STELLAR CHEMISTRY

Spitzer Spies Intergalactic Sonic Boom

by Staff Writers
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New infrared observations by NASA's Spitzer Space Telescope have revealed the presence of a huge intergalactic shock wave, like a sonic boom, roaring through the middle of Stephan's Quintet, a group of galaxies in the midst of multiple collisions. The observations could help astronomers improve their understanding of what powers the most energetic galaxies in the universe.

This false-color composite image of the Stephan's Quintet galaxy cluster clearly shows one of the largest shock waves ever seen (green arc), produced by one galaxy falling toward another at over a million miles per hour. It is made up of data from NASA's Spitzer Space Telescope and a ground-based telescope in Spain.

Four of the galaxies in the Stephan's Quintet cluster, located about 300-million light-years away, are in the process of colliding. Even in visible light, the galaxies are clearly distorted, suggesting they might have experienced gravitational encounters in the past - perhaps multiple times.

One of the galaxies, called NGC 7318b, is moving toward the other three at high speed, generating a giant bow shock that is emitting X-rays, radio waves and intense infrared radiation. The shock wave also contains huge quantities of gas - perhaps 100 billion solar masses, in an area larger than the Milky Way, stretching across intergalactic space between the colliding galaxies.

Shock waves occur when an object moves faster than the speed of sound through any kind of medium -- from water to stars to intergalactic gas. The most commonly known form of shock waves is the sonic boom produced by high-speed aircraft. As a supersonic jet exceeds the speed of sound, called Mach 1, it catches up with its own sound waves, which pile up in front of the aircraft in the shape of a cone. The bow shock then travels outward and produces the familiar sonic boom heard on the ground when a supersonic jet flies by.

Philip Appleton of the California Institute of Technology in Pasadena, and colleagues at the Max Planck Institute in Heidelberg, Germany, and elsewhere in the United States and Australia, used Spitzer's sensitive Infrared Spectrograph to probe the bow shock preceding NGC 7318b, a visibly dark area between the galaxies. As reported in the March 10 issue of the Astrophysical Journal, the instrument detected the telltale fingerprint of an extremely powerful molecular-hydrogen emission.

"The strength of the emission and the fact that it shows the gas to be Doppler-broadened was a huge surprise to us." Appleton said. "We expected to see the spectral signature of dust grains, but instead we saw an almost pure laboratory-like spectrum of hydrogen molecules and almost nothing else. It was quite unlike anything we had seen before in a distant galaxy system."

Appleton and his team measured the widest spectral lines ever observed for hot hydrogen molecules, corresponding to turbulent gas motions of 870 kilometers (555 miles) per second, or 3.1 million kilometers (2 million miles) per hour.

"Hydrogen molecules are apparently forming either in or behind the shock," Appleton said, "but on an enormous scale."

The discovery may lead to a better understanding of the most infrared-luminous galaxies in the universe, called Ultra-luminous Infrared Galaxies.

"Ultra-luminous Infrared Galaxies typically have infrared luminosities 100 to 1,000 times greater than the Milky Way, and their numbers increase as you look out to higher and higher red-shifts," Appleton explained. "We know that these galaxies are also involved in vast mergers and collisions. It’s possible that some of the emission we see from them is created not by stars, but by vast shocks in the gas between colliding galaxies."

The Spitzer observations provide "a local view of what might have been going on about 10-billion years ago, soon after the first galaxies formed, when the density of the intergalactic medium and the density of galaxies were much greater than today," said Cristina Popescu of the Max Planck Institute. "In that respect, these observations are a bit like stepping into a time machine."

The astronomers also think this discovery could have implications for the Milky Way. In about 2 billion years, the galaxy will collide with the slightly larger Andromeda, and perhaps create bow shocks of its own.

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