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PREFACE

Physics in one dimension

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With modern microelectronics moving towards smaller and smaller length scales on the (sub-) nm scale, quantum effects (apart from band structure and band gaps) have begun to play an increasingly important role. This especially concerns dimensional confinement to 2D (high electron mobility transistors and integer/fractional quantum Hall effect physics, graphene and topological insulators) and 1D (with electrical connections eventually reaching the quantum limit). Recent developments in the above-mentioned areas have revealed that the properties of electron systems become increasingly exotic as one progresses from the 3D case into lower dimensions.

As compared to 2D electron systems, much less experimental progress has been achieved in the field of 1D electron systems. The main reason for the lack of experimental results in this field is related to the difficulty of realizing 1D electron systems. Atom chains created in quantum mechanical break junction set-ups are too short to exhibit the typically 1D signatures. As an alternative, atomic chains can be produced on crystal surfaces, either via assembling them one-by-one using a scanning tunnelling microscope or via self-assembly. The drawback of the latter systems is that the atomic chains are not truly 1D since they are coupled to the underlying crystal and sometimes even to the neighbouring chains. In retrospect, this coupling turns out to be an absolute necessity in the experiment since true 1D systems are disordered at any non-zero temperature [1]. The coupling to the crystal and/or neighbouring chains shifts the phase transition, for example, a Peierls instability, to a non-zero temperature and thus allows experiments to be performed in the ordered state.

Here, we want to emphasize that the electronic properties of the 1D electron system are fundamentally different from its 2D and 3D counterparts. The Fermi liquid theory, which is applicable to 2D and 3D electron systems, breaks down spectacularly in the 1D case and should be replaced by the Luttinger liquid theory [2, 3]. In 1D electron systems electron–electron interactions play a very prominent role, and one of the most exciting predictions is that the electron loses its identity and separates into two collective excitations of the quantum mechanical many body system: a spinon that carries spin without charge, and a holon that carries the positive charge of a hole without its spin.

In this special section, we have attempted to collect a series of papers that gives an impression of the current status of this rapidly evolving field. The first article is a comprehensive review by Kurt Schönhammer that provides the reader with an introduction into the exciting theory of the 1D electron system as well as its mathematical formalism.

Acknowledgments

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References

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