Estimation of the temperature-density relation in the intergalactic medium at z_˜2-4 via Lyα forest

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Abstract

Quasar spectra provide a unique opportunity to investigate the intergalactic medium (IGM) at high redshifts. The spectral analysis of the Lyman-α (Lyα) forest allows us to constrain the equation of state of the IGM and its changes during the evolution of the Universe. We present new measurements of the power law temperature-density relation based on the Voigt profile fitting of Lyα forest lines.

We select and fit the solitary Lyα forest lines from a large sample of the quasars spectra from KECK with the automatic procedure [1]. The final sample of Lyα lines is cleaned from the metal lines by visual inspection. The obtained distribution of the lines parameters – column density N and Doppler parameter b – has a prominent lower envelope, which is attributed to a pure thermal broadening of the line [2]. Various methods were proposed to estimate the position of this envelope and consequentially infer the parameters of the IGM equation of state (e.g. [2-5]). In the present work we fit the (N, b) sample by a model distribution function using the Markov chain Monte Carlo method instead of focusing only on the low boundary position. Such approach allows us to take into account the presence of outliers – systems whose parameter b is substantially less than the thermal one and cannot be described in the framework of the adopted model. To handle those, we use a robust method based on simultaneous modeling of the distribution in question and the outliers distribution within the Bayesian framework. As a result, we obtain the power-law index of temperature-density relation in IGM for several redshift bins in the range z = 1.6 – 3.7. We find that the IGM state is close to isothermal at z≈3, which may indicate that HeII reionization occurred at this redshift.

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