X21a Molecular outflow in the reionization-epoch quasar J2054-0005 revealed by OH 119 μm observations

Dragan Salak[1], Takuya Hashimoto[2], Akio K. Inoue[3], Darko Donevski[4], Tom J. L. C. Bakx[5], Yuma Sugahara[3], Yoichi Tamura[5], Nario Kuno[2], & Yusuke Miyamoto[6] (1: Hokkaido Univ., 2: Tsukuba Univ., 3: Waseda Univ., 4: NCBJ (Poland), 5: Nagoya Univ., 6: Fukui Univ. of Technology)

Gas outflows are expected to play a pivotal role in regulating star formation and supermassive black hole growth in galaxies. However, there have been few detections of outflows, especially those of molecules, in galaxies at redshift $z > 6$, making it difficult to evaluate the impact on star formation and quasar activity in the epoch of reionization. To search for molecular outflows, we performed observations of the OH 119 μm line doublet toward J2054-0005, a quasar at $z = 6.04$, at $0.2''$ (1 kpc) resolution using the Atacama Large Millimeter/submillimeter Array. The quasar exhibits a relatively high total infrared luminosity ($L_{\rm IR} \sim 1.3 \times 10^{13} L_\odot$) and [O III]88 μm/[C II]158 μm luminosity ratio (2.1 ± 0.4), making it a promising case-study source. We report the discovery of an OH outflow, the highest-z detection toward a quasar. The OH line exhibits blueshifted absorption that can be explained by outflowing gas, and systemic emission that traces the warm and/or dense gas in the host galaxy. We found that the mean line-of-sight outflow velocity is ~ 700 km s^{-1}, and that the maximum velocity is ~ 1500 km s^{-1}. Simple models yield a mass outflow rate of $\gtrsim 250\ M_\odot$ yr^{-1} (optically-thin limit), and possibly as high as $\sim 1400\ M_\odot$ yr^{-1}, indicating a significant impact on star formation. The results suggest that OH 119 μm can serve as a robust tracer of molecular outflows in quasars at $z > 6$.