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Modeling AGN Feedback in Cool-Core Galaxy Clusters

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We study the influence of momentum-driven AGN feedback on cool-core clusters using high-resolution adaptive mesh refinement (AMR) simulations. Run-away cooling first happens only in the central 50 pc region while no local instability develops outside the very center of the cluster. The gas is accreted onto the supermassive black hole which powers AGN jets at an increasing rate as the entropy continues to decrease in the core. The ICM first cools into clumps along the propagation direction of the AGN jets. As the jet power increases, gas condensation occurs isotropically, forming spatially extended (up to a few tens kpc) structures that resemble the observed Hα filaments in Perseus and many other cool-core cluster. Jet heating elevates the gas entropy and cooling time, halting clump formation. The cold gas that is not accreted onto the SMBH settles into a rotating disk. The mass cooling rate averaged over 7 Gyr is ~ 30 M_sun/yr, an order of magnitude lower than the classic cooling flow value (which we obtain in runs without the AGN). Owing to its self-regulating mechanism, AGN feedback can successfully balance cooling with a wide range of model parameters. Besides suppressing cooling, our model produces cold structures in early stages (up to ~ 2 Gyr) that are in good agreement with the observations. However, the long-lived massive cold disk is unrealistic, suggesting that additional physical processes are still needed.

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