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Superfluid behavior of a 2D Bose gas

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Two dimensional Bose gases cannot undergo a conventional phase transition associated with the breaking of a continuous symmetry. Nevertheless they may exhibit a phase transition to a state with quasi-long range order via the Berezinskii–Kosterlitz–Thouless (BKT) mechanism. Even if they cannot undergo Bose-Einstein condensation at non-zero temperature they become superfluid above a critical phase space density. The quasi-long-range coherence and the microscopic nature of the BKT transition have been recently explored with ultracold atomic gases. Here we report the direct observation of superfluidity in terms of frictionless flow. We probe the superfluidity of a 2D trapped Bose gas by stirring a moving obstacle formed by a repulsive potential created by micrometre-sized laser beam. We move this obstacle on circles of different radii at constant velocity. Depending on the degree of degeneracy of the gas at the obstacle location we find a dramatic variation of the response of the fluid. We demonstrate a superfluid behavior where the local phase space density is high enough and a normal one otherwise. Using the local density approximation we compare our findings with the expected results for a uniform gas. Finally we present the heating rates measured for normal or superfluid behavior.