The Final Merger of Massive Black Holes: Recoils, Gravitational Waves, and Electromagnetic Signatures

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The final merger of two massive black holes produces a powerful burst of gravitational radiation, emitting more energy than all the stars in the observable universe combined. The resulting gravitational waveforms will be easily detectable by the space-based LISA out to redshifts $z > 10$, revealing the masses and spins of the black holes to high precision. If the merging black holes have unequal masses, or asymmetric spins, the final black hole that forms can recoil with a velocity exceeding 1000 km/s. And, when the black holes merge in the presence of gas and magnetic fields, various types of electromagnetic signals may also be produced.

For more than 30 years, scientists have tried to compute
black hole mergers using the methods of numerical relativity. The resulting computer codes have been plagued by instabilities, causing them to crash well before the black holes in the binary could complete even a single orbit. Within the past few years, however, this situation has changed dramatically, with a series of remarkable breakthroughs. This talk will focus on new results that are revealing the dynamics and waveforms of binary black hole mergers, recoil velocities, and the possibility of accompanying electromagnetic outbursts.