Heat spots reveal growth rate of a galaxy 12 billion years ago

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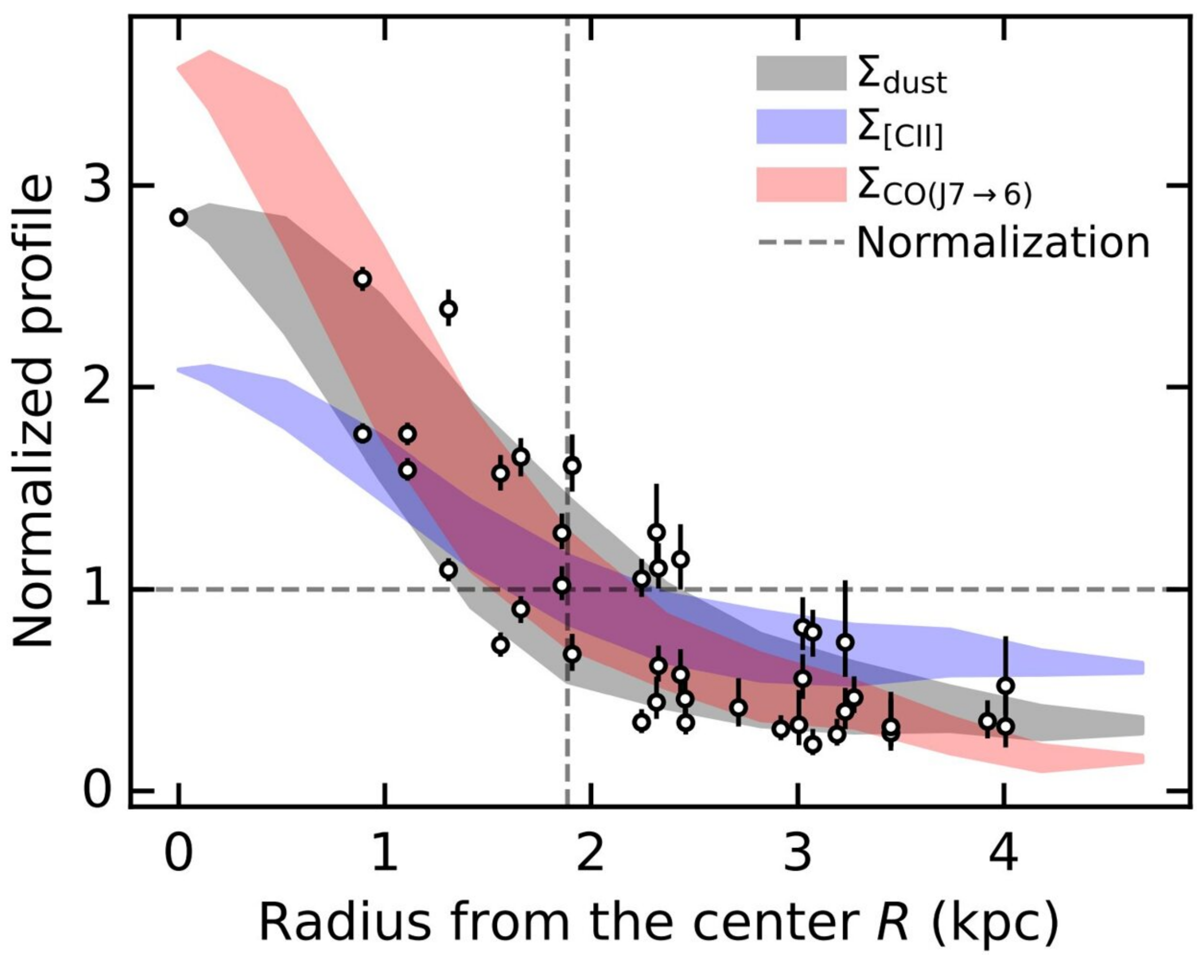

Radial profile of normalized gas mass surface densities of BRI 1335-0417. The black points with error bars and black shade show gas surface density assuming the constant gas-to-dust ratio, extracted in the same way as Fig. 4 from the dust surface density map (Fig. 3B). We also show two additional gas mass estimates from [C ii] (blue shade) and CO(J=7→6) (redshade) using a constant mass-to-light ratio. All the profiles are normalized to 1 at a radius of ~2kpc. Credit: *Monthly Notices of the Royal Astronomical Society* (2023). DOI: 10.1093/mnras/stad1464

An international team of astronomers has drawn a temperature map of the dust drifting within one of the oldest spiral galaxies of the universe which provides new insights into how fast the galaxy is growing. Until now researchers have only been able to measure the temperature of most distant galaxies in broad terms, without showing how temperatures vary in individual areas.

This research, described in a paper published today in *Monthly Notices of the Royal Astronomical Society* (*MNRAS*) shows unambiguous temperature variation within the distant galaxy indicating two distinct heat sources—a supermassive black hole at the center of the galaxy, and the heat generated by newly-formed stars in the surrounding rotating disk.

"The temperature of a galaxy's dust can vary greatly according to which region it is in," says of the Australian National University (ANU) in Canberra, lead author of the paper. "But most of the measurements of dust temperature for distant galaxies in the past have been for the galaxy as a whole, due to limited instrument resolution.

"We were able to measure the temperature by region to region that we could determine how much heat is coming from individual sources. Previously, such mapping has mostly been limited to nearby galaxies."

The research reveals a clear distinction between warm dust in the central region—where the heat is derived from the galaxy's supermassive black hole—and colder dust in the outer region, which is likely being heated by star formation.

Most galaxies have a supermassive black hole in the center, which are thought to grow in mass with the galaxy. When the gas accretes to the black hole, it is heated up by collisions of the fast-moving particles in the vicinity of the black hole and sometimes shines brighter than the stellar body of the galaxy itself.

"The heating energy from the black hole reflects the amount of the gas being fed into it and so the black hole growth rate, while the heating energy from star formation reflects the number of stars newly forming in the galaxy—the galaxy growth rate," Dr. Tsukui says.

"This discovery provides a clearer picture of how galaxies and central massive black hole form and grow in the early universe."

The current research was made possible thanks to the Atacama Large Millimeter/submillimeter Array (ALMA) telescope operated by the European Southern Observatory (ESO) in Chile.

"This study demonstrates the detailed mapping ability of the ALMA telescope, operated by ESO," Astro3D Director Professor Emma Ryan-Weber said. "ALMA is the most powerful array for measuring millimeter and submillimeter radiation. It's incredible that ALMA can look at a 12-billion year old galaxy and separate the image into two components—one of dust heated from the central super massive hole, and the other from the dust in underlying host galaxy."

More information: Takafumi Tsukui et al, Spatially resolved dust properties and quasar-galaxy decomposition of a HyLIRG at z = 4.4, *Monthly Notices of the Royal Astronomical Society* (2023). DOI: 10.1093/mnras/stad1464

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