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Einstein Prize (2021): Testing the No-Hair Theorem and the Area Theorem with LIGO: Application of Kerr Perturbation Theory

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One of the key results of general relativity is that an astrophysical black hole in equilibrium is uniquely described by just two parameters, its mass and spin. This is called the No-Hair Theorem, a result that is not true in alternative theories of gravity. For many years, people have speculated about testing the theorem using gravitational waves from merging black holes. The merger forms a single black hole, which rings down emitting gravitational waves as quasi-normal modes, just like a struck bell. The theorem predicts that the measured mode frequencies and damping times should depend only on the mass and spin of the remnant black hole. For a long time, the consensus has been that this test will require the sensitivity of next-generation detectors. I will show that this consensus is wrong for a surprising reason, and report a test with data from GW150914, the first LIGO gravitational wave detection. An extension of the test confirms Hawking's Area Theorem at the 97% limit.