Title: First detections of the \([\text{NII}]\) 122 \(\mu\text{m}\) line at high redshift: Demonstrating the utility of the line for studying galaxies in the early universe

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Abstract: We report the first detections of the \([\text{NII}]\) 122 \(\mu\text{m}\) line from a high redshift galaxy. The line was strongly (> 6\(\sigma\)) detected from SMMJ02399-0136, and H1413+117 (the Cloverleaf QSO) using the Redshift(z) and Early Universe Spectrometer (ZEUS) on the CSO. The lines from both sources are quite bright with line-to-FIR continuum luminosity ratios that are \(\sim 7.0 \times 10^{-4}\) (Cloverleaf) and \(2.1 \times 10^{-3}\) (SMMJ02399). With ratios 2-10 times larger than the average value for nearby galaxies, neither source exhibits the line-to-continuum deficits seen in nearby sources. The line strengths also indicate large ionized gas fractions, \(\sim 8\) to 17\% of the molecular gas mass. The \([\text{OIII}]\)/[\text{NII}] line ratio is very sensitive to the effective temperature of ionizing stars and the ionization parameter for emission arising in the narrow-line region (NLR) of an AGN. Using our previous detection of the \([\text{OIII}]\) 88 \(\mu\text{m}\) line, the \([\text{OIII}]\)/[\text{NII}] line ratio for SMMJ02399-0136 indicates the dominant source of the line emission is either stellar HII regions ionized by O9.5 stars, or the NLR of the AGN with ionization parameter \(\log(U) = -3.3\) to -4.0. A composite system, where 30 to 50\% of the FIR lines arise in the NLR also matches the data. The Cloverleaf is best modeled by a superposition of \(\sim 200\) M82 like starbursts accounting for all of the FIR emission and 43\% of the \([\text{NII}]\) line. The remainder may come from the NLR. This work demonstrates the utility of the \([\text{NII}]\) and \([\text{OIII}]\) lines in constraining properties of the ionized medium.