MAGNETIC CONSEQUENCES OF UNCONVENTIONAL AND NON-UNIFORM SUPERCONDUCTORS

by

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APPROVAL

of a dissertation submitted by

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This dissertation has been read by each member of the dissertation committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to The Graduate School.

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STATEMENT OF PERMISSION TO USE

DEDICATION

I dedicate this dissertation to Mumbo Jumbo

PREFACE

While the research presented in this dissertation is ultimately an attempt to understand basic physical processes in the cosmos, in particular the storage and release of energy by magnetic fields in plasmas, it does have important societal impacts. It is for this reason that the work was funded, primarily through NASA's Living With a Star (LWS) program and associated missions and grants. Work presented in the second chapter was supported directly by NASA LWS. Work in the third and fourth chapter were supported by NASA under contract SP02H3901R from Lockheed–Martin to MSU. The author also acknowledges the teams responsible for the Helioseismic and Magnetic Imager (HMI) and Atmospheric Imaging Assembly (AIA) instruments onboard the Solar Dynamics Observatory (SDO) and the X–Ray Telescope (XRT) instrument onboard the joint Japanese/US satellite Hinode. This work would not be possible without the data and support provided by these instruments.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

"If it wasn't for the magnetic field, the Sun would be as boring of a star as most astronomers seem to think it is."

— R.W.Leighton

Some stuff

writing writing writing

1.1. Sections within a chapter

In 1908, George Ellery Hale published an amazing article in *The Astrophysical Journal*, entitled "On the Probable Existence of a Magnetic Field in Sunspots" . The work drew on a surprising number of contemporary experiments to conclude, even if only tentatively, that sunspots contained magnetic field. These experimental findings included: that a charged, spinning disk produces a magnetic field; that gases, when ionized, contain charged particles; that many neutral elements at high temperature emit numerous negative "corpuscles", and so must also have positively charged particles; that the Sun contains such hot gases; that the Sun also has rapidly moving "vortices," and so likely generates a magnetic field in places; that Zeeman had demonstrated that radiating gas placed in a magnetic field produces emission doublets, with noted polarization states; and finally that a new spectrograph on the Mount Wilson telescope allowed for precise measurements of the solar spectrum at various locations on the solar disk, and various polarization states. Combining all these, Hale succeeded at comparing observations of line splitting and polarization in sunspots to laboratory observations of emitting gases in magnetic fields, finally concluding that the sunspots likely contained magnetic field of about a kilogauss in magnitude.

1.2. Hey look another section

See §1.1 for impressive work.

1.3. Now we just sort of end

Nothing special at the end of chapterX.tex files. You just stop writing.

2. CALCULATING ENERGY STORAGE DUE TO TOPOLOGICAL CHANGES IN EMERGING ACTIVE REGION NOAA 11112

Contribution of Authors and Co–Authors

Manuscript in Chapter 2

Author: Lucas A. Tarr

Contributions: Conceived and implemented study design. Wrote first draft.

Co–Author: Dana W. Longcope

Contributions: Helped to conceive study. Provided feedback of analysis and comments on drafts of the manuscript.

Manuscript Information Page

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ABSTRACT

The Minimum Current Corona (MCC) model provides a way to estimate stored coronal energy using the number of field lines connecting regions of positive and negative photospheric flux. This information is quantified by the net flux connecting pairs of opposing regions in a connectivity matrix. Changes in the coronal magnetic field, due to processes such as magnetic reconnection, manifest themselves as changes in the connectivity matrix. However, the connectivity matrix will also change when flux sources emerge or submerge through the photosphere, as often happens in active regions. We have developed an algorithm to estimate the changes in flux due to emergence and submergence of magnetic flux sources. These estimated changes must be accounted for in order to quantify storage and release of magnetic energy in the corona. To perform this calculation over extended periods of time, we must additionally have a consistently labeled connectivity matrix over the entire observational time span. We have therefore developed an automated tracking algorithm to generate a consistent connectivity matrix as the photospheric source regions evolve over time. We have applied this method to NOAA Active Region 11112, which underwent a GOES M–2.9 class flare around 19:00 on Oct.16$^{\mathrm{th}}$, 2010, and calculated a lower bound on the free magnetic energy buildup of $\sim 8.25 \times 10^{30}$ergs over 3 days.

2.1. Introduction

It is now widely believed that solar flares are powered by magnetic energy which had been stored in the corona through slow stressing applied from the photospheric boundary. In an idealized model the energy builds up as the coronal magnetic field responds without resistance (every field line line–tied and unbroken). The flare then occurs as coronal reconnection exchanges those field line footpoints to achieve a lower energy state. In this process, the footpoints are changed by the reconnection, but the vertical photospheric field in which the field lines are anchored is not. The potential field from this fixed photospheric field has the minimum magnetic energy possible.

The maximum energy available for release is the amount by which the initial field exceeds this potential field energy, called the *free energy*.

And so forth and applesauce.

Graham Barnes graciously provided code for producing the potential field connectivity matrices using a Monte Carlo algorithm with Bayesian estimates, as described in . Development of the code was supported by the Air Force Office of Scientific Research under contract FA9550-06-C-0019. We also thank our Summer 2010 REU student Johanna Bridge for her work in assessing the performance of the automatic tracking algorithms. This work was supported by NASA LWS.

Don't end, just stop.

3. RETROSPECTIVE

Look at my dissertation go. Wasn't it fantastic journey? An holistic reading experience?

I thought so.

Once again, in the various chapter.tex files, we don't end so much as stop.

REFERENCES CITED