X61a Lyα halos around quasars at $z > 6$

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The circumgalactic medium (CGM) of quasars is a key ingredient to understanding the evolutionary process of supermassive black holes (SMBHs) and its connection to host galaxies ("coevolution": e.g. Kormendy & Ho 2013). Host galaxies form stars by acquiring gas from the intergalactic space through the CGM (e.g. Dekel et al. 2009a,b). During and subsequent to the star-formation activities, SMBHs grow in mass shining as quasars, and finally return a large amount of gas in the host galaxies to the CGM by negative feedbacks, thereby quenching the subsequent star formation (e.g. Scannapieco et al. 2005; Dave et al. 2011). Thus, the evolution of SMBHs and host galaxies through gas exchanges to/from the CGM is evident in the CGM. The spatial extent of quasars' CGM is often traced by hydrogen Lyα emission, which is called Lyα halos. Recently, we have detected a very luminous $z > 6$ Lyα halo with > 30 pkpc extent around the quasar J2329-0301 (Momose et al. 2018 submitted). By combining another three $z > 6$ quasars' Lyα halos (one small Lyα halo and two non-detections), we have found that J23290301 has the smallest dust mass $M_{\rm dust} < 10^7$ M$_\odot$ and the least massive black hole $M_{\rm BH} = 2.5 \times 10^8$ M$_\odot$ among the four quasars. It indicates that J2329-0301 is still in a growing phase of quasar activity. One possible explanation why this quasar has such a luminous Lyα halo invokes that a small dust content helps ionizing photons to escape from the host galaxy to the CGM.