

## X52a A protocluster at $z = 2.5$ III. Cold gas kinematics

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We present cold gas kinematics of star forming galaxies associated to a protocluster at  $z=2.49$  using CO (4–3) line observed with ALMA. Our target field, protocluster 4C23.56, was identified as overdensities of H $\alpha$  emitters (HAEs) with Subaru/*MOIRCS*, where a total of 25 HAEs are likely to be associated to it. We detect a total of 11 HAEs in CO (4–3) line including six galaxies that were previously detected in CO (3–2). Our higher angular resolution ( $\sim 0''.4$ ,  $\sim 3$  kpc in physical scale) imaging in CO (4–3) has allowed a detailed kinematical modeling of two disk-like galaxies which are with the measurements of gas mass and its fraction from our previous CO (3–2) observations. The best-fit modeled parameters reveal a high ratio between rotational velocity,  $V$ , and intrinsic velocity dispersion,  $\sigma$ , i.e.,  $V/\sigma > 1$ , suggesting rotation-dominated kinematics. We discuss the nature of these disk-like galaxies in a plane of baryonic Tully-Fisher relation and in terms of specific angular momentum. These galaxies follow the correlation and exhibit the value, respectively, found in field disk-like galaxies at similar redshift, indicating the sub-dominant dark matter fraction within an effective radius. We additionally find signatures of mergers for other galaxies, which may also be a mechanism that contributes to the evolution of protocluster galaxies. The diversity found in the kinematical properties of galaxies in the protocluster requests deeper and higher angular resolution imaging observations toward the protocluster.