PhD Dissertation: Solar Eruptive Events Outline

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**CU & AES Dissertation Requirements**

* PhD defense deadline: 2016/04/08
* Dissertation due by: 2016/04/15
* Double spaced + various requirements on title page, numbering, tables, etc
* External links not allowed
* Lauren Blum, Quintin Schiller, and David Gerhardt dissertations all have a short introduction that frames the dissertation
  + Particularly useful in cases like mine where there’s a bifurcation of topics – introduction provides a place to tie them together as best I can (same situation all 3 of them faced with science + CubeSat)

**Dissertation based on papers:**

1. Mason and Hoeksema 2010, ApJ, solar flare prediction (background)
2. Mason et al. 2014, ApJ, coronal dimming physics and case study
3. Mason et al. 2016a (*accepted*) Journal of Spacecraft and Rockets, MinXSS CubeSat overview
4. Mason et al. 2016b, (*submitted in early January)* ApJ, coronal dimming and CME relationship semi-statistical study
5. Mason, Lamprecht, & Woods 2016c, *(in prep at time of defense)* Journal of Small Satellites, thermal balance analysis

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# Introduction

* Solar eruptive events are rapid releases of energy on the Sun that are sometimes directed Earth-ward, making it important to understand them and to forecast their arrival time and magnitude of their impact
* Three basic types of eruptive event: flare, coronal mass ejection, energetic particles – this dissertation focuses on the first two
* Some background about solar flare prediction provided in Chapter 2, including my own massive statistical study, which went to print in ApJ my first year of graduate school
* The relationship between coronal mass ejections and the void they leave behind in the solar corona is the primary topic of the dissertation and its discussion spans several chapters.
  + Chapter 3 discusses the various physical processes that can lead to an observation that may be interpreted as a dimming, and the amalgamation of related observations that can theoretically be used to identify and isolate each mechanism
  + Chapter 4 puts theory to the test in a detailed case study of a single, relatively simple, event. The aforementioned conglomeration of observations were used to determine that this was indeed a simple case with one dimming mechanism dominating the observation; that which theory says should be most strongly related to the associated CME
  + Chapter 5 expands the study of the relationship between dimming and CMEs by performing an analysis similar to that of the case study but for approximately 30 events. Thus, a tentative statistical correlation between dimming and CME parameterizations could be derived.
* The topic of solar flares is picked up again briefly in the science motivation for the solar CubeSat MinXSS. An overview of the mission is the topic of Chapter 6, which includes science motivation, system overview, and lessons learned.
* Chapter 7 delves deeper into the CubeSat engineering with a detailed thermal balance test and model analysis, culminating in the (likely) first ever tuned CubeSat thermal model that has been validated by dedicated testing and on-orbit measurements.
* Chapter 8 provides a summary of deliverables and results, and lays out plans for future work. The latter will be the first steps in my post-doc that has already been secured through my first grant being funded as well as SDO/EVE and MinXSS extended mission funding.

# Relevant Background

## Solar Corona

* Basic structure – spatial extent, temperature, density, constituents, magnetic field
* Dynamics – description of Beta, timescales of magnetic evolution

## Physics of Solar Eruptive Event Initiation

* Energetics – how much energy can be released in how short a time
* Energy storage via twisting etc. of magnetic field
* Energy release via magnetic reconnection (details poorly understood) but provide the cartoon models of separatrix
* Energy release into new photons, direct particle acceleration, massive kinetics with CMEs

## Space Weather

* If these eruptive events are directed toward Earth there can be myriad negative consequences (cite NRC report and can go into some detail about the consequences)
* Hard to predict when solar eruptive events will occur
* One popular method relies on using photospheric magnetic field measurements to forecast solar flares, but while a signal exists it not particularly effective for real time prediction (**Mason and Hoeksema, 2010**)
* New routine observations of photospheric vector magnetic field from SDO/HMI are now being used but hasn’t resulted in a windfall of prediction capability – next best observational promise is coronal magnetic field measurements
* Fortunately, CMEs are the most geoeffective type of solar eruptive event but take hours to days to reach the Earth, which makes nowcasting possible using observations of light emitted during the eruptive event; that light only takes 8 minutes to get to Earth and processing of it can take as little as a few seconds.

## EUV Emission

* How EUV emission is formed in the corona
* It’s obvious that these emissions can tell you something about a flare (whose primary manifestation is high-energy photon emission)
* Hint that measuring these photons can tell us something about ejected mass as well. This hint will be a natural lead into the next section.

# Mechanisms of Coronal Dimming

(**Mason et al. 2014)**

## Thermal Dimming

## Obscuration Dimming

## Wave Dimming

## Two Possible but Unobserved Dimming Mechanisms

* Doppler
* Bandpass

## Mass-loss Dimming

# Coronal Dimming Case Study

(**Mason et al. 2014)**

## Observations

## Flare-dimming Deconvolution Method

## Error Propagation

## Dimming and CME Parameterization Results

# Semi-Statistical Study of Coronal Dimming

(**Mason et al. 2016b)**

## Observations and Selection Method

## Dimming Fitting Method

## Dimming and CME Parameterization

## Parameterization Error Analysis

## Comparison of Dimming and CME Parameters

# Overview of MinXSS Solar CubeSat

* This chapter can be nearly a copy-paste of the **Mason et al. (2016a)** JSR paper

## Science Objectives

### Solar Flare Studies

### Topics Beyond Solar Eruptive Events

* Since my dissertation is focused on eruptive events, I’ll collapse the quiescent Sun and Earth atmospheric science to a single section with only a few paragraphs

## Mission Architecture

* Consisting primarily of a subsystem breakdown

## Lessons Learned

# Thermal Balance Analysis for a CubeSat

(**Mason, Lamprecht, & Woods 2016c)**

## Thermal Vacuum and Balance Test Procedure

## Thermal Desktop Model

## Model Tuning and Comparison to Test Results

## Predicted Orbital Temperature Performance

## Actual Orbital Performance and Comparison to Prediction

# Summary and Future Work

## MinXSS Summary and Future Work

## Coronal Dimming Summary and Future Work

# Appendix A: Coronal Dimming Event List and Ancillary Data

# Appendix B: MinXSS CubeSat Mass/Power Tables

# Appendix C: MinXSS Thermal Model Parameter Tables