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NMR probing of quantum electron solids in high magnetic fields[1]

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In the presence of a high magnetic field, a two dimensional electron system (2DES) is expected to manifest Wigner crystal phases. Over thirty years ago, the search for the Wigner solid led to the discovery of the fractional quantum Hall effect (FQHE). Since then, with the advent of GaAs quantum wells with increasingly high mobility, 2DESs in the quantum Hall regime have proved to be a hunting ground for exceedingly rich many-body physics. Incompressible liquid FQHE states were found to occur in the first Landau level at several fractional filling factors v with odd-denominator. The sequence of FQHE states is truncated by the formation of a Wigner crystal of electrons at very low filling factors, the transition being affected by disorder. In the second Landau level, composite fermions, the quasiparticles of the FQHE, can pair to yield a remarkable even-denominator FQHE state, whose properties are at the forefront of investigation. More recently, electron solid phases have been shown to emerge around integer quantum Hall states. In this talk, I will discuss a new tool, resistively detected NMR, which serves as a direct local probe of in-plane charge density modulations in the 2DES. In our recent work [1] we probe the local charge density landscape of Wigner solids in the vicinity of $v=2$ and $v<1/3$ revealing quantum correlations. This unprecedented access to the microscopic behavior of these exotic solid phases opens up new venues in FQH studies. Furthermore, our NMR technique can probe in-plane charge density fluctuations due to disorder, allowing increased access to understanding roles of disorder in quantum Hall systems. In addition, our latest NMR measurements reveal evidence for charge inhomogeneity in the third Landau level which leads to the possibility of studying bubble and stripe phases in this regime. Future directions may find our NMR technique applied to other exotic phases such as quasiparticle solid phases, which have been proposed to emerge near the $v=1/3$ and 5/2 FQHE states.

[1]L. Tiemann(*), T.D. Rhone(*), N. Shibata, K. Muraki, Nature Physics 10, 648 (2014). [*- equal contribution]