In my project, I aim to understand the process of magnetic reconnection more deeply by computationally simulating it. On the surface of the sun, there are many dangerous phenomena that have the potential to harm people. Solar wind, solar flares, and Coronal Mass Ejections contain lots of power and are able to violently attack the Earth with radiation and plasma. Astronauts in space and people in airplanes flying over the poles are more likely to be heavily irradiated by UV light, causing sunburns and an increased risk of skin cancer. Coronal Mass Ejections (CMEs) are also able to hit the Earth with masses of plasma, causing electrical failures and a loss of communication. Even with measures to shut down electrical grids, a strong CME could cost tens of billions of dollars. These effects are disastrous and the damages need to be mitigated. However, our current prediction methods are only slightly faster than seeing the solar flare as it is hitting Earth. And for CMEs, in the best case scenario, we would be able to tell 18 hours in advance. That is very little time for international scale shutdowns and would make hospitals and other public necessities have to run on emergency power. A CME could be very catastrophic for third world countries with power insecurities. All of these phenomena are driven by a process called magnetic reconnection. Understanding magnetic reconnection is key to better predictive models of solar flares, solar wind, and Coronal Mass Ejections.

To simulate magnetic reconnection in Python, I used a model called the Sweet-Parker model. This is the most standard model of magnetic reconnection and has been studied in a paper by D. Biskamp, et al. Biskamp does a stability test of the system and finds that sufficiently strong enough magnetic field lines stabilize the model to perturbations. I am replicating his work and adding onto our understanding by affecting more parameters.

I have written a Python program to simulate a Magnetohydrodynamic (MHD) system. MHD combines the laws of fluid dynamics and electromagnetism, this is needed since plasma is both a fluid and magnetic. In the case of my project, these laws can be described by the magnetic vorticity equation. I have also created the initial conditions of the Sweet-Parker model and have shown a general agreement to the simulations by Biskamp. I have verified my code several times through the process. In my most recent verification, I simulated the fluid dynamics “Bickley Jet.” The Bickley Jet is the velocity profile of the Sweet-Parker model and is a steady-state solution. That means it shouldn’t change with time. My code shows this with some error due to computational inaccuracies.

I am expecting to find results that show the accuracy of the Sweet-Parker model to real-world observations. These results will help refine our understanding of magnetic reconnection according to this model.

[1] Laboratory, L. A. N. (n.d.). *Forecasting space weather: Discover los alamos national laboratory}*. LANL Discover RSS. Retrieved January 20, 2023, from https://discover.lanl.gov/publications/national-security-science/2022-spring/vania-jordanova/?source=facebook&fbclid=IwAR0mtlKVmxvJiHP-L5GHmJTD9vRhRw-dDl_E_xdseQxBy8Eq2qMCk3dPkro

[2] Zhong, Z., Guo, Y., & Ding, M. D. (2021, May 12). *The role of non-axisymmetry of magnetic flux rope in constraining solar eruptions*. Nature News. Retrieved January 20, 2023, from https://www.nature.com/articles/s41467-021-23037-8

[3] NASA. (n.d.). *Prominence from the Solar Dynamics Observatory*. NASA. Retrieved April 10, 2023, from https://earthobservatory.nasa.gov/images/43717/prominence-from-the-solar-dynamics-observatory

[4] Biskamp, D., Schwarz, E., & Zeiler, A. (1998). Instability of a magnetized plasma jet. *Physics of Plasmas*, *5*(7), 2485–2488. https://doi.org/10.1063/1.872931

[5] *Solar storms could cost USA tens of billions of dollars*. University of Cambridge. (2017, January 19). https://www.cam.ac.uk/research/news/solar-storms-could-cost-usa-tens-of-billions-of-dollars