Massive black holes halt star birth in distant galaxies

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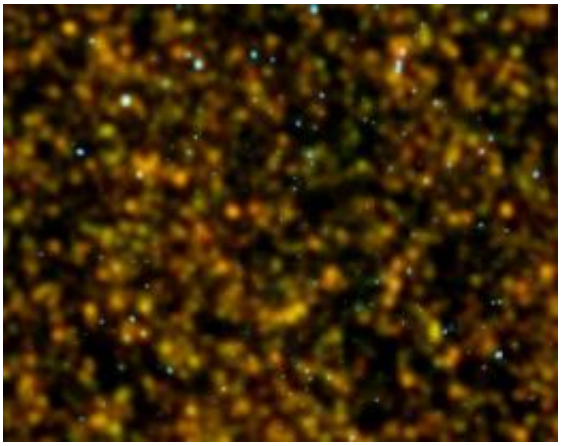

This is a composite X-ray/submillimeter image of the Chandra Deep Field North. The Chandra Deep Field North lies in the constellation of Ursa Major, Green and red correspond to the Herschel SPIRE 250 and 350 micron images showing the sky crowded with submillimeter-bright, dusty galaxies. Blue shows the X-rays recorded by Chandra, most of which come from active galactic nuclei. Credit: ESA/Herschel/HerMES; NASA/CSX

Astronomers, using the European Space Agency's (ESA) Herschel Space Observatory, have shown that the number of stars that form during the early lives of galaxies may be influenced by the massive black holes at their hearts. This helps explain the link between the size of the central bulges of galaxies and the mass of their central black holes.

All large galaxies have a massive black hole at their centre, each millions

of times the mass of a single star. For over a decade scientists have been puzzled as to why the masses of the black holes are linked to the size of the round central bulges at the hearts of galaxies. The suspicion has long been that the answer lies in the early lives of the galaxies, when the stars in the bulge were forming. To study this phase, astronomers need to look at very distant galaxies, so far away that we see them as they were billions of years ago.

Although the black holes themselves cannot be seen, the material closest to them can get incredibly hot, emitting large amounts of light over a very wide range of wavelengths, from radio waves to x-rays. The light from this super-heated material can be trillions of times as bright as the Sun, with brighter emissions indicating a more massive black hole. Ther e are also strong flows of material (winds and jets) expelled from the region around the black hole.

The hot material near the black hole outshines almost all the light from rest of the host galaxy, except for the light with wavelengths just less than a millimetre. This sub-millimetre light is invisible to normal telescopes but is seen by the Herschel Space Observatory and indicates the rate at which stars are being formed in the galaxy.

The Herschel Space Observatory has shown that galaxies with the most powerful,

active, supermassive black holes at their cores produce fewer stars than galaxies with less active black holes. Supermassive black holes are believed to reside in the hearts of all large galaxies. When gas falls upon these monsters, the materials are accelerated and heated around the black hole, releasing great torrents of energy. In the process, active black holes oftentimes generate colossal jets that blast out twin streams of heated matter. Inflows of gas into a galaxy also fuel the formation of new stars. In a new study of distant galaxies, Herschel helped show that star formation and black hole activity increase together, but only up to a point. Astronomers think that if an active black hole flares up too much, it starts spewing radiation that prevents raw material from coalescing into new stars. This artistically modified image of the local galaxy Arp 220, captured by the Hubble Space Telescope, helps illustrate the Herschel results. The bright core of the galaxy, paired with an overlaid artist's impression of jets emanating from it, indicate that the central black hole's activity is intensifying. As the active black hole continues to rev up, the rate of star formation will in turn be tamped down in the galaxy. Astronomers want to further study how star formation and black hole activity are intertwined. Credit: NASA/JPL-Caltech/R. Hurt

"Herschel provides a new perspective and is conducting a number of surveys of galaxies near and far, in order to unravel the mysteries of the formation and evolution of galaxies across cosmic time," explains Göran Pilb'ratt, the ESA Herschel Project Scientist.

The latest study, led by Dr. Mat Page of University College London's Mullard Space Science Laboratory, used images from the SPIRE camera on board Herschel to calculate the amount of star formation in distant galaxies. This can be compared with the X-rays detected by NASA's Chandra X-ray satellite, which indicates the growth-rate of the black hole.

"Space telescopes like Herschel let us look back in time, and that's just what we need to do to find out how today's galaxies were built. Galaxies were forming stars like crazy when the Universe was young, but trying to

see the light from star formation against the glare from the hot stuff around the black hole has been almost impossible until now. That's all changed with the new wavelengths opened up by Herschel's SPIRE camera" said Dr. Page.

Galaxies with massive black holes were found to have high rates of star formation, with some forming stars at a thousand times the rate of our own Milky Way galaxy today. But intriguingly, the Herschel results show that the fastest-growing black holes are in galaxies with very little star formation – once the radiation coming from close to the black hole exceeds a certain power, it tends to "switch off" star formation in its galaxy.

Prof. Seb Oliver from the University of Sussex and co-leader of the HerMES project, said "This fantastic result provides an amazing link between black holes and star formation in the early Universe. It is a huge clue to this decade old riddle and could mean that once a black hole is big enough and producing enough radiation, it somehow shuts down the formation of stars in the surrounding galaxy."

The most likely explanation is that the incredibly strong winds from around these very powerful black holes are preventing the gas and dust in the rest of the galaxy from forming stars.

"This means that the total number of stars that form is limited by the power of the black hole that shapes that galaxy" said Dr Myrto Symeonidis, a co-author of the study.

Prof. Matt Griffin of Cardiff University, who is the Principal Investigator of the international team which built the Herschel-SPIRE instrument said "This important discovery shows how the great sensitivity of SPIRE is allowing us to look back in time and understand the early history and development of the galaxies that populate today's

universe. Only a small fraction of the instrument's observations have been fully analysed so far, and we're looking forward to many more exciting results."

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