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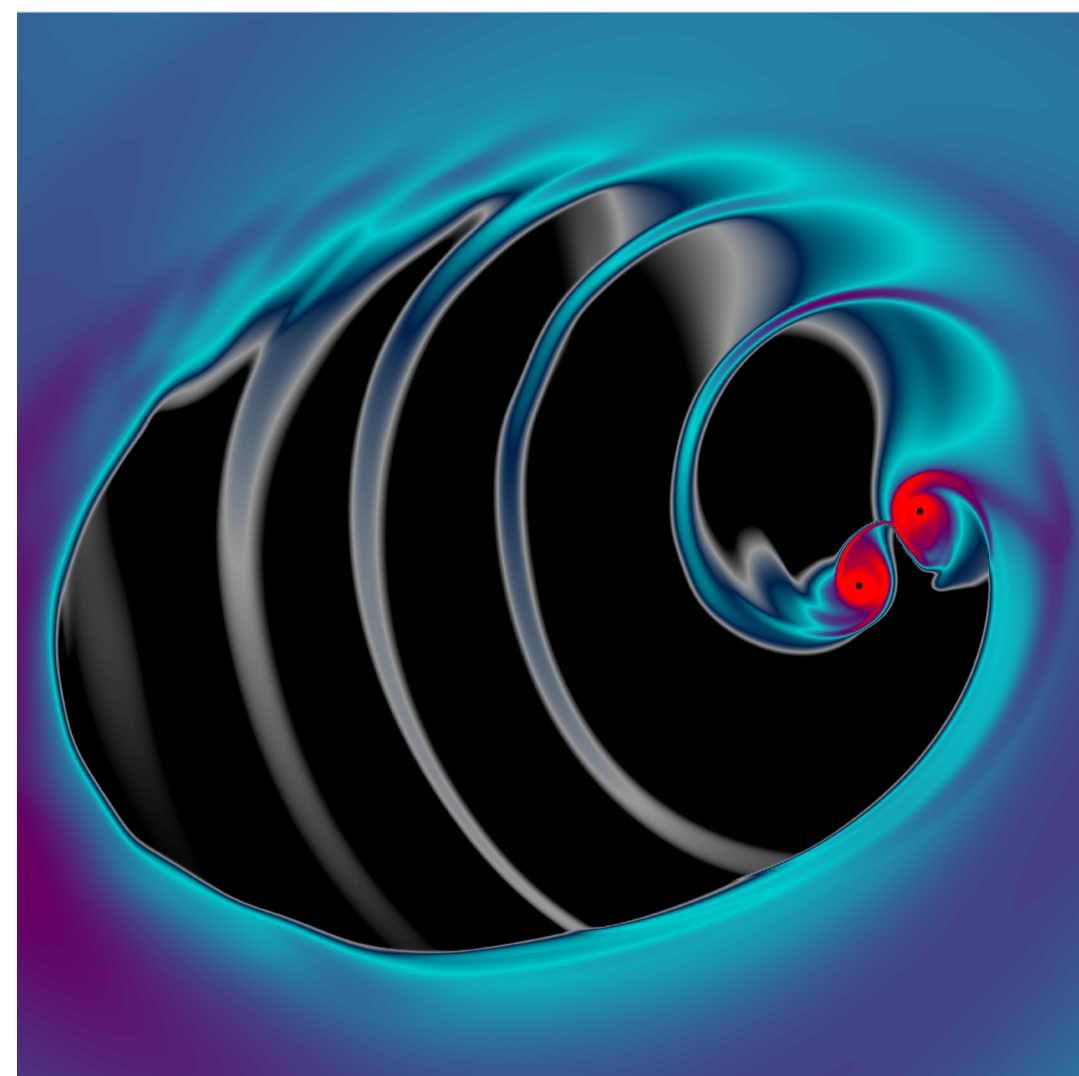
The Formation and Growth of Massive Black Holes

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Black holes as massive as several billion solar masses appeared within a billion years after the Big Bang. The origin of these objects remains a mystery. I will present three competing ideas on how such massive black holes may have formed in the early universe, (i) via the catastrophic collapse of gas in the centers of protogalaxies, (ii) via rapid gas accumulation onto the black hole remnants of the first stars, or (iii) via many successive mergers between black holes.

I will then discuss the role of ambient gas in facilitating mergers between black holes, producing unique observational signatures and impacting their gravitational wave emission. Upcoming observations with the recently launched James Webb Space Telescope (JWST) and with the space-based Laser Interferometer Space Antenna (LISA) will help us understand the origin of massive black holes, including the details of their mergers.



Hydrodynamical simulation of a binary black hole with a circumbinary gas disk. The distorted nonaxisymmetric disk helps catalyze the merger of the black holes.