From a Star Journal

EMMA LEHMAN, a senior **astrophysics major** from Concord, N.H., is researching **planetary nebulae** with astronomy professor **Karen Kwitter**. Currently working on her Senior Honors Thesis, she traveled to Mauna Kea and the **Gemini telescope in Hawaii** to gather data for her **senior astrophysics thesis** on planetary nebulae.
We asked Emma to keep a **journal** of her experience, which she shares with us here.

About the Project

Planetary nebulae are the glowing shells of gas ejected by medium-sized stars at the end of their life. We can determine their chemical composition by analyzing the spectra of these objects. Obtaining this information for many planetary nebulae in different parts of the galaxy allows us to see how elements are distributed throughout the galaxy and give us clues as to how galaxies are formed.

In 2008, the National Science Foundation (http://www.nsf.gov) awarded a three-year grant to pursue this research to co-principal investigators Kwitter, Prof. Richard Henry from the University of Oklahoma, and Prof. Bruce Balick from the University of Washington. The purpose of this trip to the Gemini-North Observatory was to obtain spectra of planetary nebulae in the halo of the Andromeda galaxy.

Day 1: Thursday, October 22

After a three and a half hour drive to Newark, a 10-hour flight to Honolulu, and a short flight to Hilo, Hawaii, we are finally here! Professor Karen Kwitter (http://www.williams.edu/Astronomy/people/kkwitter/) (my advisor) and I traveled together, and met up with one of our collaborators, Professor Richard Henry of the

University of Oklahoma, at the Hilo airport. After 20 plus hours of traveling, I am exhausted!

Tomorrow we drive up to the base station on Mauna Kea, (http://www.ifa.hawaii.edu/mko/) where we will stay in a dormitory for the next four nights. The telescope time we have was awarded to Karen and her collaborators as part of their larger project to study galactic chemical gradients. I get to tag along because I will be reducing and analyzing the data.

Day 2: Friday, October 23

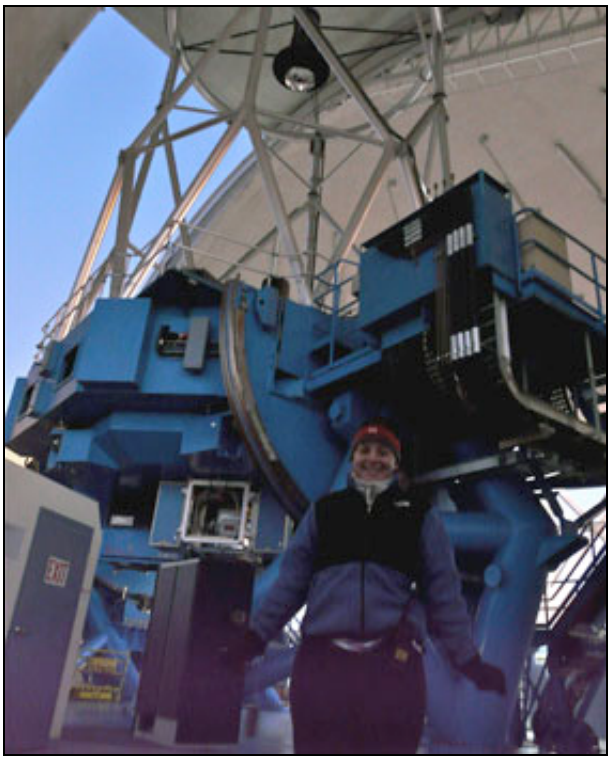
We arrived at the hotel in the dark last night, so it was a wonderful surprise to wake up to a beautiful view of the Pacific Ocean. In the distance I could see Mauna Kea towering over the island, with three white dots indicating observatory domes up top. After breakfast we drove up to the base station on Mauna Kea. The base station is at 10,000 ft. while the summit is almost 14,000 ft. All observers are required to spend a night at the base station before they begin to acclimate to the altitude. It was a bit cloudy this morning, so we got the unique experience of driving right up to and through the clouds!

At 4 p.m., we sat in on the daily videoconference between the base station (where I am), the Gemini office down in Hilo, and the crew at the summit. Our team introduced ourselves and Karen talked a bit about our project. We have now met with Professor Bruce Balick, our second collaborator from the University of Washington, so everyone is here and ready to go.

The day ended at midnight with a security briefing at the base station. Kathy Roth (Gemini Science Fellow) taught us how to use pressurized breathing to get more oxygen into our lungs if we start feeling faint. We learned about the signs of altitude sickness, emergency procedures, and the do's and don'ts of the observatory. I am very excited to go up to the summit tomorrow!

Day 3: *(the night of)* Saturday, October 24

We left for the summit at about 5 p.m., and the trip up was at once breathtaking and terrifying. The views were astounding, but the road was so rough that I was convinced we were going to bounce off the road and tumble down the mountain at any moment. Rosemary Pike (system support associate at *Gemini North*) and Kathy, who are both Gemini operators, drove us up. They gave us a quick driving tour of the summit and the other telescopes.



Rosemary allowed us in the dome to watch as she opened it up and started the telescope's systems. The telescope is HUGE! The building itself has five floors, with the telescope and big silver dome on the fifth floor. The mirror is 8.1 meters across, and weighs about 24 tons. The telescope takes up most of the room in the dome, which is the size of a large house.

Once the telescope was started up, we went back to the control room, which was video linked to the office in Hilo where Karen was working from. As soon as the sun set we jumped into action, slewing the telescope to point at our targets and collecting data. Our main objective is to get the spectral line at 4363 Angstroms for each object, which will help us determine the electron temperature of the nebulae. We had budgeted three hours of exposure time per object in order to get this line.

The data for the first exposure of our first nebula came in, and everyone was very excited to see a faint white stripe at 4363 Angstroms. We hadn't expected to see it so soon! After only an hour we had a good enough signal to move onto our next object. It looks like we will get through all of our planned targets within the first two nights! This realization sent all of us to finding other targets we could point at, looking up finding charts for the new objects, and beginning the target approval steps, which will have to be rushed if we want them approved by Monday.

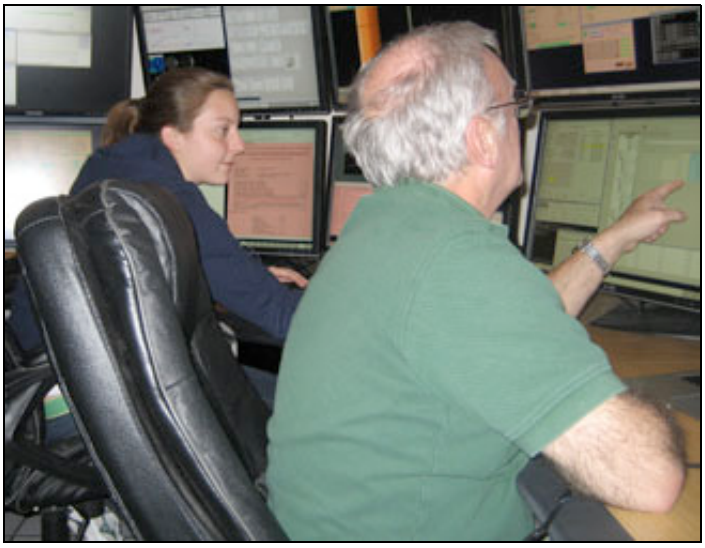
Once things were running smoothly, Kathy trained me on how to queue up the next objects, center the telescope, check for pointing accuracy, and check the data coming in. I had not expected that I would be allowed anywhere near the controls, so this was really exciting. I felt very powerful. The night was punctuated by brief periods of high humidity when we had to close the dome to prevent dew or frost forming on the mirror. The last of these was very tense as we raced to finish up our exposure before the dome had to be closed.

The stars up here are spectacular, and I saw several shooting stars from the Orionids meteor shower brought on by the passing of Haley's comet. As twilight approached, I saw the Zodiacal Light for the first time. This is a glowing stripe across the sky near the horizon caused by the dust in the disk of our solar system reflecting light from the approaching sun.

We closed up around 5:30 a.m., and drove back down to base station as the sun rose over the clouds. I had a quick breakfast with a handful of very sleepy astronomers, and now I am very excited to go to bed!

Day 4: *(the night of)* Sunday, October 25

I woke up at 3 pm this afternoon, and arrived in the dining hall in time for dinner, which starts at 4 p.m. If you are on an observing schedule here, you eat three meals: dinner, “night lunch,” and breakfast, just before bed. There are ten major telescopes at the summit, so there are many different international groups of astronomers mingling in the dining hall, along with the technical staff for each telescope and the kitchen and custodial staff for the base station.



We drove up to the summit around 5:30 p.m., and arrived just in time to see the sunset. As soon as the dome was opened we began taking data. After the data for each object comes in, we measure the fluxes and ratios for different spectral lines and determine whether it is worth spending more time on the object.

Our goal is to get data on as many objects as possible, so if an object is not emitting a very bright spectrum we move on. During long exposures when there is downtime I do homework, stargaze, or nap on the sofa.

Last night I had a bearable but constant altitude headache. Rosemary tells me that the first night at the summit is always the hardest, and it must be true because I feel much better tonight. Besides headaches, the high altitude has many other small effects: Chip bags expand until it looks like they will burst any minute; soda turns to foam in your mouth; the microwave works very quickly (as I learned when I exploded hot chocolate all over it!); and it is a bit more difficult to concentrate very hard on something. There is an unofficial “no consequential math” rule up here, so Karen does all of the important calculating down in Hilo.

The night was fairly smooth, with only a few hiccups due to apparatus errors. We have now collected data for all nine nebulae that were on our initial list, and we have moved on to our back-up program. At the end of the night we paused to enjoy the sunrise with a handful of brave tourists, then returned to the base station. I wont be getting much sleep today because we are going down to meet with Karen in Hilo in the afternoon.

Day 5: *(the night of)* Monday, October 26

The meeting in Hilo today went very well. We sat in Starbucks and Karen, Dick, and Bruce

talked about upcoming projects while I tried to soak up as much information as I could without asking too many questions! Most of the upcoming projects involve proposals for more telescope time. In particular, everyone is hoping for time on the Hubble Space Telescope so that we can learn about the carbon abundances in planetary nebulae.

We got a bit of a late start on collecting our data tonight because there was a “project of opportunity,” something that needs to be observed immediately and therefore takes precedence over everything else. In this case it was a gamma ray burst in a distant galaxy.

There were a few notable moments tonight. When we were looking at the star field to identify one of our objects, we noticed a blurry streak in the background. We did some quick maneuvering to move our spectral slit over the object, and it turned out to be a distant red-shifted galaxy! Later in the night during a long exposure Kathy let us take the infrared goggles outside. With them, I could see all sorts of things, including the Orion Nebula, various star clusters, and Andromeda Galaxy.

We finished around 5:30 a.m., and watched our last Mauna Kea sunrise as we drove down the mountain.

Day 6: Tuesday, October 27

I slept until 1 p.m. today, and then Karen picked me up and we drove back down to Hilo. We spent some time at the Gemini office learning how to use some of the software we will need to reduce the data. We are both pretty exhausted, so we went back to the hotel to sleep at 6:30 p.m. It feels great to be able to breath easily and run up stairs again, now that I am back at sea level!

Day 7: Wednesday, October 28

Karen and I didn’t have to catch our flight until 3 p.m. today, so we took advantage of the extra time and drove out to Volcano National Park. We saw huge old craters, smoking vents, and lots and lots of dried lava. Unfortunately

we didn't have time to go out and see the flowing lava, but we could see the huge plumes of smoke from the visitor's center.

After a stop at the farmer's market and a quick lunch we headed to the airport, and now it is time for the long journey home.

We had a successful run on Gemini, gathering more data than we had anticipated. I learned so much about telescopes and observational astronomy. When the trip is over, I will begin the process of reducing and analyzing our data (as well as catching up on all the work I missed while I was gone!). It was a long trip, but well worth it. I am so lucky that I got to tag along!

A bit about Emma Lehman:

Lehman is a teaching assistant in the astronomy department and the head TA at the Hopkins Observatory's Milham Planetarium (http://hopkinsobservatory.williams.edu/) . She has also worked on a research project at Swarthmore College, studying planet formation in the accretion disks of young stars under a grant from the Keck Consortium. In addition to astronomy, Emma enjoys working as a writing tutor, playing the violin in the student symphony, and writing for the ScientEPHic, a student science magazine.

---

reproduced with permission

Williams College
Office of Public Affairs
P.O. Box 676
Williamstown, MA 01267
413.597.4279