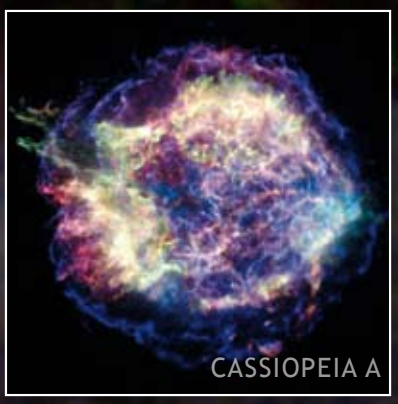
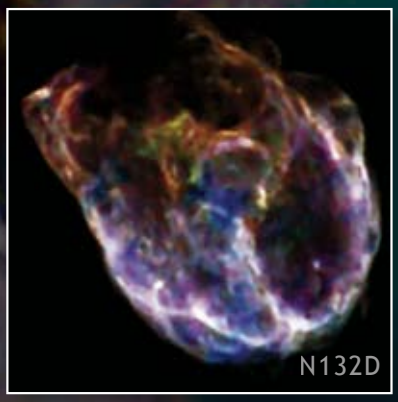
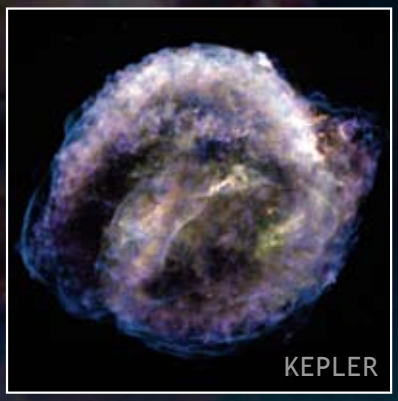
CELESTIAL FIREWORKS: SUPERNOVA REMNANTS


CASSIOPEIA A


N132D

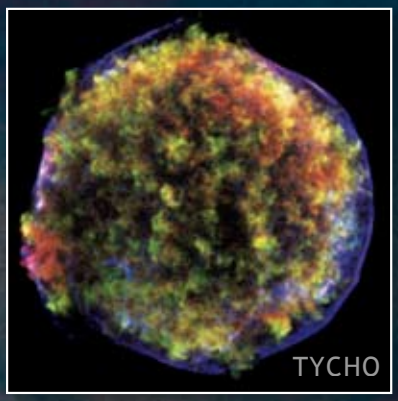

CRAB NEBULA


DEM L71


KEPLER

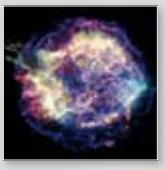

W49B


G21.5-0.9

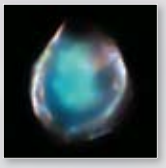

TYCHO

Supernovas that signal the end of massive stars are some of the most dramatic events in the cosmos. With its unique mirrors and instrumentation, Chandra has captured these celestial explosions in spectacular X-ray images. These titanic events send shock waves rumbling through space and create giant bubbles of multimillion-degree Celsius gas. Chandra's X-ray images enable astronomers to determine the energy, composition, and dynamics of these explosions. In the centers of many of these bubbles, Chandra has revealed the presence of pulsars—rapidly rotating, highly magnetized neutron stars—that are pumping wave after wave of extremely energetic matter and antimatter particles into space.

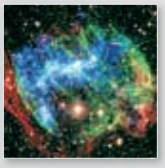
MORE ABOUT CHANDRA'S SUPERNOVA REMNANTS...



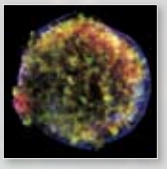
CASSIOPEIA A: This extraordinarily deep Chandra image shows Cassiopeia A (Cas A, for short), the youngest supernova remnant in the Milky Way. Analysis of Cassiopeia A shows that this supernova remnant accelerates electrons to enormous energies. The blue, wispy arcs reveal the acceleration is taking place in an expanding shock wave generated by the explosion that destroyed the progenitor star. This acceleration is close to the theoretical limit and provides strong evidence that supernova remnants are key sites for generating cosmic rays, mysterious high-energy particles that bombard the Earth.



DEM L71: Astronomers consider DEM L71 to be a textbook example of what happens when a star explodes and ejects matter at high speeds into the surrounding interstellar gas. Chandra's X-ray image of DEM L71 reveals a 10-million-degree inner cloud (aqua) of glowing iron and silicon, which is surrounded by an outer ring of 5-million-degree gas. An analysis of the Chandra data identified the inner cloud as the remains of a white dwarf star that exploded. The white dwarf pulled matter from a nearby companion star onto itself until it became unstable and blew apart in a thermonuclear explosion. Like N132D, DEM L71 is located in the Large Magellanic Cloud.



W49B: This is a composite Chandra X-ray (blue) and Palomar infrared (red and green) image of the supernova remnant known as W49B, which lies some 35,000 light years from Earth. The data reveal a barrel-shaped supernova remnant consisting of bright infrared rings around a glowing bar of intense X-radiation. These X-rays are produced by jets of 15-million-degree gas that is rich in iron and nickel. These features indicate that W49B could have been produced when the core of a rapidly rotating massive star collapsed to form a black hole, triggering the ejection of high-energy jets of material.



TYCHO'S SUPERNOVA REMNANT: Chandra's image shows a bubble of hot gaseous supernova debris (green and red) inside a more rapidly moving shell of extremely high-energy electrons (blue). These features were created as the supersonic expansion of the debris into interstellar gas produced two shock waves—one that moves outward and accelerates particles to high energies, and another that moves backward and heats the stellar debris. The relative expansion speeds of the hot debris and the high-energy shell indicate that a large fraction of the energy of the outward-moving shock wave is going into the acceleration of atomic nuclei to extremely high energies. This finding strengthens the case that supernova shock waves are an important source of cosmic rays, high-energy nuclei which constantly bombard Earth.

Credits — Crab Nebula: NASA/CXC/SAO/F.Seward et al.; G21.5-0.9: NASA/CXC/U.Manitoba/H.Matheson & S.Safi-Harb; Kepler's SNR: NASA/CXC/NCSU/S.Reynolds et al.; N132D: NASA/CXC/NCSU/K.J.Borkowski et al.; Cassiopeia A: NASA/CXC/MIT/UMass Amherst/M.D.Stage et al.; DEM L71: NASA/CXC/Rutgers/J.Hughes et al.; W49B: X-ray: NASA/CXC/SSC/J.Keohane et al.; Infrared: Caltech/SSC/J.Rho & T.Jarrett; Tycho's SNR: NASA/CXC/Rutgers/J.Warren & J.Hughes et al.; Illustration: CXC/M.Weiss

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