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Talk Title: What atomtronics experiments teach us about many body physics and what this means for integrated matter wave circuits

Abstract: The concepts of integrated microscopic atom optics, now often called atomtronics were conceived more than 30 years ago with the goal to do for atomic matter waves what was achieved in quantum electronics. Whereas the relations between deBroglie waves and structure size can be easily comparable a big difference is that in quantum electronics most of the time the electrons can be treated as 'non-interacting' whereas for atoms (or ions and molecules) the interactions most of the time dominates the kinetic terms. This is especially true if one wants to work in reduced dimensions. After establishing the basic techniques and the AtomChip as the experimental platform, we concentrated on the rich many-body physics in such devices, emerging from the dominance of interactions. In my talk I will give an overview of how the fundamental quantum noise in splitting a many-body state combined with the interactions leads to de-coherence and relaxation even in a completely isolated quantum system [1], and how these effects can be mitigated by designing the system in such a way that it shows recurrences [2], or reduced by quantum control of the fluctuations [3]. These experiments show that it is not the atoms but the quantum excitations of the many-body system which dominate the rich physics. I will give than an example of how to create topological states and excitations with arbitrary large correlations [4], and how to characterize the system [5]. This nicely illustrated that it is the effective quantum field theory emerging from the microscopic physics of the atoms in the circuit which dominate the quantum physics accessible, especially if working in the regime akin to quantum electronics circuits. I believe this will open up new regimes which might be much richer than what the microscopic constituents, the atoms, would give you. As an example, I will sketch the concept to build a quantum thermal machine using these atom chip circuits [6].

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