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The Lyman-alpha forest in a blazar-heated Universe

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It has been realised only recently that TeV emission from blazars can significantly heat the intergalactic medium (IGM) by pair-producing high-energy electrons and positrons, which in turn excite vigorous plasma instabilities, leading to a local dissipation of the pairs' kinetic energy. In this work, we use cosmological hydrodynamical simulations to model the impact of this blazar heating on the Lyman-alpha forest at redshifts z~2-3. We find that blazar heating produces an inverted temperature-density relation in the IGM and naturally resolves many of the problems present in previous simulations of the forest that included photoheating alone. In particular, our simulations with blazar heating simultaneously reproduce the observed effective optical depth and temperature as a function of redshift, the observed probability distribution functions of the transmitted flux, and the observed flux power spectra, over the full redshift range 2<z<3 analysed here. Additionally, by deblending the Lyman-alpha forest into a sum of thermally broadened individual lines, we find superb agreement with the observed lower cutoff of the line-width distribution and abundances of neutral hydrogen column densities. Using the most recent constraints on the cosmic ultraviolet (UV) background, this excellent agreement with observations does not require rescaling the amplitude of the UV background; a procedure that was routinely used in the past to match the observed level of transmitted flux. We also show that our blazar-heated model matches the data better than standard simulations even when such a rescaling is allowed. This concordance between Lyman-alpha data and simulations, which are based on the most recent cosmological parameters, suggests that the inclusion of blazar heating alleviates previous tensions on constraints for sigma_8 derived from Lyman-alpha measurements and other cosmological data. [abridged]

Comments: 18 pages, 13 figures, added an analysis in which all simulations are scaled to the observed effective optical depth, added some discussion about the local Lyman-alpha forest, accepted for publication in MNRAS

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