*This is a popular article I wrote about research I did as an summer researcher at the University of Rochester in 2005, the results from which were later published in both* Nature *and the* Astrophysical Journal. *The article was published in 2007 in the* Chronicle Express, *the local newspaper in my hometown of Penn Yan, NY (hence the "Finger Lakes" reference). —Chat Hull*

**HEADLINE: Chat Hull's Astronomy Research Is Published in *Nature* Magazine**

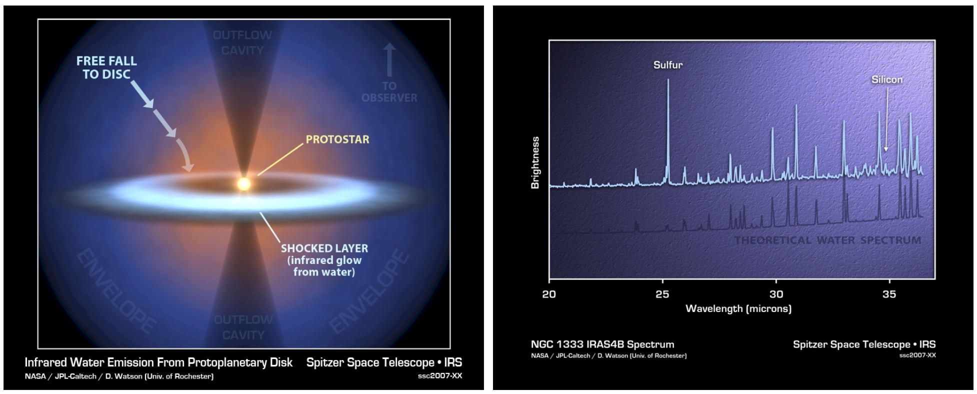


Fig. 1.— *Left:* artist's rendition of the Class 0 protostar NGC 1333-IRAS 4B. *Right:* the simulated spectrum of the water emission from IRAS 4B.

ROCHESTER — Penn Yan native and resident Chat Hull, with University of Rochester physics and astronomy professor Dan Watson and their colleagues from UR and other North American universities, may have found a missing link in the formation of solar systems like our own.

In their paper, published in the August 30, 2007 issue of *Nature,* a leading international science journal, they describe how they used the Spitzer Space Telescope to peer into the cold, dark regions of a young, developing star, known as a protostar, called NGC 1333-IRAS 4B, located about 1,000 light-years from Earth.

What they saw was a stormy scene: a protostar surrounded by enough water to fill the Earth's oceans five times, and a forecasted precipitation rate of approximately 23 Earth-masses of water per year.

"Raining" down at speeds faster than a mile per second, supersonic chunks of ice pelt the surface of a dense, dusty disk surrounding the infant star and vaporize on impact, creating what astronomers call an "accretion shock."

The astronomers detected this supersonic hailstorm by analyzing the infrared light emitted by the star. Much of this light was emitted by the "shocked" water as it cooled down after falling from a cloud surrounding the natal star and slamming into the protostellar disk.

"The news here...is this missing link of how the disks assemble themselves within these envelopes," says Watson in *Nature's* August 30 podcast, referring to how the spherical envelope—the cloud of dust, gas, and ice that surrounds a very young protostar—collapses to form the pancake-shaped disk. "This is the first time we've ever seen the process by which the surrounding envelope's material arrives at the disk," he adds.

Astronomers think that stars begin as cold blobs of dust and gas, which then begin to contract and form a hotter, protostellar core in the blob's center. As time goes on, the spherical cloud surrounding the protostar collapses onto a flat, dense disk. And finally, the material in the disk either falls inward onto the forming star, or condenses to form planets, sometimes resulting in solar systems similar to our own.

The discovery in IRAS 4B of an accretion shock, which, according to Watson, "has been searched for and theorized about for decades," fills a gap in the long-accepted theory of stellar and planetary formation: while astronomers have long been able to study the later stages of star formation, they had never seen evidence of the earlier stage when the envelope falls onto the disk.

One of the reasons astronomers haven't been able to solve this puzzle until now is that the clouds that surround the youngest, "Class 0" protostars such as IRAS 4B are simply too thick and dusty. "What's special about the Spitzer Space Telescope," says Watson, "is that it lets us see through dense dust and gas clouds. In fact, we're now able to see what used to be invisible material at the cores of protostellar condensations."

Class 0 protostars are stars in their earliest stages of formation, and may be anywhere from a few thousand to ten or twenty thousand years old. "We think that what we're seeing in [IRAS 4B] now is quite a lot like what our solar system was like at the same age," Watson says.

This research also sheds light on how our own, rocky, watery Earth may have come to be. "For the first time," Watson says, "we're witnessing the arrival of some future solar system's supply of water."

However, although the water vaporizes after crashing into the disk, it isn't ready to fill any Finger Lakes yet. According to Watson, afterward the water must refreeze to form "asteroids and comets before it will be the stuff that will decorate the surfaces of the rocky planets someday and form oceans."

*Related article: http://adsabs.harvard.edu/abs/2007Natur.448.1026W*

**SIDEBAR HEADLINE: More Research**

Chat Hull also contributed research to another paper, which was published in the July 1 issue of the *Astrophysical Journal.*

In the paper, Hull, Dan Watson (see associated article), and other astronomers used the *Spitzer Space Telescope* to observe a star known as AE Aquarii, located in the constellation Aquarius.

AE Aquarii is a binary (two-star) system known as a cataclysmic variable, which consists of a bloated, aging star that is sloughing off much of its material onto a quickly rotating white dwarf, an extremely dense, ancient star remnant.

The white dwarf is thought to expel most of the material streaming onto it from the aging donor star. However, the exact conditions near the star are not known, as the spectrum of light emitted from the binary system includes several features that have yet to be explained. Research is ongoing.

*Related article: http://adsabs.harvard.edu/abs/2007ApJ...663..516D*