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Simulations of black hole binaries

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Binary black hole mergers are among the most energetic events in the universe, converting several per cent of the rest mass to energy emitted as gravitational waves. Ground-based gravitational wave detectors are already searching for stellar mass black hole binaries. In the future, space-based detectors will measure gravitational waves from supermassive black holes. Numerical simulations of the late inspiral and merger of black hole binaries are essential to exploit the full potential of these detectors. The first black hole simulations have been performed more than 30 years ago, however, accurate and stable evolutions have become possible only in the last two years. Difficulties arise because of unique properties of Einstein's equations, like the inherent coordinate freedom and the presence of singularities inside the black holes. Furthermore, high accuracy requirements over long evolution times paired with multiple length scales pose a formidable numerical challenge. In this talk, I explain the analytical and numerical breakthroughs which have led to long-lasting stable binary black hole evolutions and highlight some of the impressive results obtained. I also present recent results of the spectral evolution code of the Caltech-Cornell collaboration and might venture to discuss some of the open questions.