Steward Observatory’s Dr. Kate Alexander is the recipient of a Sloan Research Fellowship to advance her studies of extreme cosmic events

Dr. Kate Alexander, Assistant Professor for the UArizona Department of Astronomy and Assistant Astronomer at Steward Observatory, is the winner of a 2024 Sloan Research Fellowship. Awarded this year to 126 of the most innovative young scientists across the U.S. and Canada, a Sloan Research Fellowship is one of the most competitive and prestigious awards available to early-career scholars. “The Fellowships are often seen as a marker of the quality of an institution’s faculty and proof of an institution’s success in attracting the most promising early-career researchers to its ranks” said Nate Williams, Communications Director for the Alfred P. Sloan Foundation.

During her first year as faculty at UArizona, Alexander took a lead role in understanding the gamma ray burst event GRB 221009A: the brightest cosmic explosion ever seen by humanity.
Gamma ray bursts are the short-lived bursts of high-energy light that can signal the deaths of very massive stars, often with an accompanying underlying supernova. This particular burst demolished all previous records and is enabling a detailed look at these cosmic explosions and their aftermath to inform high energy physics models of how they are produced. Alexander co-led analyses of the relativistic jet associated with this explosion, which broke the theoretically motivated “structured jet” model usually used to explain gamma-ray bursts.

Alexander also worked prominently on analyses that searched for the anticipated underlying supernova emission, which was nearly impossible to see from ground-based data, but was uncovered in recent James Webb Space Telescope (JWST) observations.

In her research, Alexander studies “energetic transients”—extreme, short-lived cosmic events such as gamma ray bursts, neutron star collisions, and tidal disruption events: when a supermassive black hole tears a star apart. In the latter process, Alexander is especially interested in the powerful jet of particles that shoots out of a black hole when it consumes a star, with emissions launching at the speed of light. “Black holes are messy eaters,” Alexander said, and she studies what they spit back out when they devour stars.

To get a full picture of these distant, cataclysmic events, Alexander pulls data from various telescopes around the world, including the Very Large Array (VLA) in New Mexico. The jets she studies emit light across the electromagnetic spectrum. In order to get a full picture of the behavior of a black hole and its surrounding environment, “you really need to put together a very rainbow-colored look at it,” Alexander said. Her data is a high-tech patchwork of radio waves, X-rays and optical light, gathered simultaneously from different observatories.

Alexander’s work bridges astronomy and extreme physics. “Black holes are intrinsically cool, but they are also important for understanding galaxy evolution and stellar physics, and trying to understand how massive stars actually die.” At the moment a star is ripped apart, it releases a huge amount of energy. Alexander sees these dramatic events as perfect laboratories for advancing our understanding of high-energy physics.

“Kate Alexander is not just among the leaders working to discover and observe transient sources, she is also a driving force for our ambitious efforts to understand the physics behind their spectacular and astonishing observed properties,” said Buell Jannuzi, Head of the UArizona Department of Astronomy and Director of Steward Observatory. “The Sloan Fellowship recognizes Kate Alexander’s demonstrated scientific leadership and will help her to lead the exciting progress the coming decade is anticipated to contribute to our understanding of the Universe.”

Alexander took a faculty position at UArizona’s Steward Observatory last year, after completing her Ph.D. at Harvard (2018) and securing a NASA Einstein Postdoctoral Fellowship at Northwestern University. “It’s great to be at a large department like Steward because transients span a lot of different subfields in astronomy,” said Alexander. “There are so many great observational resources here.” Steward Observatory is also a notable place for astronomy students to gain hands-on research experience using world-class telescopes, and Alexander is quick to celebrate the grad students on her research team: “I’m very proud of my students that
I've been working with since I've gotten here.” The Sloan Fellowship will allow Alexander to continue to grow her research group. “I'm really excited to continue working with students,” she said, and “I'm really happy to be joining a cohort of amazing scientists.”

In addition to helping fund deeper research and a growing team, the Sloan Fellowship will aid Alexander in developing software infrastructure to help share her data sets from various observatories with other researchers. “Since we collect data from so many different telescopes over such a wide range of time scales, if you're a newcomer to the field, it can be prohibitive to figure out where to track down all the information that exists.” Alexander's aim is to develop a centralized database to share with the broader community of astronomers.

Alexander’s Sloan Fellowship comes at a pivotal time in transient research: recent large-scale surveys that cover big regions of the sky have revealed far larger numbers of transients than Alexander had access to in previous years. Instead of studying individual jets from supermassive black holes, Alexander can begin to draw comparisons across whole populations of black holes. “We've been doing a first systematic radio survey of tidal disruption events,” she said, “and we've already found a bunch of surprising things that we hadn't seen before and didn't expect.”

Looking ahead to other ambitious sky surveys that will imminently begin at the Vera Rubin Observatory and the Legacy Survey of Space and Time (LSST), Jannuzi said “we are about to enter an unprecedented age of opportunity in the area of ‘Time Domain Astronomy.'” Alexander is poised at the brink of this new era of radio astronomy, and her research will illuminate new facets of high-energy physics that would be impossible to recreate in an Earth-based lab.

Because black holes don’t directly emit any light, these tidal disruption events are also a chance to see what scientists have long worked to visualize. “Watching a black hole messily devour a star is a chance to shine a flashlight on something that's otherwise hidden from view and hard to study,” said Alexander.