LOW-DIMENSIONAL QUANTUM GASES OUT OF EQUILIBRIUM WORKSHOP SUMMARY

In recent years, there has been steep progress in experimental techniques allowing the fabrication, manipulation and probing of various ultracold atomic gases and their mixtures. One of the key developments is the idea of optical lattices, which allow dimensionality to be controlled and which made it possible to investigate low-dimensional (1D and 2D) bosonic and fermionic quantum liquids. This has given rise to a number of fundamental theoretical problems, which range from properties of few-body bound states to exact integrability of many-body systems. One of the most exciting novel directions is the potential to drive these systems away from the thermal equilibrium in an extremely controllable fashion and measure their subsequent evolution with a high degree of time and space resolution. This leads to the formulation of an entirely new set of questions, which in turn require development of a new set of theoretical tools and approaches.

The William I. Fine Theoretical Physics Institute (FTPI) at the University of Minnesota sponsored and hosted a workshop **"**Low-Dimensional Quantum Gases out of Equilibrium**"** from May 11 to 13, 2012. The goal of which was to bring together the leading experimentalists and theoreticians to facilitate the exchange of ideas and information in this rapidly evolving and extremely active area of research. The workshop was organized by **Alex Kamenev** (FTPI), **Michael Koehl** (Cambridge) and **Austen Lamacraft** (University of Virginia and Cambridge) and featured 24 talks divided almost equally between theory and experimental. The participation of young researchers (graduate students and postdocs) was especially encouraged, with those who attended giving a number of plenary talks as well as presented posters during coffee breaks and social hours.

The Friday session focused on realizations of 1D quantum liquids. It was opened by one of the pioneers of the field, **Weiss** of Penn State University, who outlined specific non-equilibrium experimental techniques to tackle 1D gases. He was followed by **Caux**, who focused on the aspects of exact integrability, which may be transferred to non-equilibrium setups. **Naik**, **Gangardt**, and **Demler** talked about experimental and theoretical aspects of impurity atoms embedded and manipulated within 1D quantum gases. This is a novel setup, brought by the advent of low-dimensional cold atomic systems, which stimulates a lot of recent activity. **Tan** gave an exciting presentation on universal properties of three- and four-body states (so called Ekimov states) in various dimensions. Talks by **Zwierlein** and **Pertot** gave an update of the latest experimental developments in 2D fermionic gases with attractive and repulsive interparticle interactions.

The primary focus of Saturday's session was the most recent development in atomic gases with spin-orbit (SO) interactions. The phenomenon of SO coupling is well established in solid state electronics context. However it was only last year when the SO interacting bosons were realized in an experiment of the NIST group. This group was represented by **Beeler**, who told the participants about ongoing efforts toward the realization of synthetic magnetic fields in quasi-2D bosonic gases. The theoretical aspects associated with SO bosons were discussed by **Zhai** and **Sedrakyan**. **Radzihovsky** gave an enlightening presentation of Larkin-Ovchinnikov phases in superconductors and liquid crystals, which happen to have close resemblance with SO bosons.

Another topic prominently featured during the workshop was the dynamics of quantum quenches and subsequent thermalization. The subject is raised by the very recent experiments with cold atoms, which allowed for sudden instantaneous change of the interparticle interaction potential (including its sign!). This topic was represented by talks of **Giamarchi**, **Altland**, and **Gurarie**.

One of the most memorable and inspiring talks was the presentation by **Adilet Imambekov**. He talked about his latest findings on exact correlations, which are possible to establish between excited states of 1D integrable models. Nobody before him dared to tackle the problem. Unfortunately, Adilet's life was cut short at the age of 30, only two months after the workshop. The talk in Minneapolis was one of his last presentations. We shall remember him as a terrific scientist and a wonderful person.

By all accounts, the workshop was a smashing success. It achieved its main goal of facilitating conversations between theorists and experimentalists and a cross-dialog between researchers in various subfields. It conveyed the breadth and excitement of this very young field of physics, which has grown on the intersection of atomic and condensed matter physics. Ideas, contact, and collaborations initiated during the workshop will certainly propel the field in the years to come.