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Fermi-to-Bose crossover in a trapped quasi-2D gas of fermionic atoms

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Neither long-range order nor Bose condensation may appear in uniform 2D systems at finite temperature. Despite that, 2D superconductors, such as cuprates, are among the systems with highest critical temperatures. 2D quantum systems remain intriguing, and their understanding is incomplete despite huge progress seen in the recent decades. Ultracold atoms are a platform for studying 2D physics. Using tunability of atomic gases, we have realized a crossover between a 2D gas of Fermi atoms and a 2D gas of weakly-bound diatomic Bose molecules by varying s-wave interactions in the gas. Between these two asymptotic states, there is a regime of strong interactions, whose quantitative description is challenging, e. g., a mean field of Cooper pairs fails to describe the crossover even qualitatively, unlike in 3D gases. At the lowest achievable temperatures, $\sim 10\%$ of the Fermi energy, the pressure is measured in the whole Fermi-to-Bose crossover and compared with the available theoretical models, including those which appeared over the last year. In the Fermi regime of weak interactions, the pressure is systematically above a Fermi-liquid-theory prediction, which maybe due to mesoscopic effects. Alternatively, this upshift is partially reproduced within a recent mean-field theory supplemented with fluctuations. On the Bose side of the crossover, the molecules easily condense, which is found in interferometric measurements. On one hand, such condensation is expected because the gas is held in a nearly harmonic trap, which favors condensation unlike the uniforms space. On the other hand, each molecule is locally in a flat potential, which is the sum of the trap and the strong repulsive mean field, and this should inhibit the condensation.