A Star Is Born: Northwestern Professor Discovers Young Stars Thriving near Supermassive Black Hole at the Galactic Center

By: Michelle M. Hunter

When Farhad Zadeh recalls the first astronomy course he took as a young student at the City College of New York, his normally composed jawline slackens, and a slight smile emerges in one corner of his mouth. Zadeh was 18 years old, a recent immigrant to the United States from Iran, and about to embark on a lifelong love affair with stars. “I was fascinated [by the idea] that stars evolve similarly to humans,” he says. “There’s the birth of a star, then they go through midlife, then they get old. These are the kinds of things I never knew about stars.”

Thirty years after he first immersed himself in the phenomena of star formation and lifecycles, Zadeh, now a professor of astrophysics at Northwestern University, made a surprising discovery. He found evidence of very young stars forming near the black hole at the center of the Milky Way galaxy—a region believed to be too turbulent and chaotic for star formation. If confirmed, Zadeh’s findings would not only mark the first such confirmation of early star formation near the black hole, but they would also give us deeper insights into how stars form in uncongenial environments—a key piece in the puzzle of understanding our universe.

Zadeh sits beside a gray, metallic table—the only clear surface in his long, rectangular-shaped office. Every inch of remaining space is covered with papers, brightly colored binders, a bulky laser printer, an ancient Mr. Coffee. Zadeh, dressed in an olive jacket over a blue turtleneck and black trousers, relaxes in a plush chair, his long legs comfortably folded, one hand cradling his cheek near his graying temples. His heavily accented voice resounds, deep and rich, throughout the narrow room.

"It was not something that I expected at all," Zadeh says of his accidental finding. Three decades after discovering his fascination with the human-like patterns of stars, Zadeh was about to stumble onto crucial new information about star lifecycles. He had applied for observation time at the newly constructed Atacama Large Millimeter/submillimeter Array (ALMA) Observatory, a state-of-the-art sky watching facility in the dry heart of the Atacama Desert in Chile. Disappointingly, Zadeh's application was denied due to high competition and demand. However, he didn't stop there.

Zadeh was able to turn a minor defeat into a major discovery when ALMA released to the public several images of the center of the Milky Way captured from its powerful telescope. Analyzing this public data, Zadeh and his colleagues were amazed to see clumps of silicon oxide, a material that commonly appears during star formation, near the black hole at the center of the galaxy. Zadeh then turned to data from previous observations of his own, which verified the presence of silicon oxide. At that point, he knew had early confirmation of a controversial idea: that young stars could be born in the wake of a dying star.

Let's take a moment to put "young" into context. Scientists have observed stars that are a million to a few million years old near the supermassive black hole, giving credence to the theory that star formation might take place there. The formations identified by Zadeh are about 10,000 years old, which is the youngest stage at which we can detect stars. If stars that young are spending their formative years near the black hole, this lends support to the notion that they have somehow overcome the inhospitable conditions created by the black hole and are growing up into normal, healthy stars right in its face.

But why has the black hole been considered by scientists such an unfriendly spot for star formation? Black holes live up to their reputation for being massive, ominous forces of outer

space destruction. The remnant of a former star, a black hole is a tightly condensed pack of matter with a gravitational pull so strong it can destroy anything that comes into its path, even a beam of light.

The "tidal forces" created by the black hole's Hoover effect have generally been thought to make the creation of new stars impossible. A star is born when a cloud of dust forms and becomes strong and dense enough to collapse under its own gravitational pull. Black holes can halt this process by ripping apart budding stars with *their* gravitational forces. Once ripped, a cloud is no longer dense or compact enough to collapse and become a star.

Ed Churchwell, an astrophysics professor at University of Wisconsin-Madison, says that if Zadeh's findings are correct, it will give astrophysicists "a very different view on the conditions under which stars can form…around the black hole." Zadeh's theory on how this is possible, dubbed the "paradox of hostility," proposes that the inhospitable conditions created by black holes may actually play some role in helping young stars to hatch. The theory holds that while black holes have the ability to stretch a cloud apart in one direction so that it rips and cannot become a star, they can also squeeze the cloud in another direction, actually making the cloud denser and therefore able to collapse and turn into a star. "Nature has a way to do it, even in the toughest environment," Zadeh says, his eyes twinkling with wonder behind his black square glasses.

Of course, not everyone accepts the notion that Zadeh's infant stars did indeed form near the black hole. An alternative theory proposes that they may have formed elsewhere in the galaxy, under more stable conditions, and then "spiraled" to their current position. Churchwell is less inclined to accept this theory of star migration. "Even moving at high speeds, space is very

large, and so to get these very young stars in the closer neighborhood of a black hole takes some time, not something that can be done in an instant," Churchwell says.

Zadeh agrees and says that the migration theory is not as widely accepted anymore, based on the absence of star trails emitting from the stars we see near the black hole. "When you have a cluster of stars coming in toward the center [of the galaxy], you would expect to see a trail of stars behind it," Zadeh says. What's more, for stars to migrate to our galaxy's supermassive black hole, they would have to be associated with an intermediate-mass black hole, a smaller kind of black hole which still only exists in theory. The more likely alternative seems to be that stars are forming and putting down stakes near the Milky Way's supermassive black hole.

Looking forward, Zadeh plans to apply once again to ALMA for a chance to observe the stars more closely in order to see if jet flows can be detected. "Generally when stars are young, in the early phase of star formation, they have jets and outflows coming from them," Zadeh says. He adds, like a patient and understanding father bringing up an unruly teen, that this is a normal "phase" in star development. "I mean the sun went through this also. Stars go through this all the time," he notes sympathetically.

Star lifecycles, supermassive black holes, gravitational forces in play tens of thousands of light years away from the Earth. It might not seem to have much bearing on us, but Zadeh doesn't agree. He believes anything we can learn about star formation in a hostile region may shed light on other key questions, such as how our solar system was formed and under what conditions. "It provides an insight into how nature finds a way for life to survive, which is mind-boggling and exciting," Zadeh says, the smile appearing in the corner of his mouth.