Young Astronomer Reaches for the Stars

PIPER REID

Piper Reid tackled her first astronomy project in sixth grade, and she continued to aim high — even when life threw a seemingly insurmountable obstacle in her way.

Tom Field

Eleventh grader Piper Reid was tongue-tied when she met 2006 Nobel Prize winner John Mather. Just a year earlier, Piper had waited in line in an attempt to meet the scientist who had helped make key discoveries about the nature of the cosmic microwave background. But this time, it was Mather who came up to her and extended his hand.

Not that Piper didn't have credentials of her own. She had been tackling various astronomy projects since she was 11 years old, and her most recent had won second prize in the ExxonMobil Texas Science and Engineering Fair, fourth prize in the Intel International Science & Engineering Fair, and even garnered her the 2012 Priscilla and Bart Bok Award from the American Astronomical Society and Astronomical Society of the Pacific.

Piper is one of a number of young adults who are showing the exciting science amateurs can do from their backyards. And Piper's recent recovery from a life-threatening car accident makes her story even more impressive.

BOK AWARD Piper accepts the Priscilla and Bart Bok Award for her research. She stands with Katy Garmany, the former president of the Astronomical Society of the Pacific, and Henry Wanjune Lin, the second-place Bok recipient. The award included a trip to the 2013 annual meeting of the American Astronomical Society.

An Early Start

Piper grew up in Austin, Texas, in a home that encouraged scientific thinking. Her father, Mike, had been observing since the 1990s. So he wasn't surprised when Piper wondered out loud in sixth grade if she could make her own color-coded all-sky brightness maps, like those that appeared in these pages (*S&T*: February 2006, page 99). Mike drove his daughter all over Austin so they could take snapshots of skyglow from different locations. Piper turned the data into a science project that made it to the finals at the regional science fair.

In the following months, as she watched her father doing astronomical imaging, she found herself wanting to do more. "Don't get me wrong, his images are really great — in fact, they're beautiful," she explains. "But to me, it was a bit frustrating. He'd say, 'This is M-something. And this is M-something-else.' And I'd think to myself, I don't know why he bothers taking pictures. He should be wondering, 'How'd that get there? What's it made of?'"

Piper eventually convinced her father to trade up from his clumsy tripod to a rock-solid pier. "It wasn't too hard to talk him into the upgrade," Piper says. "I just pointed out how much better his pretty pictures would be if he had a good mount!" Of course, the pier served a dual purpose — by eighth grade, Piper had completed another science project titled "Differential Brightness Method for Detection of Extra Solar Planets."

"How cool is that?" Piper exclaims. "You can detect the transit of extrasolar planets because they dim the starlight as they move across the face of distant stars." This time, her project won first place at the Austin Energy Regional Science Festival.

Build It and It's Yours

Soon afterward, Mike brought home a box of parts for a home-built spectrometer kit. He plunked the box down and announced, "Build it and it's yours."

Piper says she was a bit intimidated by the task, but excited too. "I like to figure things by doing them. I think you learn better if you do it yourself." After some trial-and-error, she had assembled a working spectrometer.

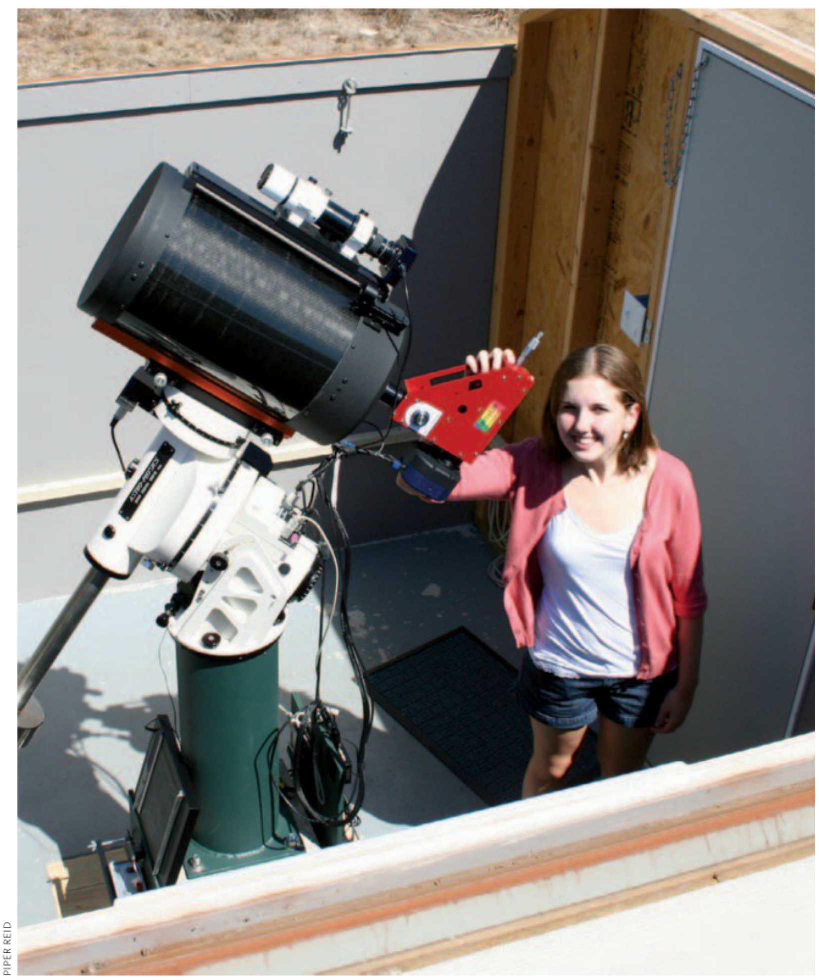
Piper used her spectrometer to analyze Jupiter's spectrum, a project that took fourth place in the regional science fair. But she knew the project, as much as she enjoyed it, wasn't pushing her boundaries. Her next project was more ambitious.

Now a tenth-grade honors student, Piper combined her new photometry and spectroscopy skills to conduct a study she titled "Photometric and Spectroscopic Analysis for the Determination of Physical Parameters of an Eclipsing Binary Star System." Her project clearly demonstrated that it's possible for a high-school student to capture the data necessary to calculate the orbital period, velocity, separation, radius, and mass of both stars in a binary system.

Piper started with the contact binary BB Pegasi, whose two stars orbit so closely that they touch each other. The system is relatively bright, has a short period of eclipse, and its position in the night sky makes it a good observing target. Using a Celestron C11 telescope and a QSI 583 camera, she spent five hours capturing 8-second images with *MaxIm DL* software. She stacked the images before measuring the brightness and importing the data into Microsoft Excel. The beautiful light curve that resulted showed a periodic dimming as the two stars passed in front of each other.

Piper had hoped to study the same system using spectroscopy, but it turned out to be too dim for her location and equipment. So she chose the brighter binary 57 Cygni for the spectroscopic half of her project. After capturing and stacking 12 ten-minute spectra, she calibrated and

ACCOMPLISHED ASTRONOMER **Piper Reid started her first project when she was 12, measuring sky glow from various locations in Austin, Texas. Now she uses a Celestron C11 and homebuilt spectrometer to take on a range of projects.**



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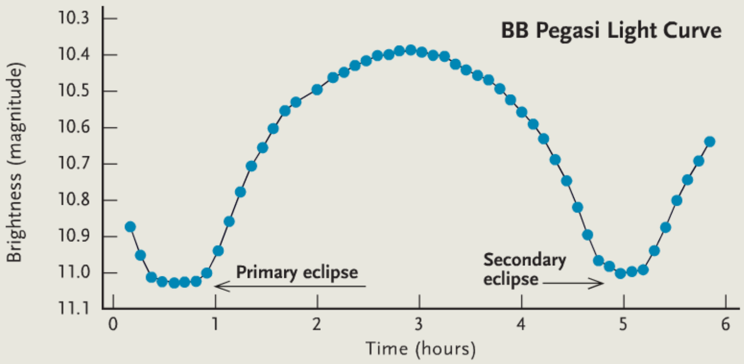
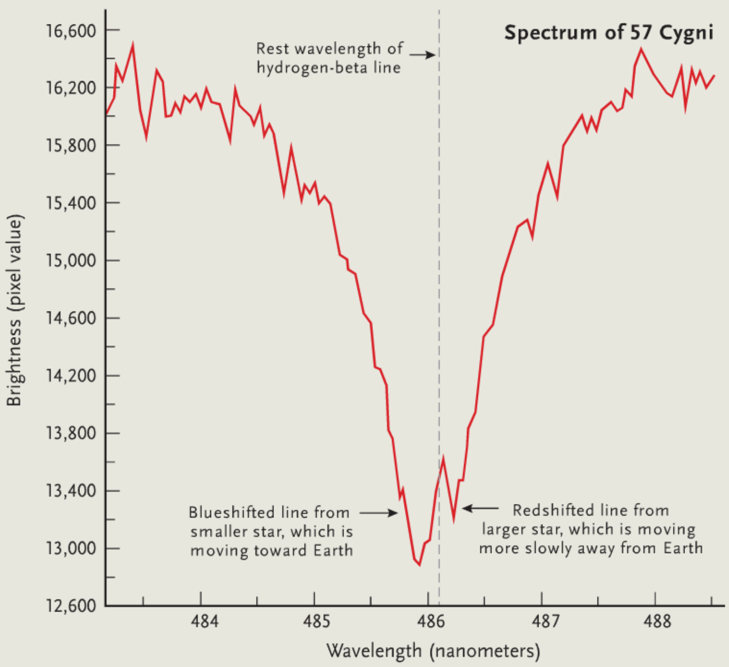
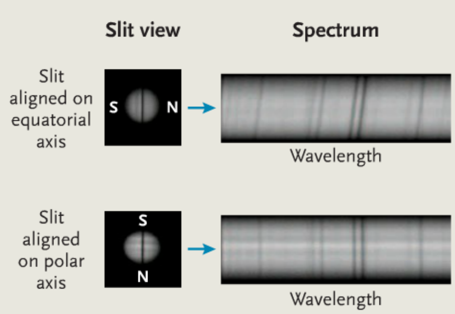


BB PEGASI Piper collected 8-second shots over a six-hour period to create a series of stacked images of a contact binary-star system. The resulting light curve shows the two stars eclipsing each other. In the primary eclipse, the fainter star passes in front of the brighter one.



SPEEDING STARS Piper measured the spectrum of 57 Cygni, a detached binary system, to see how quickly its two stars orbit each other. The spectrum shows the smaller, fainter star moving toward Earth more quickly than its more massive companion moves away.



TILT AND SPIN Jupiter's spectrum along its equator (*top*) shows tilted spectral lines: half the planet rotates away from Earth (redshifting the lines), the other half rotates toward Earth (blueshifting the lines). Comparing the tilt to the straight lines measured from pole to pole (*bottom*) gives the rotation speed.

S&T: LEAH TISCIONE, SOURCE: PIPER REID (3)

viewed the spectra using *RSpec* software. As the two stars orbit a common center of gravity, their spectral lines shift to opposite ends of the spectrum. Piper used the Doppler shift to calculate the radial velocities of the two stars. "I was worried about the accuracy of my data," she says. "But when I compared my values to the accepted values, mine were only 9.5% different."

Piper's project won first place in Physics and Astronomy at the regional science fair, as well as Best of Fair, and second place in the ExxonMobil Texas Science and Engineering Fair. These awards qualified Piper to enter the Intel International Science and Engineering Fair, where she placed fourth in the Physics and Astronomy category. At the same fair, she received the prestigious Bok Award from the AAS and ASP. "I was totally shocked to win anything," she says. There were so many amazing, amazing projects there. I didn't expect to even place in the competition."

Things Fall Apart

One day before she was to begin her junior year in high school, Piper was driving home from an SAT prep course. An unidentified driver illegally passed her on a two-lane rural country road, then swerved back into Piper's lane to avoid an oncoming car. The driver clipped the front of Piper's car, running it off the road. It flipped three or four times before coming to a rest.

"It was like slow motion," she recalls. "I was looking through the windshield, watching the trees flip upside down. I couldn't believe it."

The rest of the story comes from Piper's mother, Kim: "When we arrived at the scene of our daughter's car accident, her car was upside down." Paramedics cut Piper free from the car and took her to the emergency room. But over the next few hours, her family and doctors realized she had suffered a traumatic brain injury.

"She got very strange, talking weird. She was confused, didn't know why she was there," Kim says. "When she finally came home from the hospital, our daughter had changed. For more than a month, her personality was totally flat."

Piper tried to go back to school, but she nodded off in class and took long naps in the nurse's office. When her mother picked her up after school, Piper couldn't remember what she had done all day. Finally, for the time being, the family took Piper out of school.

Piper did little but sleep for the entire first month she was home. Then, over the next several months, she worked hard to get back on her feet. Her mother gathered home-schooling materials, and they began to study together at home.

"At first, the doctors wouldn't allow me to read or watch TV or do anything," says Piper. But eventually, the doctors allowed her to read for a few minutes at a time. "I'd get headaches. My eyes would get blurry. I'd get

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MEETING A HERO Piper was delighted to shake hands with John Mather, a 2006 Nobel Prize winner, at the AAS meeting.

confused. I'd start solving a problem and forget what I was doing. This was really difficult for me, terrible for my self-esteem. It was scary for all of us."

But gradually, over several months, and with her family's support, Piper climbed back toward being the person that she had been before the accident. Though she still hadn't fully recovered, Piper and her family decided she would attend the AAS conference that was coming up in a few months. The Bok Award that she had received at the Intel Science Fair included an all-expense-paid trip to the conference so she could present a poster of her photometry/spectroscopy research. Attending the conference gave Piper a goal to work for. And it was a goal she succeeded in reaching.

Meeting with the Pros

I first met Piper at that very AAS conference when she came to my RSpec booth to introduce herself — I was excited to see a high-school student doing such advanced work. I visited Piper at her poster too, where I found her confidently explaining her project to a steady stream of impressed astrophysicists from all over the world.

By then, Piper was in 11th grade and had recovered from her accident. She was doing sophisticated science again and explaining her research like a pro. "I love explaining things to people," she says. "In the past, I've had to explain my projects in simple terms. But the attendees at the AAS conference totally understood what I was explaining and asked me lots of great questions. I was in heaven!"

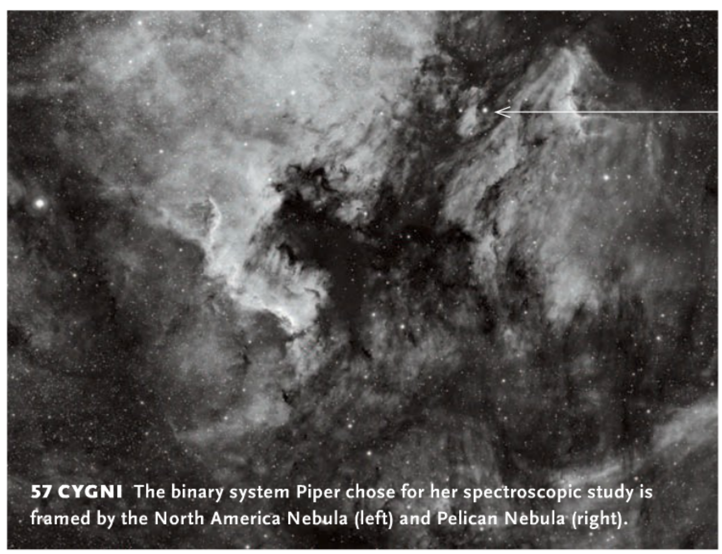
Among the hundreds of attendees to whom Piper explained her project was John Mather, Physics Nobel Laureate for his work on the microwave background. Mather wrote to me in an e-mail:

> I was very impressed by Piper's accomplishments and ingenuity. She told me about the spectrometers that she started developing at such a young age and I thought, "What a brilliant young person!" And, what a wonderful degree of progress our world has made since I was that age, when the only project a young person could imagine was to buy a few little lenses from Edmund Scientific and try to make a telescope or an elementary spectrometer. I'm really delighted to know her and see her enthusiasm for discovery.

Piper says meeting Mather was one of the high points of her year. And it gave her the confidence to pick up where she'd been before her accident. She's taking on new projects now, such as measuring the rotational speed of Jupiter and Saturn. By taking the spectrum of each planet along their equators, she measured the tilt of the spectral lines due to the Doppler shift, finding rotation rates that agree with the accepted values within 8% and 15%. That's not bad for a young amateur using backyard equipment!

Piper's accomplishments remind us that opportunities abound to take on great projects, overcome obstacles, and expand our horizons. Perhaps you'd like to do some science with your equipment, expanding your astronomical repertoire beyond visual observing and imaging? Piper shows us that we're all capable of amazing things. ✦

*S&T contributing editor **Tom Field** is the author of the popular RSpec spectroscopy software package and confesses to being a spectroscopy evangelist. He encourages readers to view Piper's research, as well as other exciting sample projects, at **www.rspec-astro.com/piper**.*



57 CYGNI The binary system Piper chose for her spectroscopic study is framed by the North America Nebula (left) and Pelican Nebula (right).

S&T: DENNIS DI CICCO AND SEAN WALKER