SCIENTIFIC/TECHNICAL REPORT

The goal of the research during this grant period was to measure the thermoelectric power of a dilute high-mobility (i. e., low-disorder) strongly interacting two-dimensional electron system in silicon a MOSFET (Metal Oxide Semiconductor Field Effect Transistor). These are samples in which unexpected metaillic-like behavior and an apparent metal-insulator at a finite critical electron density n_c had been reported, based largely on transport measurements (resistivity, Hall resistance, magnetoresistance). Whether the behavior observed in these materials is indeed evidence for a true quantum phase transition, or whether it is crossover behavior, has been the subject of a great deal of debate and many publications during the past 20 years or so.

The thermoelectric power is a different property that had not been probed in the region of interest near the transition. This turned out to be an exceptionally difficult experiment that required the reliable measurement of tiny voltages in the 0.1 microvolt range. The work entailed finding the right conditions (for example, immersion of the samples in He-3 liquid, or in thermal contact with the He-3 through exchange gas, or immersion in the liquid or out of the liquid in a He-3/He-4 dilution refrigerator fridge). Noise suppression was a major challenge that required painstaking rf filtering and sophisticated electronic techniques. The proper amplifier had to be identified. The time required to obtain a single data point increased as the temperature was decreased, reaching hours at the lowest temperatures. And other issues as well. Measurements were attempted in several different laboratories using different instrumentation and methods.

The goal was ultimately achieved. The results are definitive, and are published in the last paper listed below. In brief, we found that the thermopower *diverges* at a finite electron density n_t that is the same or very close to the density n_c deduced from the transport measurements. Such a divergence is generally the hallmark of a genuine quantum phase transition. Moreover, detailed examination of the results allowed us to conclude that the transition was driven by the interaction between the electrons rather than by disorder – a circumstance that is of greatest interest in the field. Thus, metallic behavior obtains at densities above the critical density, while insulating behavior is found below. The nature of the insulating phase is not currently known, and is the subject of on-going investigations.

PUBLICATIONS:

"Scaling of the Thermoelectric Voltage induced by Microwave Radiation at the Boundary between 2D Electron Systems," Ivan A. Larkin, N. Romero Kalmanovitz, I. Hoxha, Y. Jin, S. A. Vitkalov, M. P. Sarachik, and T. M. Klapwijk, AIP Conf. Proc. **119**, 215 (2010)

"Metal-Insulator Transition in 2D: Established facts and open questions," S. V. Kravchenko and M. P. Sarachik, in *50 Years of Anderson Localization,* edited by Elihu Abrahams (World Scientific, 2010); International Jour. of Mod. Phys. B, **24**, 1640-1663 (2010).

"Critical Behavior of a Strongly-interacting 2D Electron System," A. Mokashi, Shiqi Li, Bo Wen, S. V. Kravchenko, A. A, Shashkin, V. T. Dolgopolov, and M. P. Sarachik, Phys. Rev Lett. **109**, 096405 (2012).