Ellis Avallone — Graduate Research Statement

<u>The Magnetic Origins of Solar Coronal Plumes</u>

Sun: corona — Sun: magnetic fields —Sun: UV radiation

I. Introduction

The corona is a diffuse cloud of plasma that surrounds the Sun that is ~10^4 times hotter than the photosphere at the surface of the Sun. The mechanism for coronal heating is one of the most sought after solutions in solar physics, as it could explain the origin of the solar wind, a stream of charged particles that bombards Earth and other planets. In order to determine a solution to the coronal heating problem, solar physicists study structures that arise in the corona as a consequence of the ever-changing solar magnetic field, like coronal plumes. Plumes are sporadic, fountain-like structures that are rooted in a strong patch of dominant-polarity photospheric magnetic flux, surrounded by a predominantly-unipolar magnetic field. Plumes are located in the least active regions in the solar corona: in either coronal holes or in quiet regions.

Studying the formation of plumes could shed light on how the corona is heated, as there may be a fundamental mechanism that heats plumes that may be the same in other coronal structures. Several observations have been presented regarding how plumes form and disappear, but none have succeeded in determining the mechanism that generates plumes.

In the Summer of 2017, to further investigate plume evolution, I tracked the lifetimes of six coronal plumes, three in quiet regions and three in coronal holes using SDO/Atmospheric Imaging Assembly (AIA) 171 Å images and SDO/Helioseismic and Magnetic Imager (HMI) magnetograms with Dr. Sanjiv Tiwari at an NSF REU program at the University of Alabama in Huntsville and NASA Marshall Spaceflight Center. We based our study on two previous studies, one by Raouafi et al.[1] and Wang et al.[3]. Raouafi et al.[1] infer from observation that plume heating is a consequence of magnetic reconnection at the base, whereas Wang et al.[3] observe that plume heating is a result of convergence of the base magnetic flux. Both papers suggest that the base flux in their plumes is of mixed polarity, most of which is unobservable due to the spatial resolution of current instruments. Raouafi et al. and Wang et al. both suggest that this is the primary mechanism responsible for sustaining plume heating, and do not consider other contributing factors. *I specifically investigated whether or not a critical magnetic field strength is necessary for plume production, and determined from that a critical field strength of 250-500 Gauss, along with base flux convergence and divergence, is necessary for plume formation.* While these preliminary results were extremely promising, indicating that a critical field strength may be necessary for plume production, further work needs to be done in order to confirm them.

II. Specific Aims

As a graduate student, I will extend this study to include coordinated high-resolution spectroscopic data from the Interface Region Imaging Spectrograph (IRIS) and the Extreme Ultraviolet Imaging Spectrometer (EIS) on the Hinode spacecraft in conjunction with SDO/AIA and SDO/HMI data. We will also extend our SDO/AIA observations to include those in 193 Å, 211 Å, and 304 Å emission. This increased emission coverage will allow us to observe plumes from the upper layers of the corona down to the chromosphere, the region between the surface of the sun and the corona where smaller-scale jet eruptions occur. Including spectroscopic data will allow us to further investigate smaller-scale jet eruptions in the chromosphere and transition region by observing cooler emission lines, and will allow me to create dopplergrams, which show the redshift and blueshift of spectral lines, in order to observe how flow patterns evolve throughout each plume's lifetime. In order to determine a solution to the problem of underlying mixed polarity, we plan to propose observations to the Daniel K. Inouye Solar Telescope (DKIST) when it comes online in 2019. As the largest solar telescope in history, the increased spatial resolution of DKIST will allow us to resolve regions as small as ~20 km^2, thus giving us the opportunity to observe minute emergence of opposite-polarity regions. To ensure that any conclusions of this study are statistically significant, we will expand our dataset to include a larger sample of 100 coronal plumes, 50 in quiet regions and 50 in coronal holes.

III. Preparation and Relation to Career Goals

This project allows me to continue my already fulfilling work on coronal plumes with Dr. Tiwari, who has since moved to working at the Lockheed Martin Solar and Astrophysics Lab (LMSAL) in Palo Alto. Stanford is an ideal setting at which to conduct this research, as its close affiliation with LMSAL would allow me to continue working with Dr. Tiwari, as well as collaborate with other solar physicists at LMSAL. Extending this project to include spectroscopic data and ground-based telescope observations would give me the skills to conduct more comprehensive observations of the solar corona, and increasing my previous study's sample size would give me the statistical and computational skills I need to conduct further, more rigorous studies on larger datasets. This fellowship would give me the freedom to focus on obtaining a conclusive result, thus bringing me another step closer to a career in solar physics research, education, and outreach.

IV. Broader Impacts

With DKIST beginning operations in 2019, and the Parker Solar Probe, a mission to collect in-situ data on the corona, planned to launch in 2018, a wealth of data will soon be available for scientists to learn more about our nearest star. For most of my undergraduate career, I was unaware that there were so many unanswered questions about our nearest star. During my time as a graduate student, I look forward to involving younger students in this research in order to help the field of solar physics gain more exposure among young scientists. I have been inspired by the Pre-Major in Astronomy Program in place at the University of Washington, which is a mentorship program aimed at involving underrepresented undergraduate students in research early in their careers. I hope to do similar work by mentoring high school students in the greater Bay Area through Stanford's Science in Service program.

V. References

[1]Raouafi, N.-E., & Stenborg, G. 2014, ApJ, 787:118 — [2]Tritschler, A., Rimmele, T. R., Berukoff, S., et al. 2016, Astronomische Nachrichten, 337, 1064 — [3]Wang, Y.-M., Warren, H. P., & Muglach, K. 2016, ApJ, 818:203