Three-dimensional magnetohydrodynamical simulations of the morphology of head-tail radio galaxies based on magnetic tower jet model

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The distinctive morphology of head-tail radio galaxies reveals strong interactions between the radio jets and their intra-cluster environment, the general consensus on the morphology origin of head-tail sources is that radio jets are bent by violent intra-cluster weather. We demonstrate in this paper that such strong interactions provide a great opportunity to study the jet properties and also the dynamics of intra-cluster medium (ICM). By three-dimensional magnetohydrodynamical simulations, we analyze the detailed bending process of a magnetically dominated jet, based on the magnetic tower jet model. We use stratified atmospheres modulated by wind/shock to mimic the violent intra-cluster weather. Core sloshing is found to be inevitable during the wind-cluster core interaction, which induces significant shear motion and could finally drive ICM turbulence around the jet, making it difficult for jet to survive. We perform detailed comparison between the behaviour of pure hydrodynamical jets and magnetic tower jet, and find that the jet-lobe morphology could not survive against the violent disruption in all of our pure hydrodynamical jet models. On the other hand, the head-tail morphology is well reproduced by using a magnetic tower jet model bent by wind, in which hydrodynamical instabilities are naturally suppressed and the jet could always keep its integrity under the protection of its internal magnetic fields. Finally, we also check the possibility for jet bending by shock only. We find that shock could not bend jet significantly, so could not be expected to explain the observed long tails in head-tail radio galaxies.