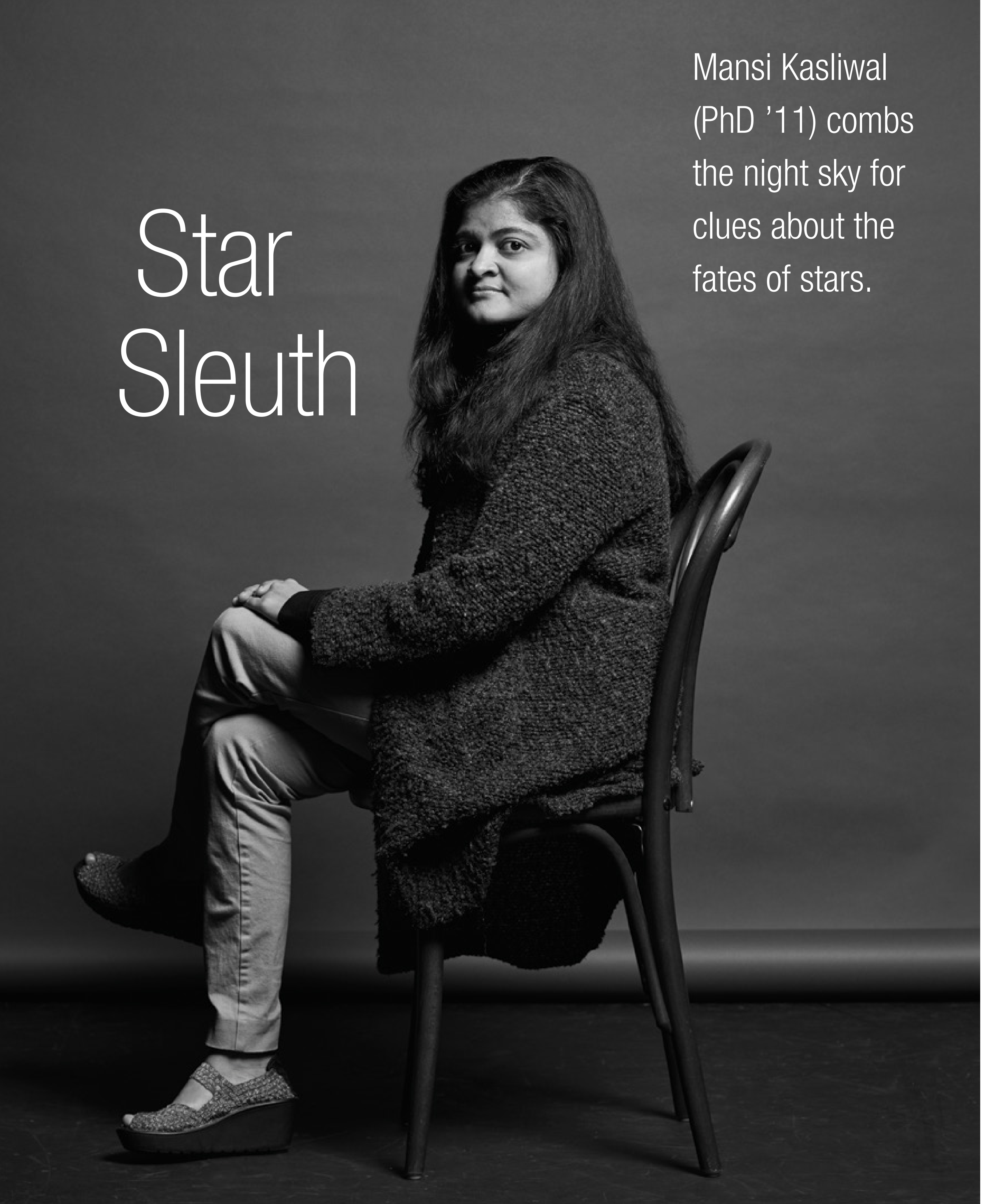


Star Sleuth

Mansi Kasliwal (PhD ’11) combs the night sky for clues about the fates of stars.

Above: In 2002, a star called V838 Mon became the brightest star in the Milky Way. This image, taken with the Hubble Space Telescope, reveals the so called light echo—the flash of light reflected from layers of dust surrounding the star.

Mansi Kasliwal (PhD ’11), an assistant professor of astronomy at Caltech, searches the night sky for astronomical transients—the flashes of light that appear when a star becomes a million to a billion times as bright as our sun and then quickly fades away. As principal investigator of GROWTH (Global Relay of Observatories Watching Transients Happen), she heads up a worldwide network of collaborators who are trying to capture the details of these transient events to find out more about how they evolved.

Kasliwal grew up in Indore, India, and came to the United States to study at the age of 15. She earned her BS at Cornell University and then came to Caltech to complete her doctoral work in astronomy. After a postdoctoral fellowship at Pasadena’s Carnegie Observatories, she joined the Caltech faculty in 2015.

We talked with Kasliwal about her fascination with the night sky, why she doesn’t mind 3 a.m. phone calls, and the dream she hopes will take her to the South Pole.

Caltech Magazine: What is the main focus of your research?

Mansi Kasliwal: It’s basically about discovering and understanding transients—the energetic flashes of light that cause the fireworks that adorn the night sky—and what they can tell us about the elements and where they are synthesized, the fates of stars, and what happens in the final stages of their lives.

There are two main themes to my research: One has to do with optical transients, or transients that can be seen with optical telescopes—that’s where GROWTH comes in—and the other is around infrared transients and exploring the dynamic infrared sky.

CM: Let’s start with GROWTH.

MK: I’ve done optical astronomy for my entire career here. GROWTH builds off of that. GROWTH is primarily looking at optical transients from a host of different observatories to build a more complete picture of the physical processes of their evolution. We have a network of 18 observatories in the Northern Hemisphere. As Earth rotates and daylight creeps in at one of our locations, we switch observations to one of our facilities westward that is still enjoying nighttime.

CM: How do you communicate with one another when one of the observatories sees an intriguing transient in the night sky?

MK: Some alerts are fully robotic, i.e., my computer calls me. Some alerts are from my collaborators on the other side of the globe. The best part about GROWTH is that even if a phone call is at 3 a.m., everyone’s sleepy voices are actually quite excited.

CM: A new system of telescopes is coming online at Caltech’s Palomar Observatory in Southern California called the Zwicky Transient Facility (ZTF). What makes it better than the Palomar Transient Factory that was there before?

MK: ZTF is an order of magnitude faster in survey speed, so we can either search more sky or we can search the sky faster or we can go deeper. This will help us find many more rare, fast, and young transients. ZTF is a fantastic new discovery engine providing targets for the GROWTH network.

CM: I know GROWTH is looking for baby supernovas, among other things. Why is that important?

MK: Supernovas shine for months. But what happens in the first 24 hours after explosion, when the supernova is in its infancy, is critical. The initial flash of light immediately interacts with the surrounding material and tells us what that pristine material was before the supernova exploded. Then, there's a 10,000-kilometers-per-second blast wave that sweeps it all up. When we study the ultraviolet light and the spectroscopic signatures with the GROWTH network, within the first 24 hours, we can get a glimpse into what type of star exploded.

CM: You're also searching for what you call the "cosmic mines," the heavy elements in the periodic table, which come from extreme gravitational events. Tell me how you work with Advanced LIGO [the Laser Interferometer Gravitational-wave Observatory] on this?

MK: As soon as the LIGO researchers think they have detected a gravitational wave, they tell me roughly which part of the sky it's in, and we drop everything we're doing and go and search this large area of the sky for any flashes of light that could be physically associated with that signal.

What we're hoping for is at least one neutron star in the merger that LIGO saw. If a neutron star smashes into a black hole or into another neutron star, then there will be light. A neutron star can feed the formation of these very heavy elements, like gold, platinum, and uranium. When these elements decay radioactively, that gives you photons.

So when we get notification of a new gravitational-wave signal, we search the sky for flashes and rack our brains about which ones are completely unrelated, which ones are in the foreground, which ones are in the background, and which one—just one, if any, out of all of them—is the real thing. It is a very complicated process of sifting through a large volume of data in a very short timescale, because we only have 24 hours before the flash, if there is one, fades away.

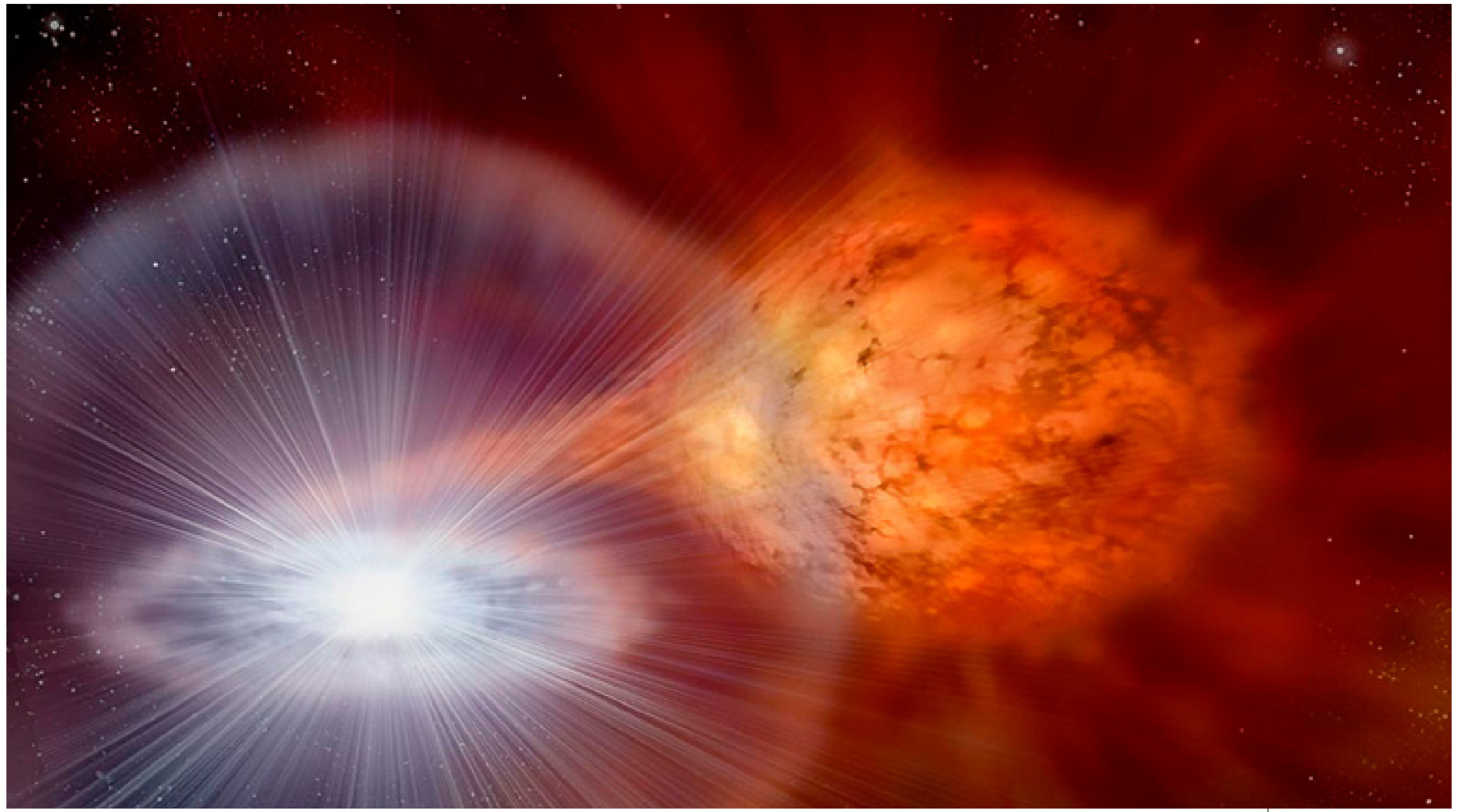
So far, every time we've done this, it turned out to be two black holes that were merging, and we found nothing because black holes are very black. They generally don't produce the electromagnetic light we are looking for. But it's all good preparation for when LIGO finds something with one or two neutron stars.

This work with LIGO ties together my two loves in my professional life, the optical and the infrared, because the signal that is expected from such a violent merger—one that should produce all these sparkling, heavy elements—has two components. One is a fast-fading optical blue component, which is what the GROWTH network is designed to pick up, and the other is a more slowly evolving infrared component. Unfortunately, no one has a wide-field infrared telescope yet.

CM: So exploring the infrared night sky is the new area you're developing now?

MK: Yes, this is the new project that I'm doing, which is something that just didn't even exist as a field a few years ago because the infrared is a very hard waveband to probe. The night sky is very bright, and detectors are very expensive. There are a lot of practical reasons astronomers have shied away from exploring the dynamic infrared night sky.

But just in the last few years, we've made some progress. I'm doing a project called SPIRITS. This is the SPitzer InfraRed Intensive Transients Survey. It's a large program of the Spitzer Space Telescope. We are looking at 200 galaxies over and over again to see if there are any new flashes of light in the infrared wavebands. The cool thing here—quite literally cool—is that the search found a class of transients that were so cold they were completely missed in optical and other wavebands. We think that some of these could be the result of the mergers of two stars, or they could be the birth of massive star binaries in which you have a shock that gets driven out. That shock excites the surrounding medium in the infrared wavebands and lights it up. We don't know what those transients are, so we just gave them a name. The project was SPIRITS, so we call them SPRITEs.



Now I'm taking this to the next level. At Palomar Observatory, I'm putting together a 25-square-degree infrared camera that will be able to cover the entire night sky in one night. I hope to commission it in November. If that goes well, and I'm able to prove the technology there, then I want to go to the cold and dark South Pole to do a really nice systematic search of the night sky for infrared transients.

CM: What is it like being back at Caltech as a professor when you were here as a doctoral student just a few years ago?

MK: Caltech is certainly a dream job for me, and it was sort of like coming back home. Caltech has the kind of students that I know are all awesome. The grad students at Caltech were my friends, and I've seen what they can do. So I knew that, being a faculty member, I would have the privilege of working with students who are not only brilliant but also have an amazing attitude.

CM: Are you down at Palomar Observatory frequently?

MK: Yes, and I'm always excited about working with Caltech's Palomar and Keck observatories. I know the telescopes well, what to do with them. Also, I've known the engineers and the staff there for many years, and I've had a really great relationship with them. It's really fun to work with the staff. They're very dedicated. They revel in the joy of discovery.

CM: You've been in the U.S. now for longer than you lived in India. Do you get back there regularly?

MK: My parents live in India, so we go back once a year. Also, I have two GROWTH co-investigators in India. In fact, one is a Caltech alum who is now a faculty member at the prestigious Indian Institute of Technology in Mumbai. His students come here for internships; I send students to him for internships. This is wonderful in terms of the collaboration.

Bringing astronomy at the cutting edge to India, with this privileged access and opportunity I have here at Caltech, to share that with my colleagues in India … it's really fun.

CM: And last, but certainly not least, you also have a young child.

MK: I have a two-year-old son. His name is Vyom. That means "the universe" in Sanskrit. I have a little baby universe who is the joy of my life. [C]

Above: An artist's impression of a white dwarf "stealing" matter from a companion star.