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Shapiro steps in strongly-interacting Fermi gases

Josephson junctions represent a powerful tool to probe macroscopic phase coherence in different systems. They are also fundamental for atomtronics circuits, thanks to their well defined current-chemical potential and current-phase. In our experimental system, we create atomic Josephson junctions using Fermi superfluids of lithium-6, realized by coupling two quasi-two-dimensional atomic clouds with a tunneling barrier. By moving the tunneling barrier across the junction while modulating the position at a given frequency, we are able to inject an alternate current. Then, measuring the chemical potential imbalance developed across the junction after a few modulation periods, we can study the dynamics resulting in the system. Our experimental results show that the AC driving of the barrier introduces a step-like behavior in the current-chemical potential curve, with a number of plateaus at a chemical potential value that is an integer multiple of the driving frequency [1]. This behavior is the analog of Shapiro steps observed in superconducting Josephson junctions illuminated by an external electromagnetic field [2]. We studied the AC response for a molecular BEC and a unitary Fermi gas junction, finding that in both cases the plateaus in the current-chemical potential characteristic coincides with the emission of a well-defined number of vortices, suggesting that the stabilization of the current in the plateaus is operated by phase slippage processes.
[1] V. Singh et al., Phys. Rev. Lett. (2024).
[2] S. Shapiro, Phys. Rev. Lett. 11(2) p. 80 (1963).

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