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From Black Holes into the Voids: What TeV Astrophysics Tells Us about Axion-like Particles

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TeV blazars, ubiquitous in the extragalactic gamma-ray sky, produce pair beams that inverse-Compton cascade into GeV gamma rays. However, the non-observation of such cascades indicates that non-thermal energy loss processes such as interactions with heavy axion-like particles (ALPs) can play a role in alleviating this GeV-TeV tension, in addition to space plasma instabilities that drain energy into the intergalactic medium plasma as well as the deflection and diffusion of the pair beam due to the intergalactic magnetic field. A direct consequence of the instability losses and heating of the IGM plasma is the modification of the thermal history at late times, which suppresses structure formation particularly in baryonically underdense regions, potentially holding a clue towards resolving the small-scale crisis in cosmology. Depending on the resonant modes and degree of heating, constraints on lighter ALPs are further tightened.

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