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Out-of-equilibrium phenomena and Transport in Cold Atoms[1]

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Transport of particle or charge current between two reservoirs is one of the most studied phenomenon in the context of condensed matter. Despite its apparent simplicity this phenomenon is in fact a case of an out of equilibrium situation requiring in principle new theoretical tools and concepts for its solution. One way to sweep the difficulty under the rug has been usually to tackle this problem in the linear response, where one can come back to the comfortable case of equilibrium. There are however many cases when the linear response is not enough and when a full solution of the non-equilibrium problem is needed. This is in particular the case for quantum point contacts or junctions where the full current-voltage characteristics gives direct information on the physics of the problem. In the recent years, in complement to condensed matter experimental realizations, due to the full control on the parameters of the problem and the fact that they realize isolated quantum systems cold atoms have proven a fantastic laboratory to produce out of equilibrium situations. This ranges from the case of quenches, to more recently via experiments of the ETHZ group to the case of real transport between reservoirs. This experimental activity has in turn thus stimulated strongly theoretical developments in this field. I will discuss in this talk some of the recent advances and realizations both at the experimental and of course the theoretical level. I will in particular focus on a recent study [1] which was able to realize a tunable, ballistic quantum point contact between two fermi reservoirs with a tunable interaction allowing to reach unitarity and to provide a theoretical description of the out-of equilibrium corresponding problem. In such a system the current has been shown to originate from multiple Andreev reflections which leads to a very non-linear current-chemical potential characteristics. The geometry of the contact can be changed showing a competition between superfluidity and thermally activated transport which leads to a conductance minimum and poses several theoretical questions for its theoretical description. [1] "Connecting strongly correlated superfluids by a quantum point contact", D. Husmann, S. Uchino, S. Krinner, M. Lebrat, T. Giamarchi, T. Esslinger and J.-P. Brantut, arXiv:1508.00578 (2015).

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