X05a Low star-formation activity and low gas content in quiescent galaxies at $z > 3.5$ constrained with ALMA

Tomoko Suzuki (University of Groningen), Karl Glazebrook (Swinburne University of Technology), Tadayuki Kodama (Tohoku University), and the ZFOURGE team

Recent deep near-infrared observations found massive quiescent galaxies at $z > 3$. However, it is not fully understood yet what physical processes are involved in the quenching of these massive galaxies. Gas properties, such as gas mass fraction and gas depletion timescale, are one of the important quantities to give a constraint on the quenching mechanisms of galaxies. In this study, with ALMA, we investigate the dust-obscured star-formation activity and gas content of four quiescent galaxies at $z > 3.5$ selected from the ZFOURGE galaxy catalog. Among the four quiescent galaxies, one source is detected with the continuum emission at $\lambda_{\rm obs} \sim 870\mu$m. We then estimated their star formation rates (upper limits) with the obtained dust continuum fluxes (upper limits). We find that all the galaxies including the continuum-detected source are located more than four times below the $M_{\rm star}$–SFR relation of star-forming galaxies at similar redshifts. We confirm the passivity of our quiescent galaxies. Three out of the four galaxies were also observed with Band-3 to detect [CI] line, and none of them is detected. The obtained upper limits on the gas mass fraction are $< 20\%$, which is more than three times smaller than the gas mass fraction of star-forming galaxies at similar redshifts. Our results suggest that massive galaxies at $z > 3.5$ stop their star-formation by consuming or expelling their gas reservoir.