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Constraining The Redshift Of Blazar 1ES 1553+113 And Implications For The WHIM

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Observations of the warm-hot ($T > 10^5$ K) phase of the intergalactic medium provide an important test of our understanding of galaxy evolution and help to verify our general cosmological paradigm. Simulations of structure growth predict that a substantial portion of baryons are shock heated to form the elusive warm-hot intergalactic medium (WHIM); however, with current facilities, very few blazars and AGN are bright enough to probe the WHIM in X-ray absorption. The luminous blazar 1ES 1553+113 provides a unique opportunity to study the WHIM in X-ray absorption over a large redshift pathlength due to investment of 1.8 megaseconds of *XMM* grating spectroscopy. Despite numerous attempts with large telescopes across the electromagnetic spectrum, observers have been unable to directly constrain the redshift of 1ES 1553+113, limiting the utility of the archival X-ray spectra. Here, we present the near-UV (NUV) spectrum of 1ES 1553+113 obtained by the Cosmic Origins Spectrograph (COS) on *HST* and perform a blind search for absorption lines to indirectly constrain its redshift. We find that the Lyα forest does not extend past $z = 0.413$. To infer a redshift constraint from this, we carry out a robust characterization of the highest-redshift intervening and associated HI Lyα lines ($\max(z_{Ly\alpha})$) in the high-quality COS FUV spectra of 132 AGN with accurate spectroscopic emission redshifts (z_{em}). We use the observed cumulative distribution of z_{em} - $\max(z_{Ly\alpha})$ to measure an updated 95% confidence interval for the redshift of 1ES 1553+113 based purely on the edge of the observed Lyα forest of $0.408 < z < 0.438$ ($0.419 < z < 0.459$) when using both intervening and associated (only intervening) lines. This redshift constraint rules out a WHIM origin for the stronger X-ray absorber detected toward 1ES 1553+113, perhaps suggesting that the WHIM is not sufficiently metal enriched to be detected in O VII or O VIII with current facilities. Finally, we consider applications to other blazars with unknown redshifts, which may be useful for future X-ray missions and studies of the extragalactic background light.