MP 9: Theoretical Aspects of Condensed Matter II

Time: Wednesday 9:30–12:30 Location: HL 102

MP 9.1 Wed 9:30 HL 102

Wegner model on a tree graph: U(1) symmetry breaking — •Julian Arenz — Institut für theoretische Physik, Zülpicher Str. 77, 50937 Köln

The Anderson transition between localized and metallic states is traditionally analyzed by assuming a one-parameter scaling hypothesis. However, there exists mounting evidence that the transition in $d \geq 3$ dimensions may have a second branch and that two relevant parameters are needed in order to describe the universal behavior at criticality. Doubt of the standard hypothesis also comes from field theory. Indeed, increasing the space dimension moves the Anderson transition point in the strong disorder regime. Here, a strong coupling approach very different from the usual weak-coupling analysis of the σ-model is called for.

In the process of developing the field theory at strong coupling we first investigate the $N = 1$ Wegner model on a Bethe lattice assuming the self-consistent theory of localization due to Abou-Chacra et al. We derive a self consistency equation for the Fourier Laplace transform of a local matrix Green's function. Its degree of freedom is a matrix field whose target is a space foliated by hyperboloids.

Our main observation is that the $U(1)$ symmetry which distinguishes retarded from advanced fields may undergo spontaneous symmetry breaking. Put in other words, in the high dimension and large disorder regime there exist stable solutions that break $U(1)$ symmetry.

MP 9.2 Wed 9:50 HL 102

Spectral localizer for line-gapped non-Hermitian topological matter — •Lars Koekenbier — Friedrich-Alexander Universität Erlangen-Nürnberg, Erlangen, Germany

Topological matter, described by short-ranged and line-gapped non-Hermitian Hamiltonians, has associated strong topological invariants that determine its phases. I will present an approach to accessing these invariants via a suitable spectral localizer, which is an operator constructed without using the band structure of the material. An example of this numerical technique with relevance to the design of topological photonic systems, such as topological lasers, is shown.

MP 9.3 Wed 10:10 HL 102

Rigorous Bounds on Tc in the Eliashberg Theory of Superconductivity — •Michael Kiessling[1], Boris Altshuler[2], and Emil Yuzbashyan[3] — [1]Rutgers University, Dept. of Mathematics — [2]Columbia University, Dept. of Physics — [3]Rutgers University, Dept. of Physics and Astronomy

The BCS theory of superconductivity uses Tc as empirical input. By contrast, the Eliashberg theory allows one to compute Tc in principle. In this talk rigorous lower and upper bounds are presented explicitly for (a) the realization of the theory with dispersionless phonons, and (b) the so-called gamma-model. For small phonon frequencies in model (a) the lower bound agrees to three significant digits with previously established numerical results. Upper and lower bounds for model (b) converge to each other when gamma goes to infinity.

20 min. break

MP 9.4 Wed 10:50 HL 102

Boundary Superconductivity in BCS Theory — •Barbara Roos[1] and Robert Seiringer[2] — [1]University of Tübingen, Germany — [2]ISTA, Klosterneuburg, Austria

We study the BCS theory of superconductivity for systems with a boundary. It has been observed numerically, that in BCS theory superconductivity persists at higher temperatures at the boundary than in the bulk. We give a rigorous proof that the BCS critical temperature increases in the presence of an interface in dimensions one, two and three, at least at weak coupling.

MP 9.5 Wed 11:10 HL 102

Magnus effect on a Majorana zero-mode — •Gal Lemut[1], Michal Jan Pacholski[2], Stephan Plugge[3], Carlo Willem Joannes Beenakker[4], and Inanc Adagideli[5] — [1]Dahlem Center for Complex Quantum Systems and Fachbereich Physik, Freie Universität Berlin, Berlin, Germany — [2]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [3]Silicon Quantum Computing, Sydney, New South Wales, Australia — [4]Instituut-Lorentz, Universiteit Leiden, Leiden, The Netherland — [5]Faculty of Engineering and Natural Sciences, Sabanci University, Orhanli-Tuzla, Istanbul, Turkey

A supercurrent on the proximitized surface of a topological insulator can cause a delocalization transition of a Majorana fermion bound to a vortex core as a zero-mode. Here we study the dynamics of the deconfinement, as a manifestation of the Magnus effect (the coupling of the superflow to the velocity field in the vortex). The initial acceleration of the Majorana fermion is $\pm 2v_f^2 K\hbar$, perpendicular to the Cooper pair momentum K, for a $\pm 2\pi$ winding of the superconducting phase around the vortex. The quasiparticle escapes with a constant velocity from the vortex core, which we calculate in a semiclassical approximation and compare with computer simulations

MP 9.6 Wed 11:30 HL 102

Dynamical simulation of the injection of vortices into a Majorana edge mode — Ian Matthias Flor[2], •Alvaro Donis Vela[1], Carlo Beenakker[1], and Gal Lemut[3] — [1]Leiden University — [2]KTH Royal Institute of Technology — [3]Freie Universitat Berlin

The chiral edge modes of a topological superconductor can transport fermionic quasiparticles, with Abelian exchange statistics, but they can also transport non-Abelian anyons: Edge-vortices bound to a π-phase domain wall that propagates along the boundary. A pair of such edge-vortices is injected by the application of an h/2e flux bias over a Josephson junction. Existing descriptions of the injection process rely on the instantaneous scattering approximation of the adiabatic regime [Beenakker et al. Phys.Rev.Lett. 122, (2019)], where the internal dynamics of the Josephson junction is ignored. Here we go beyond that approximation in a time-dependent many-body simulation of the injection process, followed by a braiding of mobile edge-vortices with a pair of immobile Abrikosov vortices in the bulk of the superconductor. Our simulation sheds light on the properties of the Josephson junction needed for a successful implementation of a flying topological qubit.

MP 9.7 Wed 11:50 HL 102

Charge-Transport Mechanisms in the Conductive Fiber Network of Cable Bacteria — •Stefani Valianti[1], Jasper van der Veen[1], Filip Meysman[2], Herre van der Zant[1], and Yaroslav Blanter[1] — [1]Kavli Institute of Nanoscience, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands — [2]Centre of Excellence for Microbial Systems Technology, University of Antwerp, Universiteitsplein 1, 2610 Wilrijk, Belgium.

Charge transfer is fundamental to life, and organisms have developed various conductive structures to support vital processes.The distance of biological charge transport has long been thought to be limited to nm scale, yet recent studies suggest that electric currents can run along cm-long wires.The most studied bacterial species that produce conductive structure are those of the cable bacteria family.They display a high electrical conductivity, opening perspectives for novel bioelectronic technologies.Here, we shed light on conductive charge-transport (CT) mechanisms by developing CT theoretical models in metal-cable bacterium filament-metal junction, based on incoherent classical and quantum hopping formalisms, that describe conductance experiments for which, there is no theoretical modelling.We propose that conduction through cable bacteria at high temperatures follows an activated Arrhenius temperature-dependence with low activation energy that is a clear signature of classical hopping mechanism including nearest-neighboring near-resonant hopping centers.When lowering the temperature below 80K, the conductivity remains elevated due to quantum-assisted hopping and eventually stabilizes regardless of temperature.

MP 9.8 Wed 12:10 HL 102

Multiple Manifestations of Negative Local Partial Density of States — •Kanchan Meena and Prosenjit Singha Deo — S. N. Bose National Centre for Basic Sciences, Kolkata, 700106, India

Mesoscopic physics has new achievements in miniature sample fabrication. With leads, one can have a hierarchy of density of states in Larmor Clock (LC) theory. New phenomena have been seen with these local entities or formulas, like local partial density of states can become negative in the presence of Fano resonances. So such new phenomena, like negative partial states, transmission zeros, π phase shift and breakdown of parity effect etc have seen in recent works. In the presence of negative electrons can behave like positron. If one electron can attract one positron, it can attract another positrons also, which can also be seen as electron-electron attraction in mesoscopic physics. In this work, we are showing that can become negative and that can be experimentally detectable. For that, we are working with two approaches. One is a continuum model and the other is discrete or tight binding model. One can see there are multiple manifestations of time travel.