PHYS ORG

Astrophysicists Move Closer to Understanding the Beauty Behind Stellar Jets

September 28 2009

(PhysOrg.com) -- Certain stars stream vast amounts of matter into space, creating some of the most beautiful objects in astronomers' telescopes. But while the astronomers can enjoy the beauty, they can't explain it. Adam Frank, professor of physics and astronomy at the University of Rochester is hoping to change that.

Earlier this year, Frank and his colleague, Eric Blackman, professor of physics and astronomy, were part of what he called "one of the greatest astrophysical experiments that's ever been done." Recreating a stellar event in a laboratory is extremely difficult, says Frank, since most astrophysical phenomena require an entire star, "which is hard to fit in a lab."

But Frank, along with Professor Sergey Lebedev's team in the Department of Physics at Imperial College London, replicated the physics of a stellar jet in a laboratory, matching the known physics of jets amazingly well. That experiment was conducted using the Imperial College's MAGPIE pulsed power facility. Now, the U.S. Department of Energy has awarded Frank and his team $2.8 million to take the experiment to the next level.

Along with researchers from Rice University and the University of California at San Diego, Frank and Lebedev will re-conduct the initial experiment and carry out new ones on Sandia National Laboratories' Z-Machine—an X-ray generator 10 times more powerful than the MAGPIE facility. The new grant will allow Frank and the team to replicate jets even more accurately, as well as to get new astronomical observations to nail down exactly how stellar jets evolve in nature.

"It's a whole new way of doing astrophysics," says Frank, who specializes in using supercomputers to simulate astrophysical phenomena. "The DOE grant allows us to deepen and extend an unusual international collaboration of plasma physicists, astronomers, and computational scientists. The grant is for five years and that means we have the time and resources to come together to answer a very difficult problem from very different angles."

The original experiment at Imperial College showed how "knots" form in stellar jets. Though jets are believed to emanate from a star as a steady stream of matter, they quickly become knotted and twisted, creating the astonishing shapes they are known for, says Frank. Astrophysicists had long debated what caused the knotting of jets, but Frank, Lebedev, and the team managed to recreate a small-scale version of these jets at the Imperial College' facility.

At Imperial College, Lebedev sent a high-powered pulse of energy into an aluminum disk. In just a few billions of a second, the aluminum began to evaporate, creating a cloud of plasma very similar to the plasma cloud surrounding a young star, says Frank. Where the energy flowed into the center of the disk, the aluminum evaporated completely, creating a hole through which a magnetic field, generated in the process, could penetrate.

The field initially pushed aside the plasma, forming a "bubble with a jet inside," says Frank, who carried out the astrophysical analysis of the experiment. As the field penetrated further and the bubble/jet system grew, the magnetic fields began to warp and twist. Almost immediately, a new magnetic bubble formed beneath the first bubble, and the process repeated itself, creating a series of broken bubbles in the plasma.

The resulting cloud of plasma, pinched in by the magnetic fields, so closely resembled what astrophysicists observe in real stellar jets that Frank believes the same physics underlies both. Frank says other aspects of the experiment, such as the way in which the jets radiatively cool the plasma in the same way jets radiatively cool their parent stars, make the series of experiments an important tool for studying stellar jets.

"We can see these beautiful jets in space, but we have no way to see what the magnetic fields look like," says Frank. "I can't go out and stick probes in a star, but here we can get some idea."

Provided by University of Rochester (news : web)