What's the Matter with Black Holes? Echoes from the Abyss in the LIGO Era

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ABSTRACT: Conventional equations of state suggest that in complete gravitational collapse a singular state of matter with infinite density could be reached finally, to what is popularly called a "black hole," the characteristic feature of which is its apparent horizon, where light rays are first trapped. The loss of information to the outside world this implies gives rise to serious difficulties with well-established principles of quantum mechanics and statistical physics.

The formation of a gravitational vacuum condensate star with a $p = -\rho$ interior solves these problems and remarkably, actually follows from Schwarzschild's second paper over a century ago. The advent of Gravitational Wave (GW) Astronomy will soon allow for the observational test of this hypothesis, in the discrete surface modes of oscillation and GW "echoes," which should be detectable by advanced LIGO and related experiments. The imaging of Sgr A* by the Event Horizon Telescope will furnish additional tests of the gravastar hypothesis. The same Standard Model effects responsible for the formation of a gravastar surface lead also to the prediction of addition Scalar GWs from Neutron Star mergers.