

Final Reflection on the 2022 Summer Science Program in Astrophysics at the University of Colorado, Boulder

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This summer I had the opportunity to attend the Summer Science Program (SSP) in Astrophysics at the University of Colorado, Boulder. The SSP was founded in 1959 and continues to today with the original orbital determination project (with computers now though!). SSP bills itself as “the educational experience of a lifetime”, and I could not agree more.

The Academics:

SSP in astrophysics focuses mostly on physics and math with some scientific programming thrown in. We had 3-hour morning lectures on Monday – Saturday and 3-hour afternoon lectures Monday – Friday. Typically, morning lectures focused on math, physics, and programming topics. These lectures were full of awesome demonstrations like spinning on a platform to demonstrate conservation of angular momentum, melting a nail with a stepdown transformer, or looking at different elements’ emission spectra. Afternoon lectures were mainly about astronomy and the math behind the Method of Gauss (the orbital determination algorithm). These lectures were really challenging for me as I had never before studied astronomy (who knew there are 5 different coordinate systems?) and the Method of Gauss derivations were so ridiculously complex (and frankly, magical) that they have become a joke among participants and faculty both. With a good effort though, I was able to get somewhat comfortable with all these topics.

Probably the most significant part of our lives in the first four weeks of the program was the PSets (aka problem sets). PSets are one of the defining objects of SSP and allow us to apply the knowledge we learn in lecture to challenging problems in math, physics, astronomy, and computer science. PSet problems are intentionally designed to be so hard that it’s near impossible to solve them without collaboration (we are also not allowed to bring laptops, so everyone is forced into the computer lab). Filling up three entire whiteboards with PSet work and intensely debating (read: yelling) as we work is one of my favorite SSP memories. After the OD was due, I got one last round of our crazy PSet sessions as several of us worked together to solve a few remaining physics challenge problems.

The OD:

The orbital determination (OD) project is the main objective of the SSP Astrophysics experience. We worked in teams of three to take original observations of our asteroid 2005 XJ8 and reduce the data to use as input for our OD code. My team had late shift for observations (12 – 1 AM); it was definitely a new experience for me to stay up so late in the name of science. In the red glow of the observation deck, I found the most peaceful place at SSP, and I loved staying up there playing with the telescopes and talking in the quiet night.

The OD code was quite a beast. Starting from the first PSet, we wrote Python functions that would later be used in the final OD code. In the last two weeks of the program, OD code writing started in earnest. Luckily, I had the foresight to keep my code clean, which helped me

organize and debug the extremely long OD code. On the day the report was due, this cleaned code enabled me to add another section to the paper in the last two hours!

The OD report is the penultimate conclusion of our research project. In the last week, much of our efforts were devoted to putting together a professional research paper describing everything from our observation results to the Method of Gauss to our code's final calculated orbital elements. The last Friday of SSP was certainly quite stressful as we raced to revise and added a whole new section to our paper to explain inconsistencies in our data. At 7:30 PM MST, we handed in our paper and breathed a huge sigh of relief while sadly realizing that our time at SSP was coming to an end.

After the OD was due, we were able to work with two researchers from the Southwest Research Institute (SWRI) to simulate our asteroid's orbit for the next 50 million years. Fortunately, our asteroid is pretty boring and will most likely burn up in the sun (or it has a 5% chance of crashing into Earth).

The SSPeople:

If there is one thing that SSP emphasizes above all, it is the community. On the first day of SSP, I was not convinced when they told us we would all be crying on the last day. However, SSP has tried its best to force us together from day one with rotating seating at mealtimes and making us only work in the computer lab. These rules seemed Byzantine at first, but I now realize how effective they were at bonding us together.

SSP has a work hard, play hard mentality. This can be hard to balance, but often work is play (to a degree). Working on PSets is one of the most representative depictions of my experience of the SSP community: we spend just as much time laughing as writing and tend to yell at each other whenever we get excited (which is a lot). Sometimes, spontaneity overtakes us, and we choose to do the problem in the most unnecessary way possible such as crashing the entire computer lab server with a 400-body problem, physically calculating the density of pencil lead, or counting the number of hairs in a 1 cm square on a kid's head. These hilariously nerdy moments are ubiquitous at SSP, and I will never forget them.

I am impressed not only by how well we got to know our fellow participants, but also the connections we built with the faculty. Oftentimes, we rope our professor into helping us with a hard problem, and he continues to work with us 3 hours later (when it's around midnight). I have never been in an environment before where the faculty and TAs are always so willing to help and are often personally interested in the problem. I am so grateful to all our faculty for tirelessly teaching and helping us academically, while also making sure we were thriving socially and successfully surviving dorm life. From driving (and scaring her half to death) the site director in a go-kart to going running and playing spikeball with our professors, SSP has truly built a living, learning community among all people involved.

It's impossible to mention all the amazing things we did together at SSP, but I will try to hit some of the things I never want to forget. Running in the morning; sneaking into suspiciously unlocked music rooms; raiding the kitchen very late at night; taking pretty pictures of nebulae

after finishing observations; elated shrieks in the computer lab after helping someone debug their code; building a giant fort only to have it taken down as a fire hazard; squeezing three people under a tiny, entirely ineffective umbrella; seeing the Milky Way from the top of a mountain; distractedly counting off before dinner; drawing too many dotted lines on the chalkboard; burying two people on top of each other in the sand; seeing a newly launched Starlink satellite; running through/lying in/sitting on the campus sprinklers in the dead of night; fighting off raccoons at 1 AM coming back from observation; singing karaoke at midnight; the endless r dot dot r dot jokes; somersaulting and cartwheeling across the soccer field; constantly monitoring the net consumption of bananas by certain individuals; breaking the perimeter to walk to Varsity Bridge; getting the police called on us because someone was playing the saxophone outside at 11 PM; hiking the Flatirons and climbing up a tall rock peak; seeing a shooting star during observation; the talent show gone bananas; watching the sunrise on the last day; and definitely so much more. None of this would have happened or mattered without the incredible community of SSPeople.

On the last day, as promised, we cried. A lot. We ran around the airport, seeing each other off on our many different flights. At each gate, there were many hugs and a couple tears, to the point where multiple people asked us what was going on. SSP bonded us together so powerfully that we found it incredibly hard to let each other go (luckily, as one airport observer told us, the internet exists).

In Conclusion:

SSP was everything I expected and more. Coming out of SSP, I have gained tons of new knowledge in math, physics, and especially astronomy. I also have a newfound confidence that I have what it takes to succeed in a STEM career. Just as importantly, I gained a strong group of 34 remarkable new friends, a few of whom I am very close with, and an alumni network over 3000 people strong.

Perhaps it is only fitting that I finish writing this reflection at 1:30 AM back at home in Carbondale. After 39 days of SSP, my body is still used to the late nights/early mornings in mountain time. This is the end of an era: the last late night devoted to SSP.

Thank you so much to the Garwin Family Foundation for supporting me in this “educational experience of a lifetime”! I can safely say that SSP changed me for the better, and I deeply appreciate the GFF for making it possible.