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(I) Black hole mergers and internal geometry

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How event horizons evolve and ultimately combine during a black hole merger has been understood for five decades. The theory appears in Hawking and Ellis (1972) and modern numerical simulations have confirmed those early insights. That text also included some speculation about how apparent horizons merge but left the end stages unresolved: it was known that, once they get close enough, a common horizon forms outside the two initial black holes and that those horizons persist for some time inside. However, their ultimate fate was not predicted by theory and also not resolved by numerical simulations, which always lost track of the initial horizons during the final approach.

In just the last few years, things have changed as new techniques have been introduced to locate and track marginally outer trapped surfaces (MOTS), a generalization of apparent horizons. These have revealed an intricate picture in which, as the merger progresses, a froth of MOTSs pair create, evolve and annihilate deep inside the known horizons. Most of these MOTSs are self-intersecting and, though the picture is complex, strict rules are imposed on possible behaviours by a MOTS stability operator. In particular, it is now known that the initial horizons are annihilated in encounters with members of this previously unsuspected family of objects.

As attention has focused on these exotic MOTS, it has become clear that they are present not only during mergers but also lurk inside most stationary solutions (including an infinite number in Schwarzschild). In this talk I will review recent studies of exotic MOTS and consider what they tell us about mergers as well as the geometry of spacetime inside all black holes.

Primary author: BOOTH, Ivan

Presenter: BOOTH, Ivan

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