

# First [N II]122 $\mu$ m Line Detection in a QSO-SMG Pair BRI 1202-0725 at $z = 4.69$

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We report the first detection obtained with the Atacama Large Millimeter/submillimeter Array of the [N ii] 122  $\mu$ m line emission from a galaxy group BRI 1202-0725 at  $z = 4.69$  consisting of a quasi-stellar object (QSO) and a submillimeter-bright galaxy (SMG). Combining this with a detection of [N ii] 205  $\mu$ m line in both galaxies, we constrain the electron densities of the ionized gas based on the line ratio of [N ii] 122/205. The derived electron densities are  $10^{2.5}$  and  $10^{2.8}$   $\text{cm}^{-3}$  for the SMG and the QSO, respectively. The electron density of the SMG is similar to that of the Galactic Plane and to the average of the local spirals. However, higher electron densities (by up to a factor of three) could be possible for systematic uncertainties of the line flux estimates. The electron density of the QSO is

comparable to high- $z$  star-forming galaxies at  $z = 1.5-2.3$ , obtained using rest-frame optical lines and with the lower limits suggested from stacking analysis on lensed starbursts at  $z = 1-3.6$  using the same tracer of [N ii]. Our results suggest a large scatter of electron densities in global scale at fixed star formation rates for extreme starbursts. The success of the [N ii] 122  $\mu\text{m}$  and 205  $\mu\text{m}$  detections at  $z = 4.69$  demonstrates the power of future systematic surveys of extreme starbursts at  $z > 4$  for probing the interstellar medium conditions and the effects on surrounding environments. © 2019.

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galaxies: evolution

galaxies: high-redshift

galaxies: ISM

galaxies: starburst

quasars: general

submillimeter: galaxies