Observing the unconventional scaling dimension of fractional quantum Hall anyons

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Résumé

Unconventional quasiparticles emerge in the fractional quantum Hall regime, the challenge being to observe their exotic properties unambiguously. Although the fractional charge of quasiparticles has been demonstrated for more than three decades (1,2), the first convincing evidence of their anyonic quantum statistics has only recently been obtained (3,4,5) and, so far, the predicted scaling dimension that determines quasiparticles' dynamics has not been observed (6). In particular, while the non-linearity of the tunneling quasiparticle current should reveal their scaling dimension, the measurements do not match the theory, possibly due to real device complications.
Here we experimentally obtain the scaling dimension from the thermal to shot noise crossover, and observe remarkable agreement with predictions for quasiparticles emerging at fractional filling factor = 1/3, 2/5 and 2/3. Measurements are fitted to predictions involving both the quasiparticles' scaling dimension and charge (7), in contrast to previous works using a free fermion phenomenological expression.

This establishes a central property of fractional quantum Hall anyons and demonstrates a powerful and complementary window on exotic quasiparticles.

(1) R de-Picciotto *et al.* "Direct observation of a fractional charge", *Physica B: Condensed Matter* **249-251** (1998)

(2) L. Saminadayar *et al.* "Observation of the e/3 Fractionally Charged Laughlin Quasiparticle", *Phys. Rev. Lett.* **79** (1997)

(3) H. Bartolomei *et al.* "Fractional statistics in anyon collisions", *Science* **368.6487** (2020)

(4) J. Nakamura *et al.* "Direct observation of anyonic braiding statistics", *Nature Physics* **16.9** (2020)

(5) Lee, JY.M., Hong, C., Alkalay, T. et al. "Partitioning of diluted anyons reveals their braiding statistics". Nature ***617*** (2023)

*Intervenant

(6) A. Chang. "Chiral luttinger liquids at the fractional quantum hall edge", *Reviews of Modern Physics – Rev. Mod. Phys.,* **75** *(*2003)
(7) K. Snizhko and V. Cheianov, "Scaling dimension of quantum Hall quasiparticles from tunneling-current noise measurements", *Phys. Rev. B* **91** (2015)