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Entanglement area law in superfluid ^{4}He[1] C. M. HERDMAN, P.-N. ROY, University of Waterloo, ROGER MELKO, University of Waterloo and Perimeter Institute for Theoretical Physics, ADRIAN DEL MAESTRO, University of Vermont — Area laws were first discovered by Bekenstein and Hawking, who found that the entropy of a black hole grows proportional to its surface area, and not its volume. Entropy area laws have since become a fundamental part of modern physics, from the holographic principle in quantum gravity to ground state wavefunctions of quantum matter, where entanglement entropy is generically found to obey area law scaling. As no experiments are currently capable of directly probing the entanglement area law in naturally occurring many-body systems, evidence of its existence is based on studies of simplified theories. Using new exact microscopic numerical simulations of superfluid ^{4}He, we demonstrate for the first time an area law scaling of entanglement entropy in a real quantum liquid in three dimensions. We validate the fundamental principles underlying its physical origin, and present an "entanglement equation of state" showing how it depends on the density of the superfluid.

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