Spitzer/WISE Research Program for Teachers and Students:

Student Perspective of a Multi-Wavelength Observing Campaign

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Abstract

The combined Spitzer Space Telescope and Wide-field Infrared Survey Explorer (WISE) Research Program for Teachers and Students developed through a partnership between the Spitzer Science Center (SSC), the WISE E/PO program, and the National Optical Astronomy Observatory (NOAO) provides teachers and students the opportunity to do research using data collected by the Spitzer Space Telescope and the WISE mission. Two student participants describe their experience as members of a national network of students and teachers who collected and analyzed ground and space-based data on the active galactic nucleus NGC 4051. Strategies and tools that had been used to establish and maintain a collaborative team, as well as make data analysis accessible to secondary students and teachers, will be highlighted.

Preparation

Preparation for research on this scale was a long and interesting undertaking. Our research proposal for time on the Spitzer Space Telescope had been accepted. This meant that we could collect infrared wavelength images on our target, NGC 4051. Once we had received word as to when the observing run would take place, we started to coordinate ground-based observing during the same time period. Our task was to remotely control telescopes through New Mexico Skies Observatory (NMSO) and collect visible wavelength images of the active galactic nucleus, NGC 4051 (see figure 1). Over the course of a thirty day data collection period, a few dozen astronomers and students about our age worked on a rotating schedule to collect this data. On our designated observation days, we would wait until a specific, previously determined time to begin observing. Due to time differences between New Mexico and our homes in Connecticut, oftentimes we wouldn't begin observing until well past midnight. Although many long nights were involved in this process, it was all in the name of science. As student astronomers, we would get to control massive telescopes using our computers from the comfort of our homes. Through a simple internet browser we were able to set coordinates, slew the telescopes remotely, and apply light filters. It was remarkable. The images collected over this thirty day period were then sent to the Jet Propulsion Laboratory, awaiting our analysis when we later traveled to California. Besides late-night observations, we met after school for many days in order to review literature and the goals of the project. As students, we hadn't been fully exposed to astronomy in school as of yet, so our teacher, Susan Kelly, spent hours teaching us astronomical topics relevant to our impending experience in California. We were able to, in the course of a few weeks, grow immeasurably in our understanding of many aspects of astronomy. Together, we studied black holes, galaxies, and light photometry. We also researched other studies done by scientists involving black holes. It was quite a learning experience. Several cups of coffee, multiple late nights, and a number of hours spent reviewing literature later, we were prepared for the meeting.

Figure 1 (pictured at left): The active galactic nucleus (AGN) NGC 4051 was observed and analyzed using reverberation mapping and other techniques during a summer meeting sponsored by the *Spitzer/WISE Research Program for Teachers and Students.*

Introduction

During the summer of 2008, we were presented with the opportunity to attend a Spitzer Space Telescope Research Program for Teachers and Students, to be held at the Spitzer Science Center in Pasadena, California. At the time, as eighth graders who were extremely interested in science, such an experience was something we had always dreamed of, but didn't expect to experience. At least, not until we reached adulthood. Supported by the WISE mission, we were able to attend the meeting along with our science teacher (who had been invited to apply to the program) and about thirty other students and educators from around the country. There we reviewed data representing different wavelengths from various ground-based telescopes and the Spitzer Space Telescope in order to determine the diameter of the torus that is believed to surround the active galactic nucleus (AGN), NGC 4051 through reverberation mapping. We learned how to use the Aperture Photometry Tool (APT) software in order to see if we had captured any variations in light.

Summer Meeting

After a six-hour flight, we were both nervous and anxious about going to the Spitzer Science Center (at the California Institute of Technology) and JPL to work with real scientists on a big project. However, upon meeting the people we were to work with, we were happy to discover that they were very friendly people and eager to teach us. Having entered the Spitzer Science Center in Pasadena, CA, our first experience was a lecture presented by Varoujan Gorjian regarding the AGN, NGC 4051. He explained how the light frequencies travel differently through the changing densities of dust around the nucleus of the galaxy. The next day we began working. The software we used is called the Aperture Photometry Tool (APT—see figure 3). The data analysis process consisted of going through every image, of which there were thousands, and measuring the brightness of the center of the galaxy and how it changed over the course of the month long testing period. In order to ensure validity, we did the same measurements on the largest surrounding stars as well to compare. Consistency was maintained through a tool called a finder chart. This finder chart was a map of the galaxy and surrounding stars with numbered data points that we were to analyze in a very specific order using APT (see figure 2). The entire process, though complicated, became very natural as the week progressed. We also got access to two other programs affiliated with Spitzer—SPOT and Leopard. Using the two programs we learned how Spitzer observers plan and submit proposals, and gained access to the archives of previous Spitzer data. After many long days of performing computer analysis on Spitzer and ground-based data), we were presented with an amazing opportunity. We got to go on a tour of the Jet Propulsion Laboratory with lead astronomer, Varoujan Gorjian. He took us through the regular tour as well as showing us some of the areas not on the usual tour. We were able to see how real scientists and engineers worked. We saw the Spitzer Space Telescope offices and even viewed around command central for the telescope we worked with. The experience was truly amazing.

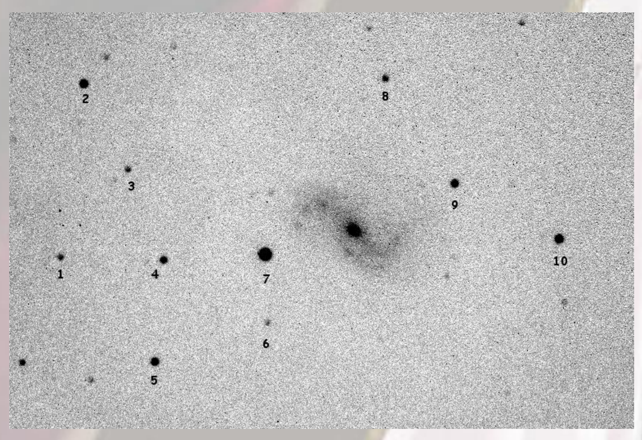

Figure 2 (pictured at left): A Star Finder Chart was created to ensure consistency.

Figure 3 (pictured at right): A program called *Aperture Photometry Tool* was used to analyze images.

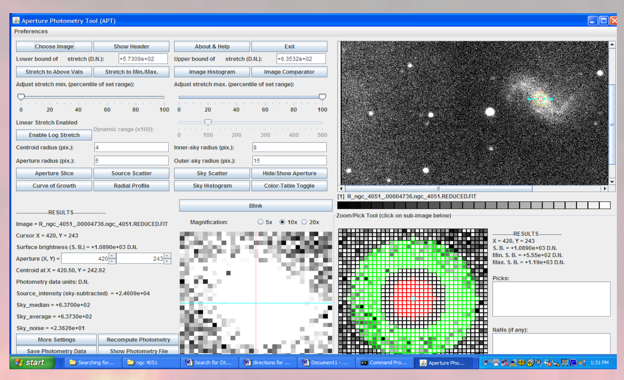

Figure 3 (pictured at left): Students, with lead astronomer Varoujan Gorjian, work to analyze data.

Continuation

At the end of the conference, with many new partnerships having been made among us as a network of scientists, we all returned to our respective hometowns. In the course of the five days that we spent at the summer meeting on the campus of the California Institute of Technology, it was impossible to accomplish everything (though we tried hard, as pictured in figure 4). Therefore, analysis continued for several months after the meeting. We needed to finish all the APT work, compile the data, and analyze it. Every group got a folder filled with dozens of images. It was our task to finish analyzing the images with the APT and compile a spreadsheet of the data. Within our team, we split up the work by color filter so that the work was evenly distributed. A system of checks was implemented, so that each set of data was analyzed at least twice to ensure validity; as such, the importance of scientific validity was reinforced in our minds. The analysis of hundreds of images was a very long process that included computer analysis, spreadsheet totals, and data graphing. The months after the summer meeting also brought a slew of emails, video conferences, phone calls, and teleconferences. Data was exchanged between every group and the lead astronomer, Varoujan Gorjian, guided students and educators through the process with expertise. New information and revised instructions, as they surfaced, were shared as well. It was a very good lesson into how to work with people and how to collaborate with a group, even over long distances. The group dynamic was one that we, as students, had never experienced before. It was one of dedication and personal motivation to accomplish something.

Reflection

This experience has changed both of our career goals completely. The people we met and the things we saw were absolutely awe-inspiring. Imagine knowing, as eighth graders, that many of the things we saw at JPL would one day be in space; imagine knowing that the people we worked with were vanguards in the scientific field. It is these realizations that really made an impact on us as students. The trip gave us a first-hand view of the scientific community and the real world scientific process. As participants in the program, we saw first-hand the true dedication to exploration, education, and innovation that scientists exemplify. We had to be innovative in how we used the available tools (software and telescopes). We also saw that the procedure often needs to be adjusted and data needs to be reanalyzed. Although we did not clearly "catch" the outbursts of light that would help us determine the diameter of the torus, we did see that real science often takes multiple tries and even some luck. This truly contributed to our understanding of the scientific method, and how experiments are not always successful the first time they are performed. In science, as in other walks of life, it is important to recognize perseverance. Furthermore, the trip totally altered how we thought scientists worked. We had always believed that scientists worked alone or in small groups in labs everywhere and published their findings independently. However, we now know that the scientific community is an actual community, a network of people and ideas. Scientists from all over the world work together and are united in their goals. They help each other and work together for the benefit of science, not just for themselves. The thing that shocked us the most was that it was okay to be wrong. Perfection was strived for, but reaching it wasn't always expected. For example, in the end, our data was inconclusive. Was anyone mad? No. Was the project a waste of time? No. Was anyone specifically to blame? No. The important thing was the experience. Everyone involved learned something new and we all learned how to make improvements for future experiments. The scientific process is a learning process. It is filled with success and failure. However, the amazing thing about the scientific community is that failure isn't failure; it is a step toward success.

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