physics Department, Massachusetts Institute of Technology, 182 Memorial Dr, Cambridge, MA 02139, USA — [2]I. Institut für Theoretische Physik, Universität Hamburg, 22607 Hamburg, Germany

Luttinger liquid theory for canonical particles or spins is typically spatio-temporally symmetric, as dictated by the symmetries of the underlying lattice models. In contrast, for one-dimensional anyons, additional fixed points arise that feature spatio-temporally asymmetric marginal couplings, belonging to the Schulz-Shastry class [1]. We investigate the finite-size effects of a two-leg model that captures anyonic low-energy excitations in a saturated spin-1/2 chain with next-nearest-neighbour interactions [2]. We compute boundary characteristics such as Friedel oscillations and persistent currents, and determine both the bulk and boundary limits of correlation functions [1] K. V. Pham, M. Gabay and P. Lederer, EPL 51 161 (2000). [2] Rahmani, Armin and Feiguin, Adrian E. and Batista, Cristian D. Phys. Rev. Lett. 113, 267201 (2014).

Q 75.3 Fri 11:30 P 11

Anyonic phase transitions in the 1D extended Hubbard model with fractional statistics — •Imke Schneider[1], Martin Bonkhoff[2], Kevin Jägering[1], Axel Pelster[1], Shijie Hu[3], and Sebastian Eggert[1] — [1]University of Kaiserslautern-Landau (RPTU) — [2]University of Hamburg — [3]Beijing Computational Science Research Center

Recent advances in quantum technology allow the realization of "lattice anyons", which have enjoyed large interest as particles which interpolate between bosonic and fermionic behavior. We now study the interplay of such fractional statistics with strong correlations in the one-dimensional extended Anyon Hubbard model at unit filling by developing a tailored bosonization theory and employing large-scale state-of-the-art numerical simulations. The resulting phase diagram shows several distinct gapped and superfluid phases, which display an interesting transition through a multicritical point as the anyonic exchange phase is tuned from bosons to fermions. The universality of the phase transitions is discussed.

Q 75.4 Fri 11:45 P 11

Three-body bound states in the anyon-Hubbard model — •Isaac Tesfaye[1], Joyce Kwan[2], Markus Greiner[2], Luis Santos[3], André Eckardt[1], and Brice Bakkali-Hassani[2] — [1]Institut für Physik und Astronomie, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Department of Physics, Harvard University, Cambridge, Massachusetts 02138, USA — [3]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover, Germany

Quantum statistics in low-dimensional systems predicts anyonic particles with fractional exchange statistics, which are neither bosons nor fermions. While anyons are typically found in 2D, as excitations of topologically ordered states of matter, recently anyon-like exchange has also been observed in two different experimental realizations of the anyon-Hubbard model (AHM). The AHM can be formulated in terms of bosons featuring density-dependent Peierls phases, described by a statistical phase angle θ. This angle has been shown to control asymmetric transport and the formation of dynamically bound pairs at finite momentum. Here, we show theoretically that the AHM also hosts three-body bound states in and outside the continuum. We provide a simple approximation to these three-body bound states using a variational ansatz and explain their binding mechanism. Moreover, we reveal that the signatures of three-body bound states in the AHM can be directly probed experimentally from the expansion dynamics starting from three localized particles.

Q 75.5 Fri 12:00 P 11

Quantum many-body scars in the tilted anyon-Hubbard model — •Ana Hudomal[1], Ivana Vasić[1], and Axel Pelster[2] — [1]Institute of Physics Belgrade, University of Belgrade, Serbia — [2]Physics Department and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, Germany

Quantum many-body scarring is a form of weak ergodicity breaking in which a small set of nonthermal eigenstates are embedded in an otherwise ergodic spectrum [1]. Scarring has been observed in both the tilted Bose-Hubbard model [2] and the tilted Fermi-Hubbard model [3], even though the underlying mechanisms appear to differ. Interestingly, in both models scarring appears in the same parameter regime and at unit filling, suggesting a deeper connection between them. Here we interpolate between bosonic and fermionic statistics by tuning the statistical angle θ in the anyon-Hubbard model [4] with open boundary conditions and a linear tilt potential. We identify characteristic signatures of scarring, including periodic revivals and atypical eigenstates, and investigate how their properties evolve as a function of θ.

[1] M. Serbyn *et al.*, Nat. Phys. **17**, 675 (2021).
[2] G.-X. Su *et al.*, Phys. Rev. Research **5**, 023010 (2023).
[3] J.-Y. Desaules *et al.*, Phys. Rev. Lett. **126**, 210601 (2021).
[4] T. Keilmann *et al.*, Nat. Commun. **2**, 361 (2011).

Q 75.6 Fri 12:15 P 11

Estimating universal parameters of 1D anyons via Bogoliubov theory — •Bin-Han Tang[1], Axel Pelster[2], and Martin Bonkhoff[3] — [1]University of Trento, Italy — [2]RPTU Kaiserslautern-Landau, Germany — [3]University of Hamburg, Germany

Recently, the one-dimensional anyon-Hubbard model was realized in a seminal experiment with Cs-atoms [1]. This allowed to confirm previous theoretical predictions that the quasi-momentum distribution is asymmetric for intermediate statistical angles, reflecting inherent spatio-temporal asymmetry. In one-dimensional systems of infinite extent, Bose-Einstein condensation is precluded by strong quantum fluctuations, and the Luttinger paradigm is the governing principle instead. However, for non-integrable models the coupling constants of the theory are only known analytically in weak-coupling limit, and have to be deduced numerically or with approximate methods in general. To this end, we use a thermodynamic description via a Landau potential, which has to be extremal with respect to both the density and the wave vector characterizing the effective condensate in [1]. The latter induces a current-density coupling as an additional response coefficient, apart from the ordinary density stiffness and phase stiffness. Imposing thermodynamic stability then implies different sound velocities for the propagation to the left or the right. And we compare the stiffnesses with the predictions of Luttinger liquid theory for the anyon-Hubbard model in the dilute limit, where we can slightly extend to higher filling fractions [2]. [1] S. Dhar et al., Nature 642, 53 (2025). [2] M. Bonkhoff et al. Phys. Rev. Lett. 126, 163201 (2021).