Resolving cold filaments in the multiphase intracluster medium with GPU–accelerated simulations

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Radio and optical surveys show that magnetically supported filaments of cold ($T \leq 10^4$ K) and dense ($n \geq 10$ cm^{-3}) gas are present in the inner regions of nearly all cool-core galaxy clusters. Because they are likely to fuel the central supermassive black hole and to interact with its outflowing jets, these structures are thought to play a crucial role in the thermal regulation of the intracluster medium (ICM). Due to a lack of computational resources, most simulations of cool-core clusters performed so far have been limited by coarse spatial resolutions, preventing them from resolving the inner structure of the filaments, whose thicknesses range down to ~ 75 pc. Consequently, key features of jet-filament interactions are missing, and implications for the ICM dynamics remain largely unconstrained.

In this talk, I will introduce a set of GPU-accelerated 3D magnetohydrodynamical simulations of an idealized Perseus cluster with self-regulated active galactic nuclei feedback, resolving the multiphase ICM with unprecedented maximum resolution of 24 pc, using performance portable code AthenaPK. I will first present an extensive morphological study of the filaments and will compare our results with available observations using mock X-ray and optical images. I will then discuss the dynamics of the cold gas, and will show how the morphology of the tens of kpc sized buoyant bubbles produced by the AGN is critically impacted by small-scale interactions with the filaments.
