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On the size of H II regions around high-redshift quasars

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Abstract. We investigate the possibility of constraining the ionization state of the Intergalactic Medium (IGM) close to the end of re-ionization ($z \approx 6$) by measuring the size of the H II regions in high-z quasars spectra, via a combination of SPH and 3D radiative transfer (RT) simulations and a statistical analysis of mock quasar spectra through the simulated cosmological volume.

Keywords. cosmology: theory, radiative transfer, methods: numerical, intergalactic medium, cosmology: large scale structure of Universe

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The size of H II regions around high-z luminous quasars prior to complete re-ionization is strongly dependent on the mean neutral hydrogen fraction of the IGM, $x_{\rm HI}$. Previous studies (e.g., Wyite & Loeb 2004) have tried to constraints $x_{\rm HI}$ using the size of high-z QSOs H II regions, measurable in their own spectra as the extent of the transmitting region between the quasar emission redshift and the onset of the Gunn-Peterson trough.

The aim of our work is to assess the robustness of the above method. We have performed a combination of state-of-art multiphase SPH and 3D radiative transfer (RT) simulations to accurately predict the properties of a typical high-z quasars H II region (eg. extent, geometrical shape, inner opacity), assuming an initial $x_{\rm HI} = 0.1$.

The simulation results show that RT effects do not induce strong deviations from spherical symmetry; we find a mean dispersion in the H II region size along different LOS of the order of roughly 6 % of the mean radius.

By deriving and analyzing mock spectra through the simulated quasar environment we have found that the H II region size deduced from quasar spectra typically underestimates the physical one by 30 %. This effect, to which we refer as *apparent shrinking*, results to be almost completely due to resonant absorption of residual H I inside the ionized bubble.

Additional maximum likelihood analysis shows that this offset induces an overestimate of the neutral hydrogen fraction, $x_{\rm HI}$, by a factor ~ 3. By applying the same statistical method to a sample of six observed QSOs spectra analyzed by Fan *et al.* (2006), our study favors a mostly ionized ($x_{\rm HI} < 0.06$) Universe at $z = 6.1$.

All together the results of our work suggest that measurements of the H II size in quasar spectra can only provide rough constraints on $x_{\rm HI}$, as far as the knowledge of intrinsic properties of observed QSOs remains incomplete.

More details are given in Maselli *et al.* (2007) and references therein.

References

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