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Anyonic statistics hidden due to “which path” detection by upstream neutral modes in quantum Hall interferometers

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Fractional quantum Hall states are predicted to host exotic anyonic excitations, which offer the exciting prospect of topologically-protected quantum computation. Mach-Zehnder interferometry has been suggested as a probe for the anyonic statistics. However, all experimental attempts to measure such an interference signal have failed to date, despite the high visibility of interference fringes in the integer quantum Hall case. In our work we have studied the relation between this null result and another recent surprising experimental finding, namely the detection of upstream neutral modes in virtually all fractional quantum Hall states (including, e.g., filling 1/3), not only in hole-like filling factors (such as 2/3). We have shown that the excitation of upstream modes acts as a “which path”detector, which degrades the interference visibility in the Mach-Zehnder geometry exponentially with the total length of the interferometer arms, even when the lengths are exactly equal. We have also found how this which-path detection can lead to doubling of the Aharonov-Bohm periodicity in a Fabry-Perot geometry. This latter phenomenon can be used to experimentally quantify the effects of the neutral modes, and thus design better Mach-Zehnder setups which could overcome the neutral-induced suppression.

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