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Maria Goeppert Mayer Prize Talk: Superfluid Atom Circuits

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We have performed a series of experiments with ring-shaped Bose-Einstein Condensates, with and without the addition of a weak link barrier. Weak connections between superconductors or superfluids can differ from classical links due to quantum coherence, which allows for flow without resistance. The properties of a weak link are characterized by a single function, the current-phase relationship. In recent experiments, we have developed a technique to directly measure the current-phase relationship of the weak link. The weak link is created using a laser beam that acts as a barrier across one side of the ring condensate. By rotating the barrier, we can control the current around the ring. When the weak link is rotated at at low rotation rates, we observe phase slips between well-defined,quantized current states, and have demonstrated that the system exhibits hysteresis. At higher rotation rates we have directly measured the onset of resistive flow across the weak link. Such measurements may open newavenues of research in quantum transport. More recently, we have studied the behavior of the ring BEC when the radius is expanded at supersonic rates. Because information can propagate only at the speed of sound, the supersonic expansion creates causally disconnected regions, whose phases evolve at different rates. Such experiments may allow us to study cosmic inflation at laboratory scales.