

Nonlinear Quasinormal Modes in the Ringdown of GW250114: Observational Evidence for Nonlinear Gravitational Waves

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The ringdown signal following a binary black hole merger offers a crucial avenue for investigating black hole properties and testing General Relativity in strong-field regimes. Beyond linear quasinormal modes, General Relativity predicts the existence of second-order quasinormal modes arising from the nonlinear coupling of gravitational waves. This talk presents an analysis of the ringdown signal from the gravitational-wave event GW250114, demonstrating observational evidence for second-order quasinormal modes. Through a systematic calculation of coupling coefficients for the first ten second-order modes, and the application of a novel data analysis method, we find a Bayes factor of 62 supporting the presence of these nonlinear modes at a selected ringdown starting time. A zero-amplitude hypothesis is excluded with a significance of 3.4 sigma, and the inferred amplitudes and complex frequencies are consistent with General Relativity predictions. We will discuss the analysis methodology, key results, and their physical implications, illustrating how black hole spectroscopy can be extended into the nonlinear regime and providing a new observational window for testing the nonlinear structure of General Relativity.

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