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Constraining Self-Interacting Dark Matter through Equal Mass Galaxy Cluster Mergers

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While the LCDM model has been wildly successful at explaining structure on large scales, it fails to do so on small scales—dark matter halos of scales comparable to that of galaxy clusters and smaller are more cored and less numerous than LCDM predicts. One potential solution challenges the canonical assumption that dark matter is collisionless and instead assumes that it is self-interacting. The most stringent upper limits on the dark matter self-interaction cross section have come from observations of merging galaxy clusters. Self-interactions cause the merging dark matter halos to evolve differently from the galaxies, which are effectively collisionless. It has been hypothesized that this leads to a spatial offset between the peaks in the dark matter and galaxy distributions. We show that in equal mass mergers, offsets matching those observed do not develop except under a narrow range of merger conditions that promote extreme dark mass loss during collision. Furthermore, offset formation cannot be described by a drag force nor by tail formation alone, as has previously been claimed. Self-interactions have a significant influence on other aspects of merger evolution, which can be exploited to derive stronger constraints on the self-interaction cross section. In particular, we expect a large fraction of BCGs to be miscentered by order 100s of kpc with cross sections greater than 1 cmˆ2/g; the lack of such large miscenterings implies a cross section no larger than 0.1 cmˆ2/g.

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