

X15a A massive quiescent galaxy confirmed in a protocluster at $z=3.09$

Mariko Kubo (Ehime University), Hideki Umehata (RIKEN), Charles C. Steidel (California Institute of Technology), Yuichi Matsuda (NAOJ), Masaru Kajisawa (Ehime University), Toru Yamada (JAXA/ISAS), Ichi Tanaka (NAOJ), Kotaro Kohno (University of Tokyo, IoA), Yoichi Tamura (Nagoya University), Kouichiro Nakanishi (NAOJ), Bunyo Hatsukade, Kianhong Lee (University of Tokyo, IoA), Keiichi Matsuda (Nagoya University)

Protoclusters are important laboratories to study the evolution history of giant ellipticals dominating clusters of galaxies today. We report a massive quiescent galaxy confirmed in a protocluster at $z = 3.09$ in the SSA22 field by detecting the Balmer absorption features with near-infrared spectroscopic observations with MOSFIRE on Keck telescope. Its redshift is $z_{\text{spec}} = 3.0922_{-0.004}^{+0.008}$ which is the most distant quiescent galaxy in a protocluster to date. We fitted the optical to mid-infrared broad-band photometries and spectrum simultaneously with spectral energy distribution models and found that this object is a quiescent galaxy formed most of the stars by a short starburst at ≈ 0.7 Gyr ago. Together with its compact size (effective radius = 1.01 ± 0.04 kpc) and large stellar mass ($\log(M_*/M_\odot) = 11.27_{-0.01}^{+0.04}$), it likely had an extremely high star formation surface density where star formation can be quenched by the radiation pressure on dust solely. Along the quiescent galaxy, we newly found three plausible [OIII] λ 5007 emitters at $3.0791 < z_{\text{spec}} < 3.0833$. The redshifts and spatial positions of two are just between this quiescent galaxy and its nearest massive galaxy. They are possible clues of their interaction. They suggest the future size and mass evolution via minor/major mergers after quenching.