PDP Teaching Summary: Team 2017-16

Team:

Andrey Vayner (Team lead), University of California, San Diego

Gregory Walth, University of California, San Diego

Xinnan Du, University of California, Los Angeles

Audience:

15 students doing summer research in astronomy at UC San Diego. They ranged from high-school students to Master's students.

Venue:

University of California, San Diego. June 29-30, 2017

Description:

The goal of this activity was for students to use the concept of signal to noise ratio to design and explore which upcoming astronomical observatory can detect their science case. In terms of core practice, our activity focused on designing and carrying out investigations, and hypothesizing and making predictions. Specifically, students were expected to (1) plan observing procedures that allowed relevant measurements to be made with tools/technology at hand; (2) refine hypotheses and predictions based on outcomes of prior experiment(s); and (3) selecting and controlling variables that were most relevant to the scientific/signal-to-noise ratio question and calculations. Since, in our activity, the students were doing cutting-edge science with upcoming telescopes, we thought that it would greatly boost their confidence in being a member of the STEM community by doing something new and meaningful, rather than investigating cases that have been explored multiple times in the past.

At the beginning of the activity, students were provided with three science cases with the use of different future observing facilities: studying first-light galaxies with JWST, studying high-redshift galaxies with TMT, and studying exoplanets with JWST. Students were given a mini presentation at each of the three stations, after which they were prompted to ask questions related to “is it possible to detect … with the capability of …?” For example, at the exoplanet station I was in charge of, students were shown different ways of detecting exoplanets, with a highlight on the transit method. The concept of transmission spectra was then introduced with example spectra of Earth-like planets. Students learned that the transmission spectra consisted of multiple atmospheric molecular lines in the infrared. Combining the information of transmission spectra and the imaging and spectroscopy capabilities of JWST in the infrared, students were encouraged to ask questions with the prompt, “how can JWST help us better understand exoplanets?”

After the rotation through all stations, student signed up for 2 science cases that they wanted to investigate. They were then paired up based on their common science interest. They were given 3.5 hours of investigation time in total (1.5 hours on Day 1 and 2 hours on Day 2). The goal of Day 1 for the students was to come up with a specific investigation question with the key parameters identified. For example, the exoplanet student groups were guided to form a question of “how long would the exposure time need to be if we want a planet of [their choice of magnitude] to be significantly detected?” They were provided with example transmission spectra, observed light curves, and a color-magnitude diagram of the confirmed exoplanet host stars to determine the brightness of the planet, and a specific molecular line they wanted to investigate. During this process, student were provided with multiple options regarding choosing the properties of the exoplanets, selecting target spectral lines, and using different observing instruments available on JWST. On Day 2, they were introduced to the exposure time calculator, and were able start their investigation on their questions on the exposure time right away with the key parameters they identified on Day 1. They were guided to plan out their observing strategies to minimize the noise for a given amount of exposure time (short exposures with large numbers of frames), and to iterate their experiment by adjusting the input parameters to the calculator based on the previous results. Midway through Day 2, the students were provided a thinking tool, a series of images of the same galaxy with different signal-to-noise ratios, and were asked to identify which of them would be considered as significant detections. With the help of the thinking tool, student were able to come up with some sort of criterion in signal-to-noise ratio to determine whether their science cases could be significantly detected with the exposure time they chose. At the end of Day 2, students were asked to fill out an activity reflection sheet individually, and to prepare a poster as a group and present their science case, specific investigation procedure, and results (with diagrams and evidence) in front of everyone. Our CAT prompt stated: “Present a poster to demonstrate the capabilities of future astronomical observatories to detect your science case with the concept of signal to noise ratio. A diagram might be helpful in illustrating your investigation process and the results. Make sure to include any evidence that has led you to the conclusion. Make sure each team member contributes in making the poster and in the presentation.”

We used both the individual reflection sheets and the group posters as artifacts to score the students. Nearly all students scored 3 out of 3 in the first two dimensions, correctly identifying how signal-to-noise ratio scales with exposure time, and coming up with a signal-to-noise threshold for significant detections. Around three quarters of the students scored 2 and above out of 3 in the third dimension, which focuses on how the noise level is related to the exposure time. Overall, the students did really well, given their answers during the poster presentation, and their responses in the reflection sheets.