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Particle-hole symmetries in condensed matter — •Martin Zirnbauer — University of Cologne, Koeln, Germany

Non-relativistic condensed matter breaks the charge conjugation symmetry C of relativistic quantum fields. However, for half-filled bands a close analog, namely particle-hole symmetry C', may emerge. The two symmetry operations C and C' are similar in that they both transform any excitation of energy E and charge Q to another excitation of the same energy E but the opposite charge -Q. They differ in that charge conjugation is a unitary operation, whereas particle-hole conjugation is anti-unitary.

After reviewing some background material from many-body theory, this talk illustrates the phenomenon of emergent particle-hole symmetries in condensed matter by a series of examples, culminating with the spectacular case of the half-filled lowest Landau level. Along the way, we argue that the Nobel Prize winning Haldane phase of antiferromagnetic quantum spin chains is a topological phase protected by a particle-hole symmetry.