The rich molecular inventory of two dusty galaxies twelve billion years ago

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Understanding the interstellar media of the galaxies in the early Universe can only be achieved by probing their full molecular complexity. However, studies of high redshift galaxies focus exclusively on only a handful of the brightest molecular lines, mostly the $^{12}C^{16}O$ lines[1,2]. To overcome this limitation, we have conducted a deep spectral line survey towards

two dusty galaxies in different extreme environments — one is characterized by an extreme starburst at z = 3.6 while another is a quasar host galaxy at z = 3.9. The line survey covers the rest-frequency in both sources, continuously, from ~320 to 550 GHz something not done previously. We have detected more than 20 molecular lines from 15 species from their rotational and vibrational spectra in each galaxy, including single or multiple transitions of the [CI], $^{12}C^{16}O$, $^{13}C^{16}O$, $^{12}C^{18}O$, HCO^+, H_2CO, HCN, v-HCN, HNC, NO, CH, CN, CS, CCH, H_2O (including a maser line), and H_3O^+ lines. I present how these observations reveal the chemical richness and detailed properties of their interstellar media. Our main conclusion from an analysis of the molecular gas excitation, ionisation states, and the astrochemical processes is that the properties of the interstellar medium are significantly different between the starburst and the quasar host. Through these line surveys, we are helping to open a new era of the study of the physical and chemical properties of interstellar media in the early Universe.

References

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