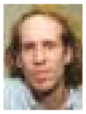


A New View of the Milky Way

With a new set of gamma-ray eyes, astronomers bear witness to the invisible machinery of the Milky Way.

by Christopher Wanjek

The first time this city boy saw the Milky Way, that ethereal wisp of light from billions of indiscernible stars stretching across the horizon, I was 23 years old and camped out alone in a canyon along the Rio Grande in northern New Mexico. Never mind what I was doing. Suffice it to say this was a sight I will not soon forget.

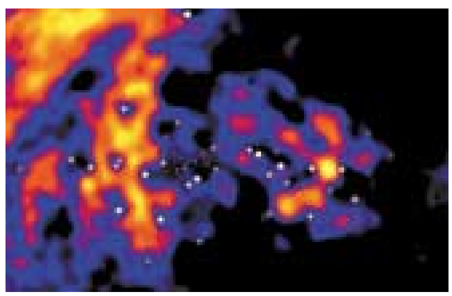
Suddenly I had a fuller appreciation for Allen Ginsberg's "heavenly connection to the starry dynamo in the machinery of the night." Growing up in Philadelphia, where the night sky comprises maybe eight stars on a good night, I had never understood the big deal, the crazed fascination, the powerful sense of belonging to the inner workings of the cosmos, the infinity of it all.

This past November, I was reintroduced to the Milky Way in a whole new light—that is, gamma-ray light. The Milky Way isn't so milky when viewed through the eyes of a gamma-ray telescope. Rather, it's downright fiery, sizzling with radioactivity from the debris of star explosions and black holes and from matter-antimatter annihilations. While the naked-eye Milky Way is largely the product of main sequence stars, the gamma-ray underworld can be more fantastic than anything hatched from Ginsberg's mind.

Only the most energetic phenomena in the Universe generate gamma rays, the most energetic form of light. This short list includes pulsars, black hole jets, and supernovae. And these were all captured, as expected, in a new map of the Milky Way from the International Gamma-Ray Astrophysics Laboratory (Integral), an observatory launched by the European Space Agency in October 2002, the results of which were published in a special November 2003 issue of the journal *Astronomy & Astrophysics*.

Among the more provocative conclusions from Integral data are that scientists may soon have a handle of the true star-formation rate in our galaxy and, as eerie as it might sound, the Galactic core appears to have too much antimatter.

Integral looks at a tiny slice of the vast band of electromagnetic radiation we call gamma rays, detecting energies roughly between 150,000 and 10 million electron volts (eV). For comparison, optical light, from red through blue, covers 1 to 3 eV. According to Chris Shrader, a scientist based at NASA Goddard Space Flight Center who helped develop software to analyze Integral data, the instruments are particularly sensitive to two telltale "gamma-ray lines" at 511 and 1809 kilo-eV (keV). This refers to a spike in spectral readouts of the gamma-ray light. The 511 keV line is the signal of electron-positron annihilation. The 1809 keV line marks the radioactive decay of aluminum-26 into magnesium.



A "significance" map shows the Galaxy's center in gamma rays. White dots signify point sources, mostly black-hole and neutron-star binaries like Scorpius X-1 (image top). Yellow and red regions are possible point or diffuse sources. Blue and black regions are less likely to have gamma-ray activity. Map courtesy of V. Beckmann, on behalf of SPI/INTEGRAL.

Aluminum-26, for the most part, is produced when stars explode. The isotope has a half-life of about a million years, so it lingers far longer than optical supernova remnants and "traces the supernova history of our galaxy," Shrader said. Astronomers are using Integral to mine for aluminum with more diligence than the Reynolds Wrap folks.

"There's a lot of history you can pick up looking back over a million years," said Marvin Leventhal, professor emeritus of astronomy at the University of Maryland. Scientists can pinpoint ages and locations of past star explosions through a technique similar to carbon-14 dating. This, in turn, provides insight into the star-formation rate and the lifecycle of matter and energy.

The 511 keV line is predominately from the Galactic core, emitted from a spherical region several thousand light-years across, and with little doubt implies the presence of electrons interacting with positrons possibly coming from neutron stars, pulsars, black holes, gamma-ray bursts, cosmic-ray interactions, and stellar flares. Yet when you add it all up, the Integral data indicate that there's too much antimatter to account for, according to Michel Casse of the Institut d'Astrophysique de Paris.

Many of Casse's European colleagues that built and operate Integral agree, and they are excited about his conclusion: the 511 keV line may be from hypothesized particles of dark matter called axions colliding and creating electron-positron pairs. If correct, this would mark the first direct detection of dark matter. Yet the speculation relies heavily on theory, and observational confirmation won't be coming soon.

"The issue is a very exciting one," said Leventhal, who was part of the team who discovered the 511 keV line in the 1970s. "But there's too much uncertainty to rule out the supernovae and black-hole contribution. The best we can do is make a very nice map." Whatever the conclusion, scientists are hopeful that Integral in years to come will ultimately reveal bold insight into the invisible machinery of the Milky Way, inspiring today's poets to muse about the starry dynamo. **m**

CHRISTOPHER WANJEK of NASA/SP Systems has since moved to Baltimore, where he can now see ten stars.