Title: First detections of the [NII] 122 μm 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 [NII] 122 {\mu}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 ~7.0\times10^{-4} (Cloverleaf) and 2.1\times10^{-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, ~8 to 17% of the molecular gas mass. The [OIII]/[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 [OIII] 88 {\mu}m line, the [OIII]/[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 ~200 M82 like starbursts accounting for all of the FIR emission and 43% of the [NII] line. The remainder may come from the NLR. This work demonstrates the utility of the [NII] and [OIII] lines in constraining properties of the ionized medium.