

Z204a WISE-Planck far-infrared detection of Hyper Suprime-Cam protoclusters at $z \sim 4$

Mariko Kubo (NAOJ), Jun Toshikawa, Nobunari Kashikawa, Yoshiaki Ono (University of Tokyo), Yi-Kuan Chiang (JHU), Roderik Overzier (University of São Paulo), Hisakazu Uchiyama, Yuichi Matsuda, Kei Ito (NAOJ/SOKENDAI), David L. Clements, Tai-An Cheng (Imperial college of London), David M. Alexander (Durham University), Tadayuki Kodama (Tohoku University), Tomotsugu Goto (National Tsing Hua University), SPICA サイエンス検討会銀河・BH 進化班

We perform a stacking analysis of *Planck*, *AKARI*, Infrared Astronomical Satellite (*IRAS*), Wide-field Infrared Survey Explorer (*WISE*), and *Herschel* images of the largest number of (candidate) protoclusters at $z \sim 3.8$ selected from the Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP). Stacking the images of the 179 candidate protoclusters, the combined infrared (IR) emission of the protocluster galaxies in the observed $12 - 850 \mu\text{m}$ wavelength range is successfully detected. This is the first time that the average total IR spectral energy distribution (SED) of protoclusters has been constrained at $z \sim 4$. The observed IR SEDs of the protoclusters exhibit significant excess emission in the mid-IR compared to that expected from typical star-forming galaxies (SFGs). They are reproduced well using SED models of intense starburst galaxies with warm/hot dust heated by young stars, or by a population of active galactic nuclei (AGN)/SFG composites. For the AGN/SFG composite model, a total IR (from 8 to $1000 \mu\text{m}$) luminosity of $5.1_{-2.5}^{+2.5} \times 10^{13} L_{\odot}$ and a star formation rate (SFR) of $2.1_{-1.7}^{+6.3} \times 10^3 M_{\odot} \text{yr}^{-1}$ are found. Our results demonstrate the importance to characterize the mid to Far-IR dust emission from SFGs/AGNs at high redshift with SPICA.