Strong magnetic fields have dramatic effects on electron motion. In metals, the result is a set of quantized electron orbits, or Landau levels. Above a critical field, only the lowest Landau level is occupied. The resulting quantum limit is highly degenerate and susceptible to instabilities yielding a rich variety of electronic phases including spin- and charge-density waves, fractional quantum Hall states, and excitonic insulators. Unfortunately, access to the quantum limit in the presence of strong electron correlations is typically impeded by the tendency of d/f-electrons to polarize in a strong magnetic field, weakening the interactions.

Here, users from Los Alamos National Lab together with PARADIM propose that the strongly correlated quantum limit can be approached in reverse, starting from an insulating state at zero magnetic field. The identified candidate material, ytterbium boride (YbB$_{12}$), was grown in single crystal form at PARADIM and studied in high magnetic fields at the NHMFL@LANL. The results not only provide access to a novel quantum phase of matter, but also provide a model that naturally explains how quantum oscillations arise in insulators.

**Figure:**

- **a)** Magnetoresistance showing quantum oscillations in the insulating state and metallic state, respectively. Inset shows derivative.
- **b)** Insulating state quantum oscillations have a field-independent frequency of 740 ± 60 T and metallic state quantum oscillations have a field-dependent frequency ($H \parallel [100]$). Lines are guides for the eye. All measurements at ≈ 650 mK.
- **c)** Schematic of the formation of Landau levels and approaching the normal and reverse quantum limit.
- **d)** Categorization of possible high magnetic field behaviors as a function of gap and normalized g-factor.

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