The interior of a binary black-hole merger

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Marginally outer trapped surfaces (MOTSs) are routinely used in numerical simulations of black-hole spacetimes. They are an invaluable tool for locating and characterizing black holes quasilocally in real time while the simulation is ongoing. However, there has been a gap in our understanding of the full binary black-hole merger in terms of MOTSs as these seem to appear and disappear unpredictably.

In this talk I will first show that MOTSs are, in fact, well behaved and that their behavior is predictable and related to the *stability operator* [1, 2]. Using numerical simulations of binary black-hole head-on collisions, we have found strong numerical evidence for the existence of a connected sequence of MOTSs taking us from the two disjoint initial black-hole horizons to the final common horizon in such a merger [3]. A key component is a new phenomenon: the merger of MOTSs in the interior of the newly formed common horizon. The fate of its inner branch, which has previously only been speculated about [4, 5], is revealed using a new numerical method [1] capable of finding even highly distorted non-star-shaped MOTSs.

Finally, I will discuss how a connected history of MOTSs provides a new possibility to tackle an important problem of mathematical relativity, namely the Penrose inequality, in the case of generic astrophysical binary black-hole configurations.

References

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