Cold Gas in High-z Galaxies: The CO Gas Excitation Ladder and the need for the ngVLA

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next generation VLA Extragalactic Imaging

The next generation Very Large Array (ngVLA; Carilli et al. 2015) will revolutionize our understanding of the distant Universe via the detection of cold molecular gas in the first galaxies (Casey et al. 2015). Its impact on studies of galaxy characterization via detailed gas dynamics will provide crucial insight on dominant physical drivers for star formation in high redshift galaxies, including the exchange of gas from scales of the circumgalactic medium down to resolved clouds on mass scales of ~10^4 M⊙. Based on a direct comparison between the inferred results from our mock observations and the cosmological simulations, we investigate the capabilities of ngVLA to constrain the mode of star formation, dynamical mass, and molecular gas kinematics in individual high-redshift galaxies using cold gas tracers like CO(1-0) and CO(2-1) in comparison to commonly-observed high-J CO tracers like CO(4-3). The factor of 100 times improvement in mapping speed for the ngVLA beyond the Jansky VLA and the proposed ALMA Band 1 will make these detailed, high-resolution imaging and kinematic studies routine at z=2 and beyond.

What is the role of major mergers versus secular disk evolution to galaxies in the early Universe? This question applies not only to the most massive, dust-obscured starbursts (e.g. Narayanan et al., 2010; Davé et al., 2010; Hayward et al., 2012), but also to the general mass assembly of galaxies at z > 1 (e.g. Förster Schreiber et al., 2009; Dekel et al., 2009). Its impact on studies of galaxy characterization via detailed gas dynamics will provide crucial insight on dominant physical drivers for star-formation in high redshift galaxies, including the exchange of gas from scales of the circumgalactic medium down to resolved clouds on mass scales of ~10^4 M⊙. Based on a direct comparison between the inferred results from our mock observations and the cosmological simulations, we investigate the capabilities of ngVLA to constrain the mode of star formation, dynamical mass, and molecular gas kinematics in individual high-redshift galaxies using cold gas tracers like CO(1-0) and CO(2-1). The factor of 100 times improvement in mapping speed for the ngVLA beyond the Jansky VLA and the proposed ALMA Band 1 will make these detailed, high-resolution imaging and kinematic studies routine at z=2 and beyond.

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Hydrodynamic Zoom Simulation of Gas in a High-z Galaxy

We employ a series of high resolution, cosmological, hydrodynamic zoom simulations from the MUFASA simulation suite and a CASA simulator to generate mock ngVLA observations. Based on a direct comparison between the inferred results from our mock observations and the cosmological simulations, we investigate the capabilities of ngVLA to constrain the mode of star formation, dynamical mass, and molecular gas kinematics in individual high-redshift galaxies using cold gas tracers like CO(1-0) and CO(2-1) in comparison to commonly-observed high-J CO tracers like CO(4-3). The factor of 100 times improvement in mapping speed for the ngVLA beyond the Jansky VLA and the proposed ALMA Band 1 will make these detailed, high-resolution imaging and kinematic studies routine at z=2 and beyond.

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