An Investigation of Coronal Structure Across Solar Cycle 24; Automated Dataset Creation and Analysis

Daniel Gass[1] and Robert Walsh[2]

Jeremiah Horrocks Institute For Mathematics, Physics and Astronomy, School of Natural Sciences, University of Central Lancashire Fylde Road, PR1 2HE

University of Central Lancashire UCLan

Jeremiah Horrocks Institute

STEM for BRITAIN

1. Daniel Gass – PhD Student – DGGass@uclan.ac.uk, 2. Robert Walsh – Professor of Solar Physics – RWWalsh@uclan.ac.uk

1. Introduction

- The **Sun's Magnetic Field** can impact life on Earth through geomagnetic storms and space weather.
- The **Solar Cycle** is an 11 year (on average) rising and falling in complexity and output. of solar magnetic activity.
- The **Corona** is the outermost layer of the atmosphere, created by the interaction of electrified gases (plasma) with the magnetic field, producing plasma filled loops millions of degrees in temperature.
- These bright, EUV[3] **Coronal Loop Structures** (CLS) reveal the changing nature of the Sun's magnetic field, offering insight into the fundamental physics of this natural plasma laboratory.
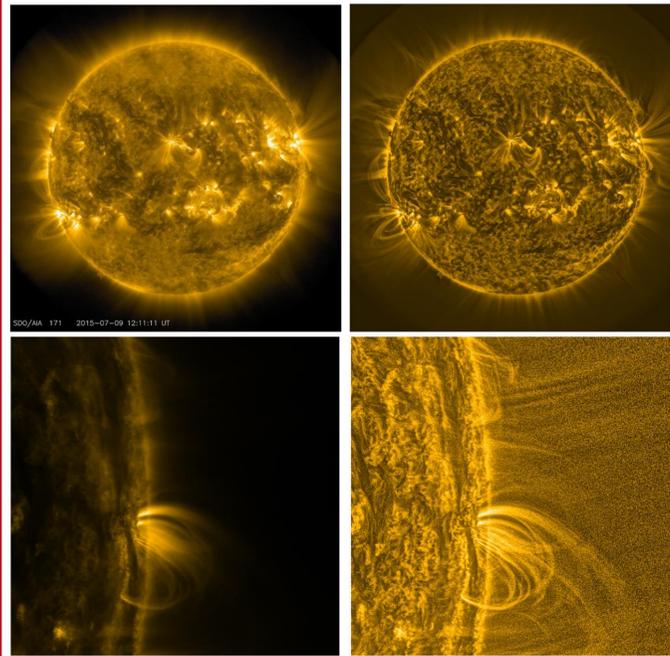
Fig 1: Before and after image processing drawing out fine structural detail of the corona.

Link to timelapse video of solar activity - 1st to 7th of March 2015. Processed 171 A footage.

https://tinyurl.com/171anim

2. Aims

- To utilise NASA's SDO-AIA[3] observations in determining the fundamental nature of the solar corona by capturing and examining the widths of a large dataset of CLS.
- An automated system of detection and measurement is required, as by hand identification can be time consuming and inefficient.
- The changing properties of CLS would signify how the atmosphere and magnetic field changes across a solar cycle (2010 – 2020).
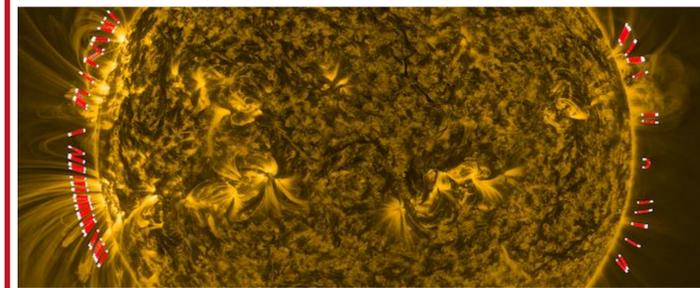
Fig 2: Detected Loop segments on a solar image, highlighted red and white.

3. Automatic Data Collection

- Potential CLS are automatically detected in an SDO AIA image (white lines), and their widths measured (dashed red lines below).
- This is performed on multiple EUV wavelengths across the 11 year cycle to sample conditions of varying activity.
- This results in the largest set of coronal structural information recorded to date.
- Producing a histogram of all appropriately observed widths allows for the determination of possible power-law gradients that are descriptive of the dominant physical conditions operating.
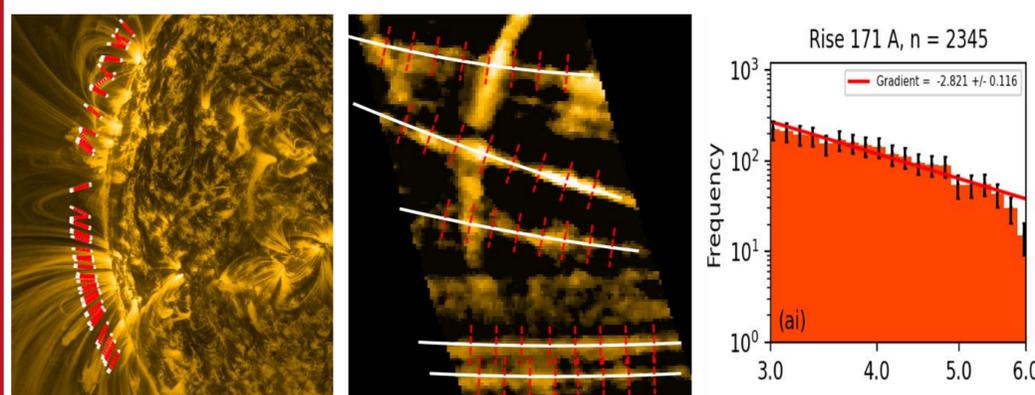
Rise 171 A, n = 2345

Fig 3: Loop segments (left, middle) are measured, and their widths compiled(right).

4. Loop Topology

- Loop widths appear to follow a power law, evidence of a dynamical, driven system, exhibiting avalanches and has power law correlated interactions. Ie; S.O.C[3]
- This can lead to a tool for studying the magnetic field and its precise role in the formation of coronal structure via analysis of predictive models versus observation.
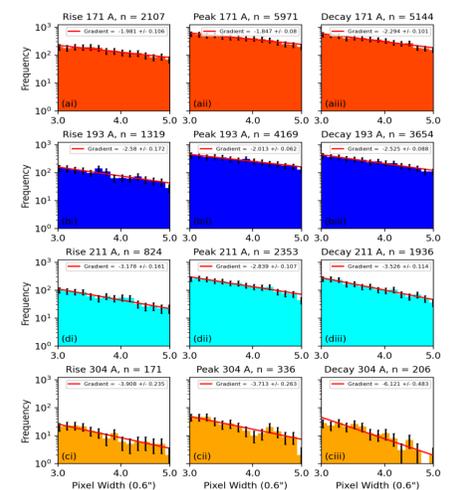
Fig 6: Histograms of loop structure width by wavelength and time.

5. Loop Asymmetry

Normlized Sunspot And Coronal Loops 171 North - South counts

- Monthly Average Sunspot Count
- Monthly Average Coronal Loop Count
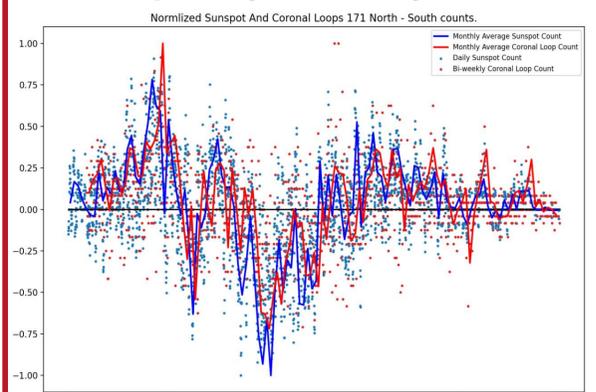- Daily Sunspot Count
- Bi-weekly Coronal Loop Count

Fig 5: Diagram of Loop and Sunspot Asymmetry vs Time

- Asymmetry in behaviour between North and South is an important aspect of the solar magnetic field.
- This study evidences for the first time the mimicking of this behaviour into coronal structures themselves across the cycle.

6. Results

Coronal magnetic loop structures have been identified and their widths measured in more detail than ever before. 100,000+ structures were detected and analysed across the solar cycle[4]. The resulting power-laws provide strong evidence for the presence of a dynamical driven process dominating the environment. Results also display a strong N-S asymmetry across the cycle, now demonstrated and examined in the corona. These results will aid future modelling of the corona and the pervasive solar magnetic field.