Runaway stars leave infrared waves in space

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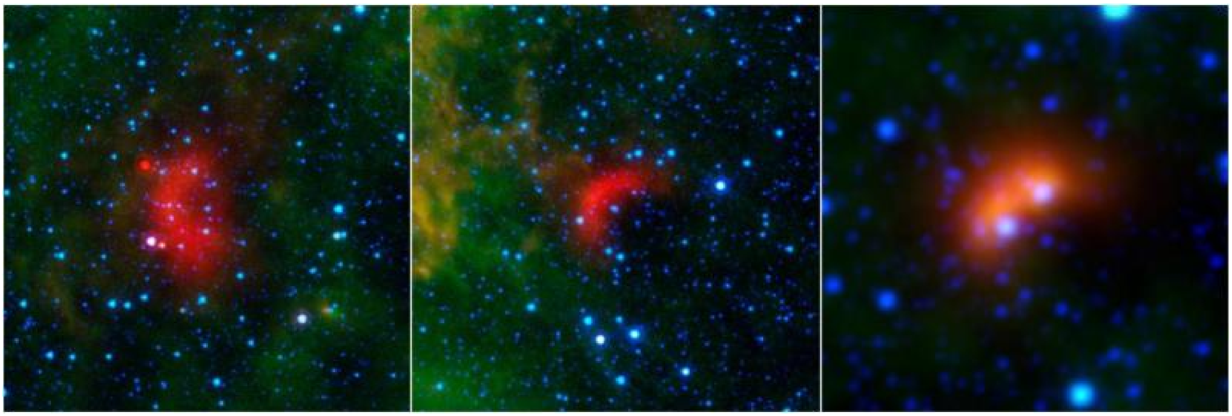


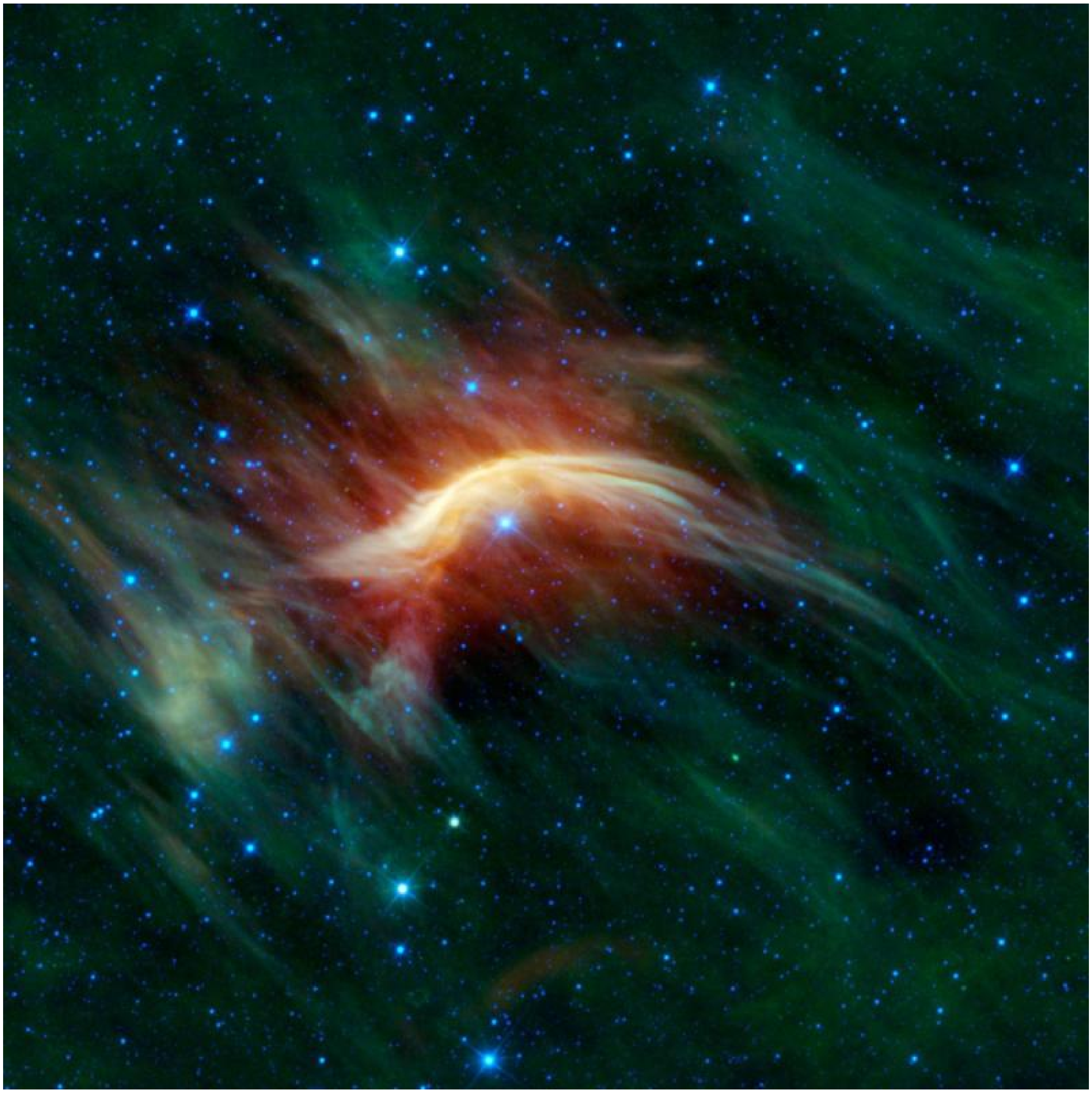
Bow shocks thought to mark the paths of massive, speeding stars are highlighted in these images from NASA's Spitzer Space Telescope and Wide-field Infrared Survey Explorer, or WISE. Credit: NASA/JPL-Caltech/University of Wyoming

Astronomers are finding dozens of the fastest stars in our galaxy with the help of images from NASA's Spitzer Space Telescope and Wide-field Infrared Survey Explorer, or WISE.

When some speedy, massive stars plow through space, they can cause material to stack up in front of them in the same way that water piles up ahead of a ship. Called bow shocks, these dramatic, arc-shaped features in space are leading researchers to uncover massive, so-called runaway stars.

"Some stars get the boot when their companion star explodes in a supernova, and others can get kicked out of crowded star clusters," said astronomer William Chick from the University of Wyoming in Laramie, who presented his team's new results at the American Astronomical Society meeting in Kissimmee, Florida. "The gravitational boost increases a star's speed relative to other stars."

Our own sun is strolling through our Milky Way galaxy at a moderate pace. It is not clear whether our sun creates a bow shock. By comparison, a massive star with a stunning bow shock, called Zeta Ophiuchi (or Zeta Oph), is traveling around the galaxy faster than our sun, at 54,000 mph (24 kilometers per second) relative to its surroundings. Zeta Oph's giant bow shock can be seen in this image from the WISE mission:



The blue star near the center of this image is Zeta Ophiuchi. When seen in visible light it appears as a relatively dim red star surrounded by other dim stars and no dust. However, in this infrared image taken with NASA's Wide-field Infrared Survey Explorer, or WISE, a completely different view emerges. Zeta Ophiuchi is actually a very massive, hot, bright blue star plowing its way through a large cloud of interstellar dust and gas. Astronomers theorize that this stellar juggernaut was likely once part of a binary star system with an even more massive partner. It's believed that when the partner exploded as a supernova, blasting away most of its mass, Zeta Ophiuchi was suddenly freed from its partner's pull and shot away like a bullet moving 24 kilometers per second (54,000 miles per hour). Zeta Ophiuchi is about 20 times more massive and 65,000 times more luminous than the sun. If it weren't surrounded by so much dust, it would be one of the brightest stars in the sky and appear blue to the eye. Like all stars with this kind of extreme mass and power, it subscribes to the 'live fast, die young' motto. It's already about halfway through its very short 8-million-year lifespan. In comparison, the sun is roughly halfway through its 10-billion-year lifespan. While the sun will eventually become a quiet white dwarf, Zeta Ophiuchi, like its ex-partner, will ultimately die in a massive explosion called a supernova. Perhaps the most interesting features in this image are related to the interstellar gas and dust that surrounds Zeta Ophiuchi. Off to the sides of the image and in the background are relatively calm clouds of dust, appearing green and wispy, slightly reminiscent of the northern lights. Near Zeta Ophiuchi, these clouds look quite different. The cloud in all directions around the star is brighter and redder, because the extreme amounts of ultraviolet radiation emitted by the star are heating the cloud, causing it to glow more brightly in the infrared than usual. Even more striking, however, is the bright yellow curved feature directly above Zeta Ophiuchi. This is a magnificent example of a bow shock. In this image, the runaway star is flying from the lower right towards the upper left. As it does so, its very powerful stellar wind is pushing the gas and dust out of its way (the stellar wind extends far beyond the visible portion of the star, creating an invisible 'bubble' all around it). And directly in front of the star's path the wind is compressing the gas together so much that it is glowing extremely brightly (in the infrared), creating a bow shock. It is akin to the effect you might see when a boat pushes a wave in front it as it moves through the water. This feature is completely hidden in visible light. Infrared images like this one from WISE shed an entirely new light on the region. The colors used in this image represent specific wavelengths of infrared light. Blue and cyan (blue-green) represent light emitted at wavelengths of 3.4 and 4.6 microns, which is predominantly from stars. Green and red represent light from 12 and 22 microns, respectively, which is mostly emitted by dust. Credit: NASA/JPL-Caltech/UCLA

Both the speed of stars moving through space and their mass contribute to the size and shapes of bow shocks. The more massive a star, the more material it sheds in high-speed winds. Zeta Oph, which is about 20 times as massive as our sun, has supersonic winds that slam into the material in front of it.

The result is a pile-up of material that glows. The arc-shaped material heats up and shines with infrared light. That infrared light is assigned the color red in the many pictures of bow shocks captured by Spitzer and WISE.

Chick and his team turned to archival infrared data from Spitzer and WISE to identify new bow shocks, including more distant ones that are harder to find. Their initial search turned up more than 200 images of fuzzy red arcs. They then used the Wyoming Infrared Observatory, near Laramie, to follow up on 80 of these candidates and identify the sources behind the suspected bow shocks. Most turned out to be massive stars.

The findings suggest that many of the bow shocks are the result of speedy runaways that were given a gravitational kick by other stars. However, in a few cases, the arc-shaped features could turn out to be something else, such as dust from stars and birth clouds of newborn stars. The team plans more observations to confirm the presence of bow shocks.

"We are using the bow shocks to find massive and/or runaway stars," said astronomer Henry "Chip" Kobulnicky, also from the University of Wyoming. "The bow shocks are new laboratories for studying massive stars and answering questions about the fate and evolution of these stars."

Another group of researchers, led by Cintia Peri of the Argentine Institute of Radio Astronomy, is also using Spitzer and WISE data to find new bow shocks in space. Only instead of searching for the arcs at the onset, they start by hunting down known speedy stars, and then they scan them for bow shocks.

"WISE and Spitzer have given us the best images of bow shocks so far," said Peri. "In many cases, bow shocks that looked very diffuse before, can now be resolved, and, moreover, we can see some new details of the structures."

Some of the first bow shocks from runaway stars were identified in the 1980s by David Van Buren of NASA's Jet Propulsion Laboratory in Pasadena, California. He and his colleagues found them using infrared data from the Infrared Astronomical Satellite (IRAS), a predecessor to WISE that scanned the whole infrared sky in 1983.

Kobulnicky and Chick belong to a larger team of researchers and students studying bow shocks and massive stars, including Matt Povich from the California State Polytechnic University, Pomona. The National Science Foundation funds their research.

Images from Spitzer, WISE and IRAS are archived at the NASA Infrared Science Archive housed at the Infrared Processing and Analysis Center at the California Institute of Technology in Pasadena. Caltech manages JPL for NASA.

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