Interstellar medium of SDSS J2310+1855 explored with ALMA

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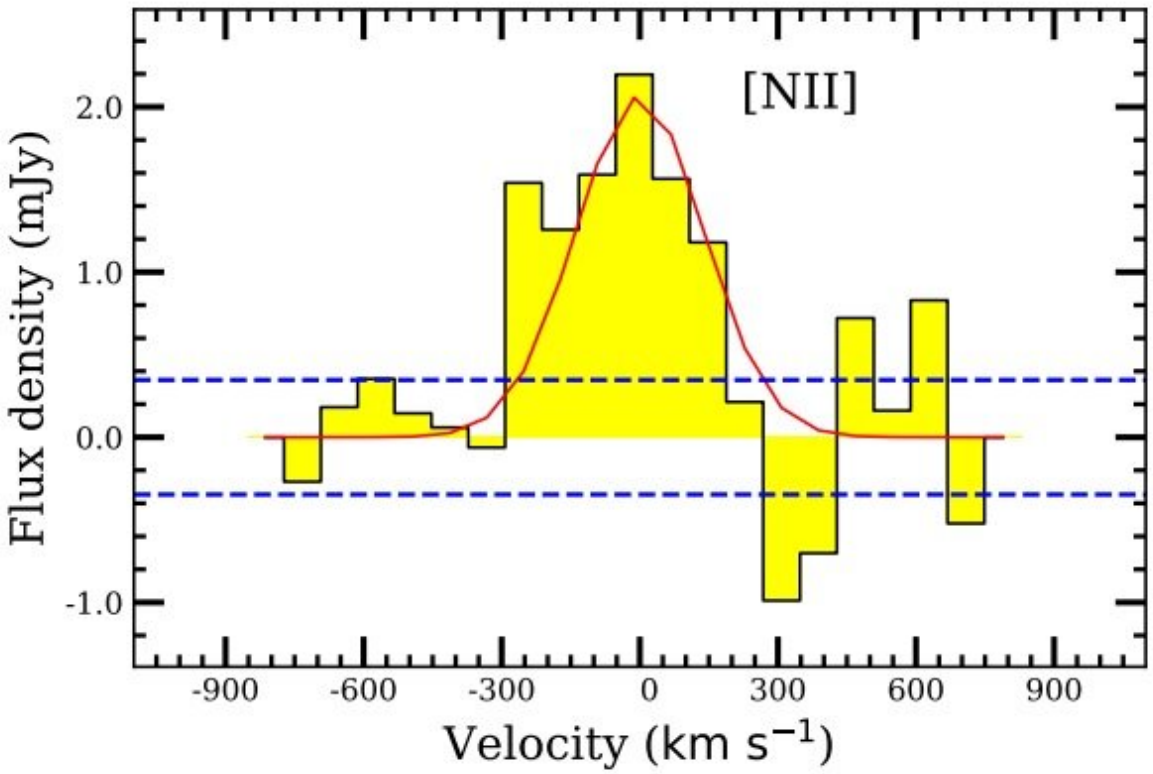

Spectra of [N II]122μm in SDSS J2310+1855. Credit: Li et al., 2020.

Using the ALMA Observatory, an international team of astronomers has conducted an observational campaign of interstellar medium (ISM) in a host galaxy of a high-redshift quasar known as SDSS

J231038.88+185519.7 (SDSS J2310+1855 for short). Results of the observations, published July 24 on arXiv.org, could improve the knowledge of the properties and nature of this quasar.

Quasi-stellar objects (QSOs), or quasars, are extremely luminous active galactic nuclei (AGN) containing supermassive central black holes with accretion disks. Their redshifts are measured from the strong spectral lines that dominate their visible and ultraviolet spectra. All observed quasar spectra have redshifts between 0.056 and 7.54.

Astronomers are especially interested in finding new high-redshift quasars (with redshift above 6.0) as they are the most luminous and most distant compact objects in the observable universe. Observations of ISM in the host galaxies of high-redshift quasars have the potential of disclosing crucial information about the process of galaxy formation and evolution. They can also be helpful in advancing the understanding of how supermassive black holes grow.

At a redshift of approximately 6.003, SDSS J2310+1855 is one of the brightest high-redshift quasars in the far-infrared known to date. Previous studies of the ISM of this QSO's host galaxy have uncovered the presence of highly excited molecular gas with complex excitation mechanisms in which heating from the powerful quasar could be involved. To further test this scenario, a group of astronomers led by Jianan Li of the Peking University in Beijing, China, performed new observations of SDSS J2310+1855 with the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile.

"To probe the gas physical conditions and search for imprints of Active Galactic Nuclei (AGN) on the ISM, we report ALMA observations of the $[N\ II]_{122\mu m}$ and $[O\ I]_{146\mu m}$ lines and the underlying continuum from the z = 6.003 quasar SDSS J231038.88+185519.7," the astronomers wrote in the paper.

ALMA observation clearly detected the nitrogen and oxygen spectral lines from SDSS J2310+1855. Given that other far-infrared fine-structure (FS) lines were observed in this source, like [C II]$_{158\mu m}$ and [O III]$_{88\mu m}$, SDSS J2310+1855 has the most complete set of FS lines available among the known high-redshift quasars.

The study focused on the investigation of physical conditions of atomic and ionized gas. It also evaluated the impact of AGN on the ISM of the quasar's host galaxy. For this purpose, the astronomers compared the line emission to other measurements of local ultraluminous infrared galaxies (ULIRGs), AGNs and other high-redshift systems.

They found that the [O I]$_{146\mu m}$ line has a line-to-far-infrared flux ratio more than two times higher than that found in local galaxies. This, according to the researchers, suggests a warm, dense neutral gas component, possibly heated by the AGN.

"The luminous [O I]$_{146\mu m}$ detection of J2310+1855 suggests warm and dense gas in the nuclear region, which is possibly heated by the photons contributed by the AGN in addition to the UV-photons from young massive stars," the astronomers explained.

Moreover, the study found that density of the ionized gas is over 45 cm^{-3} and estimated that only about 17 percent of the [C II]$_{158\mu m}$ emission originates in the ionized gas. According to the authors of the paper, these results, together with ratios of other lines to far-infrared flux, provide further evidence that the warm, dense gas is likely a result of AGN heating to the ISM of J2310+1855's host.

More information: Li et al., Ionized and atomic interstellar medium in the z = 6.003 quasar SDSS J2310+1855, arXiv:2007.12339 [astro-ph.GA] arxiv.org/abs/2007.12339.