

Relationship Between X-ray Luminosity and Magnetic Flux of Active Regions and X-ray Bright Points

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Outline

Introduction

Objective

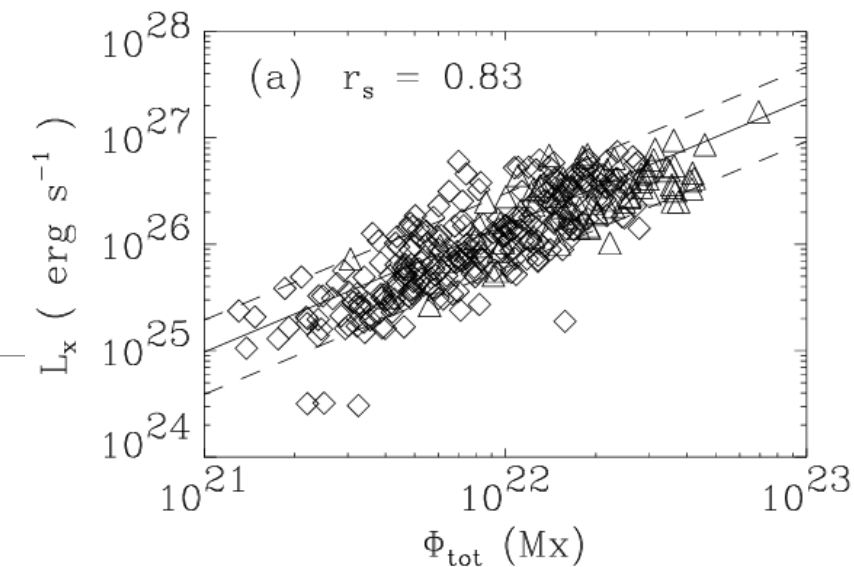
Methods

Results

Discussion

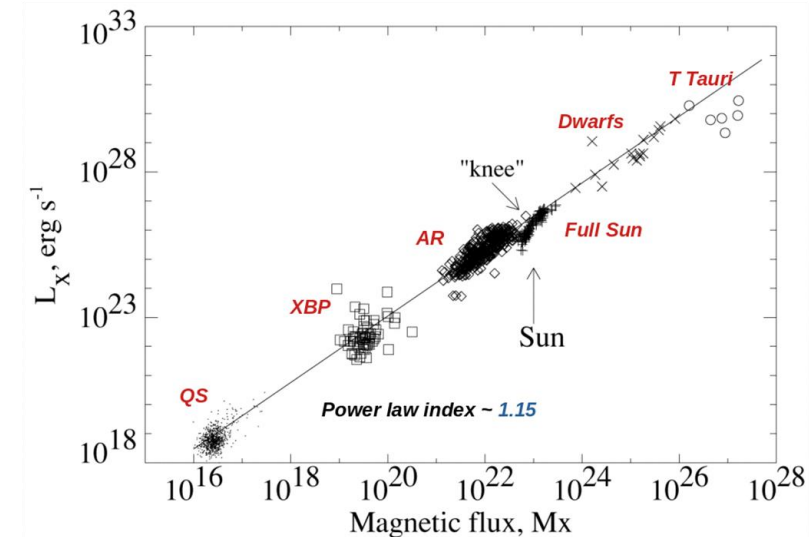
Introduction

- Studying the relationship between magnetic fields and coronal emission is one way to approach the coronal heating problem
- Study by Fisher et al. (1998) showed relationship
 - Spans 2 orders of magnitude
 - Showed power law index of 1.19
- Pevtsov et al. (2003) showed relationship
 - Spans 12 orders of magnitude from quite sun to very young stars
 - Showed power law index of 1.15



From Fisher et al. (1998). Used Yohkoh/SXT and HSP (Haleakala Stokes Polarimeter) magnetogram data.

Relationship between X-ray luminosity and magnetic flux

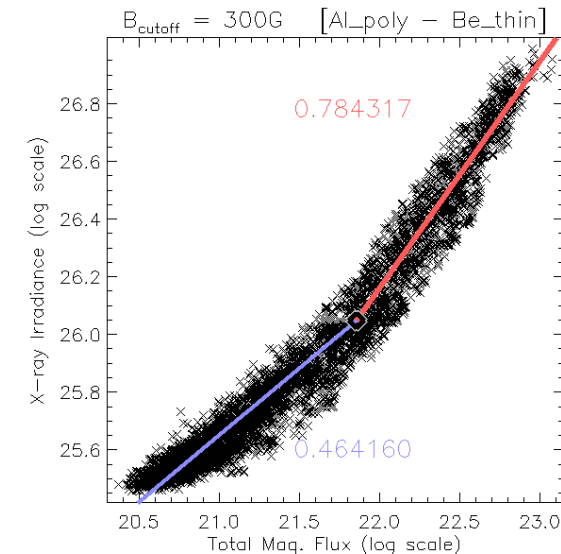
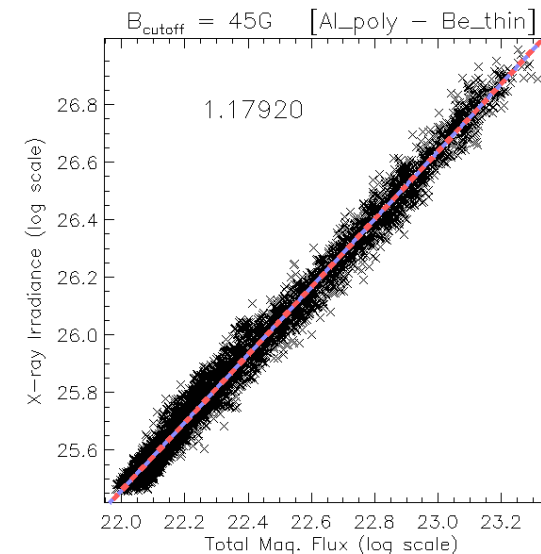
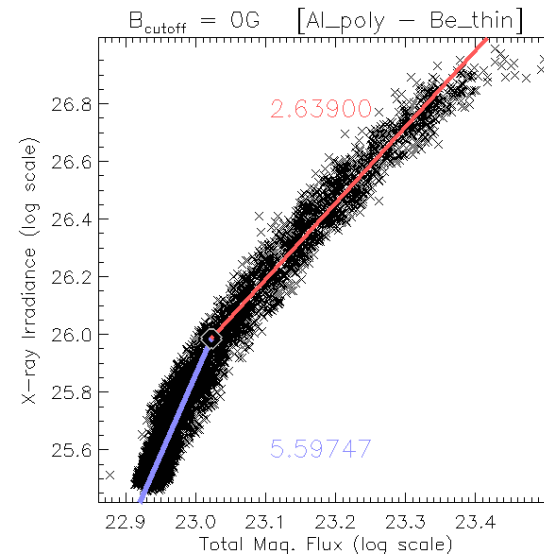
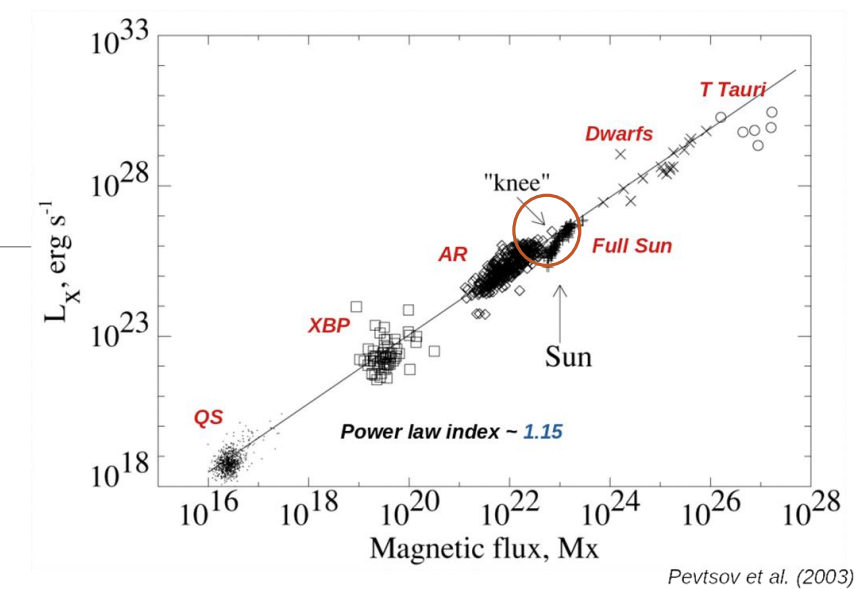


From Pevtsov et al. (2003)

Introduction

- Recently, Yoshimura et al. (2024) identified the cutoff magnetic field strength (B_c) as a key parameter in influencing the power-law relationship
- Focused on Full Sun region
- Used Hinode/XRT and SDO/HMI data

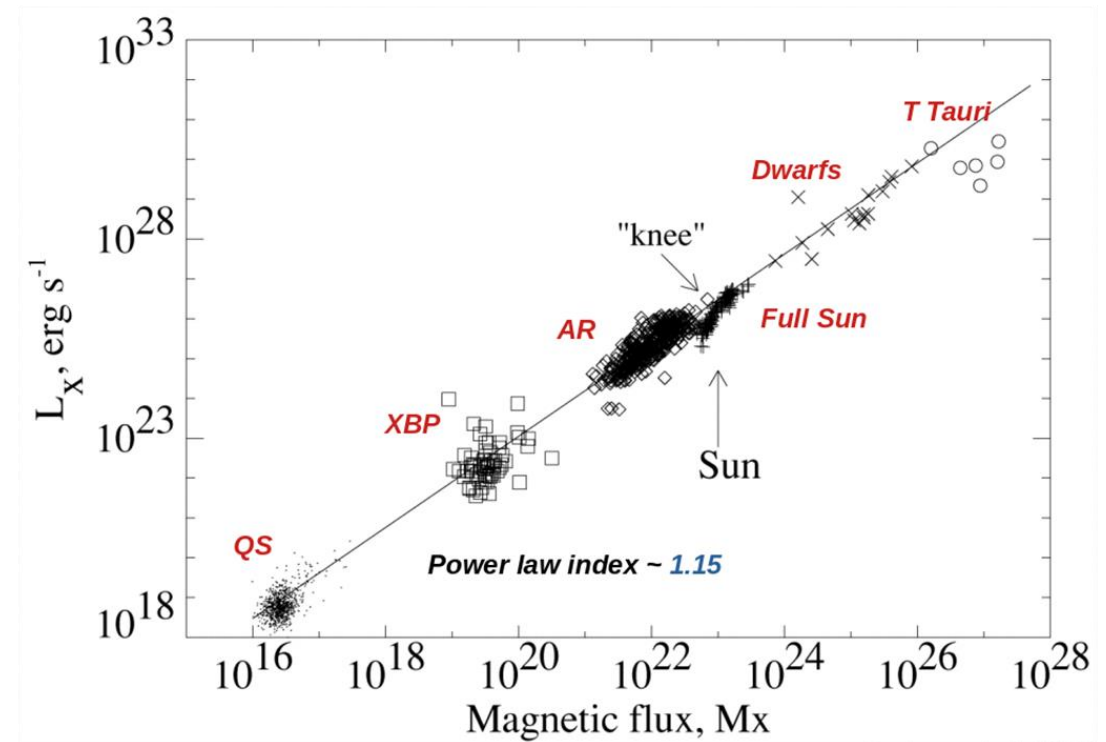
Relationship between X-ray luminosity and magnetic flux



Objective

- We will expand the dataset to include XBPs and ARs utilizing data from Hinode/XRT and SDO/HMI
- Detailed analysis on the power-law relationship and the parameters dependency between XBPs and ARs

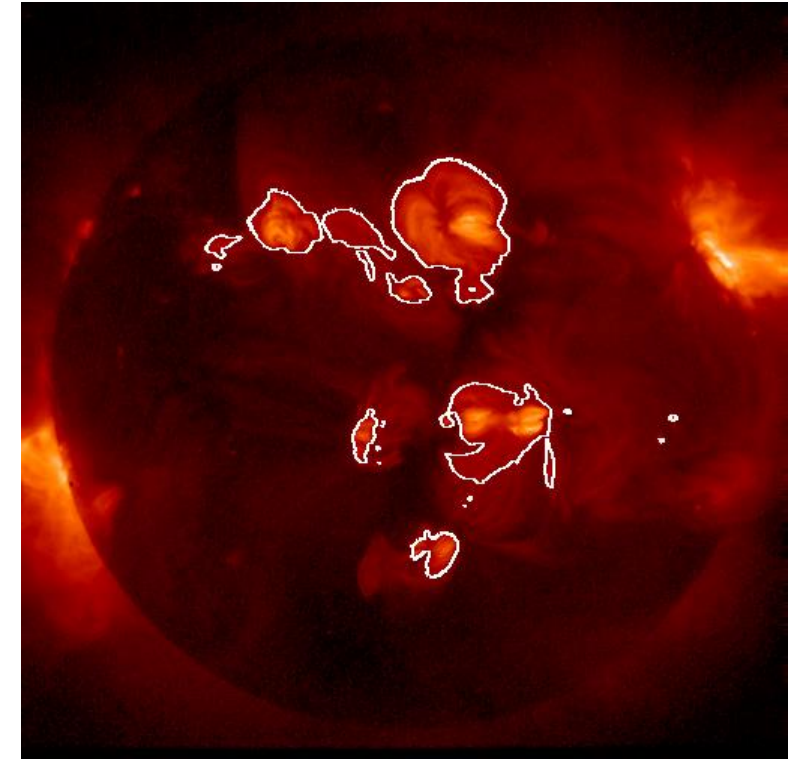
Relationship between X-ray luminosity and magnetic flux



Pevtsov et al. (2003)

Methods

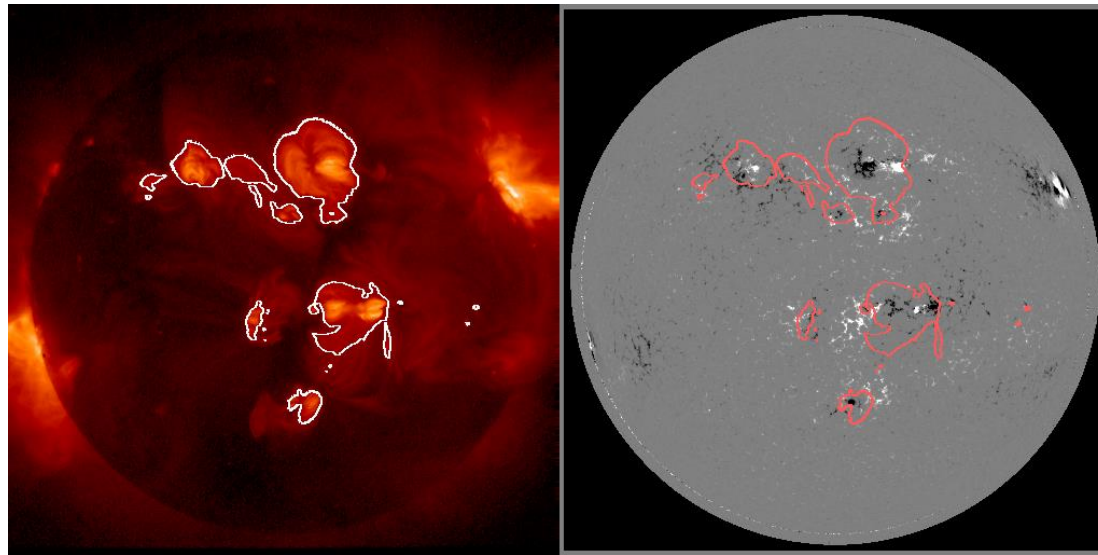
- Use composite images (Takeda et al., 2016) from Hinode/XRT data over a span of 13 years
- Select XBPs and ARs using two different thresholds of X-ray intensity in the Thin_be filter
- Calculate temperature (T_e) and emission measure (EM) using the filter ratio method mainly using Thin_be and Al_poly filters
- Synthesize the X-ray spectrum and Integrating from 2.8 to 36.6 Å to determine the X-ray luminosity



XRT Thin_Be image taken on 2024/03/01. The selected areas are shown on the maps with contours

Methods

- Project selected regions from XRT onto HMI data
- Calculated the total unsigned magnetic flux

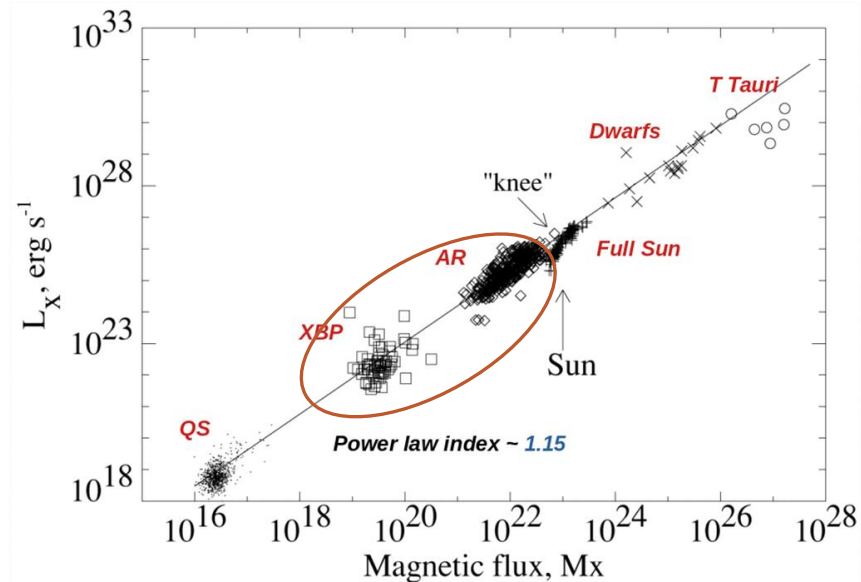


XRT Thin_Be image (left) and HMI magnetogram (right) taken on 2024/03/01. The selected areas are shown on the maps with contours.

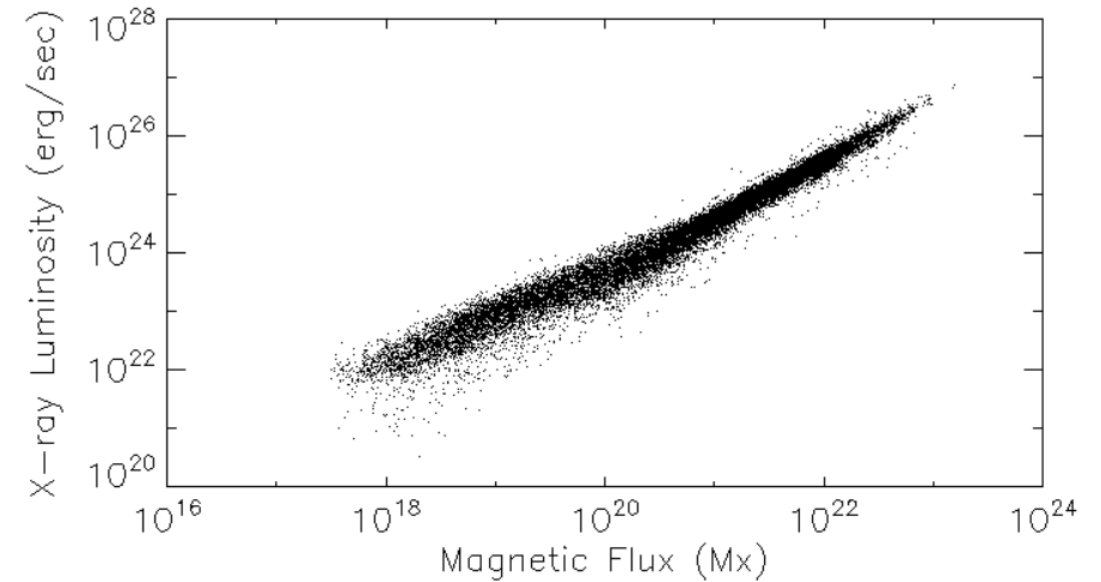
Results

- Graph of X-ray luminosity vs Magnetic flux
- Covered 5 orders of magnitude
- Covers between the lower XBP and upper AR

Relationship between X-ray luminosity and magnetic flux



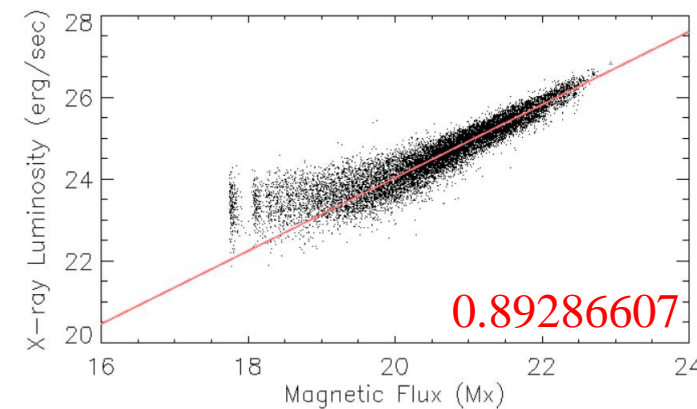
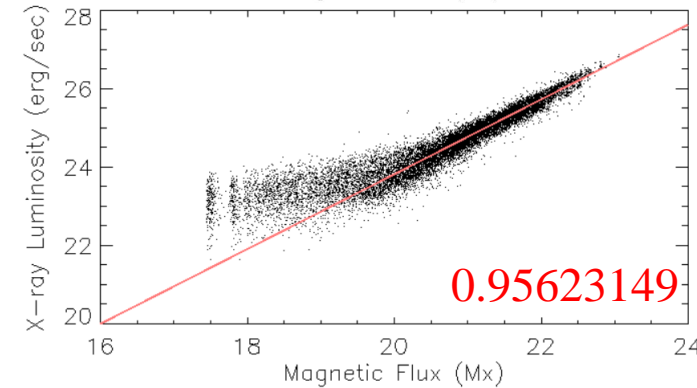
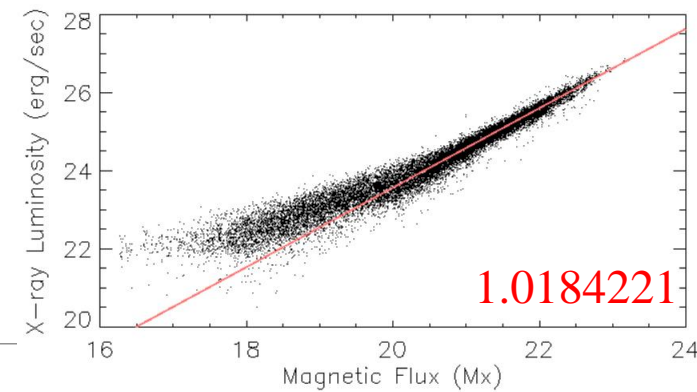
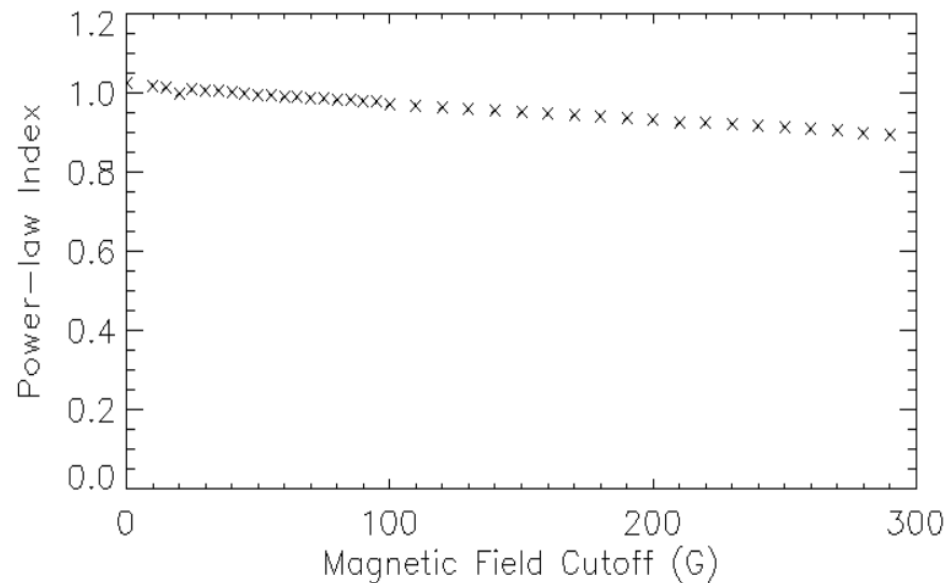
Pevtsov et al. (2003)



40 DN/sec, Bc of OG and , Filter Pair
(FP) of Thin_be and Al_poly

Results

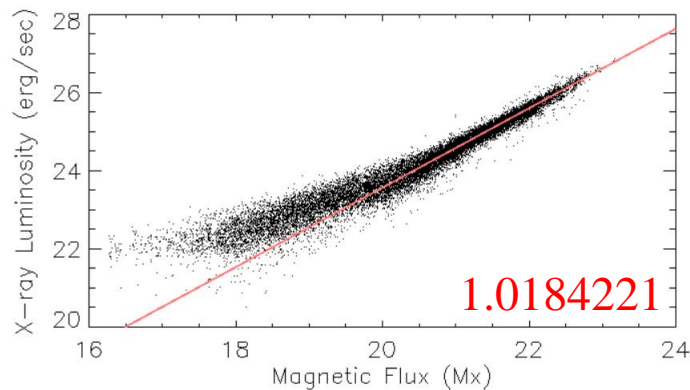
- We fitted data points above 10^{21} Mx (red line) to derive power-law index
- Figures top-down, Bc 10, 150, and 300 G
- With increasing Bc index decreases slightly



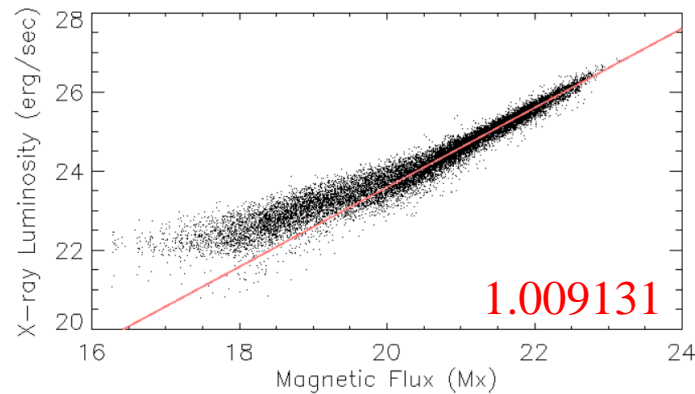
40 DN/sec, FP of Thin_be
and Al_poly

Results

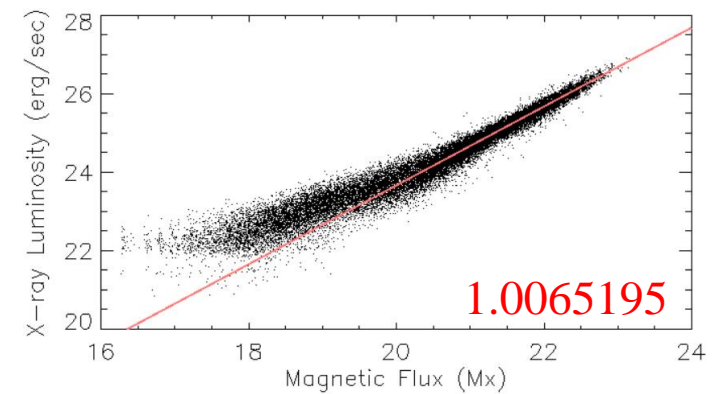
- Testing different parameters
- Changing threshold
- Changing Filter Pairs (FP)
- No significant change



40 DN/sec, FP of Thin_be and Al_poly, Bc of 10 G



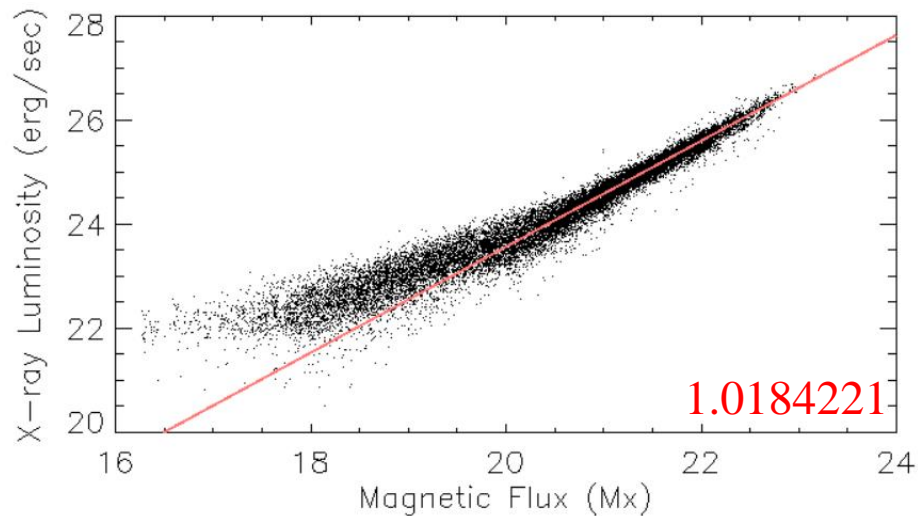
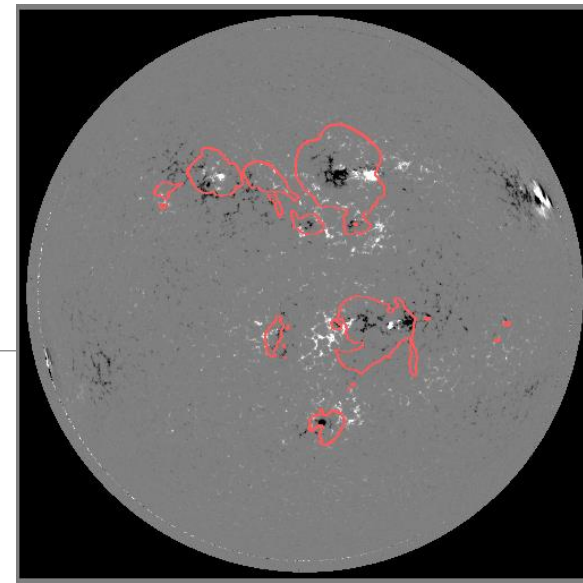
50 DN/sec, FP of Thin_be and Al_poly, Bc of 10 G



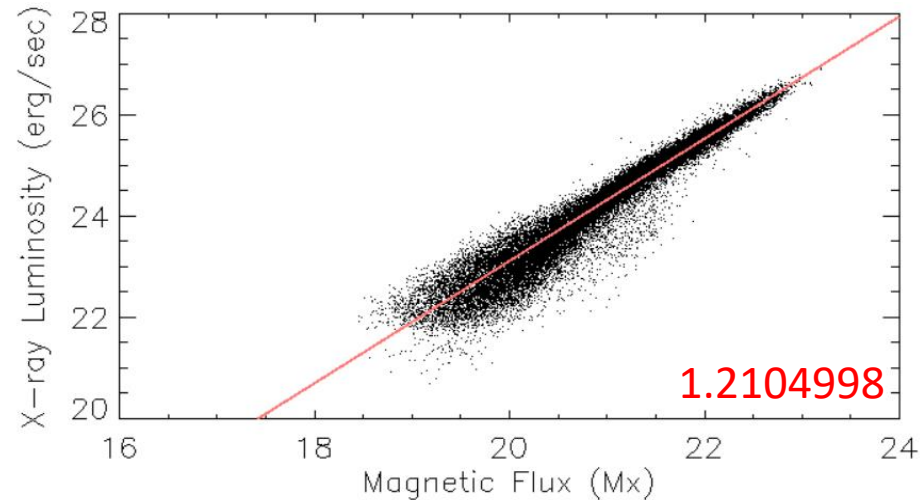
40 DN/sec, FP of Thin_be and Al_mesh, Bc of 10 G

Results

- Looking at magnetic flux below 10^{21} Mx
- Expanded selected regions in HMI data by $\sim 10''$
- Lower end different distribution could be caused due to data selection process



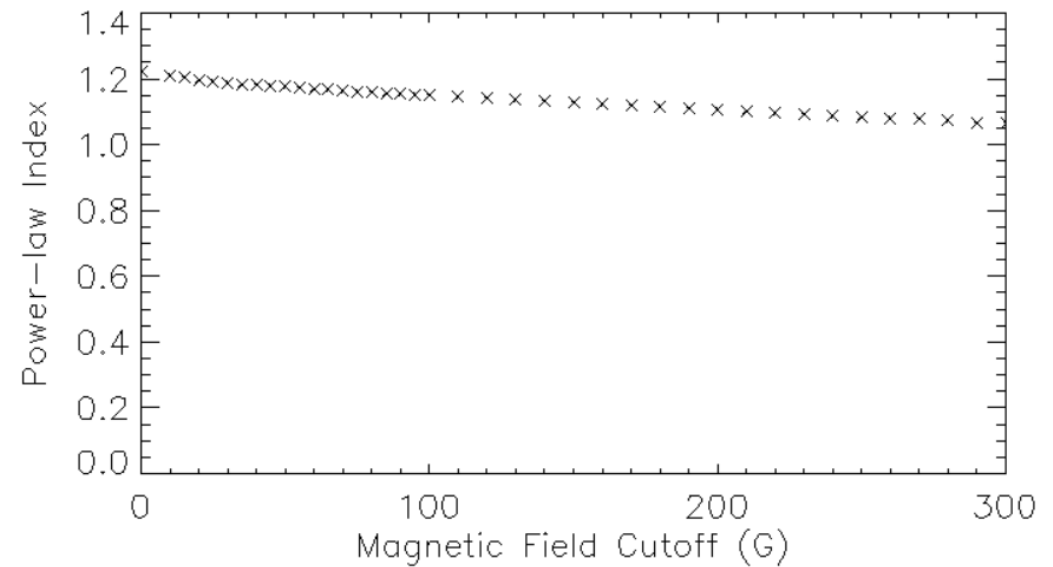
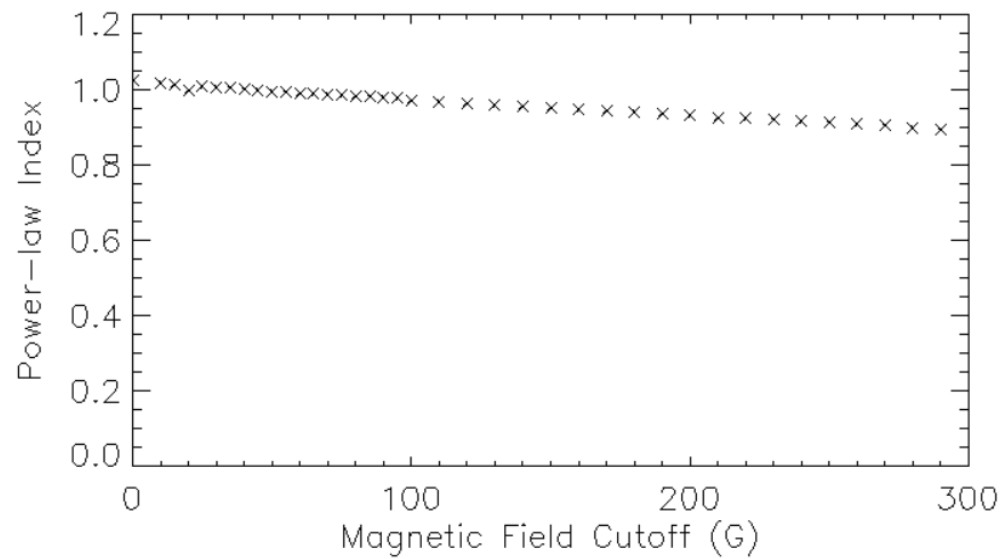
40 DN/sec, FP of Thin_be and
Al_poly, Bc of 10 G



40 DN/sec, FP of Thin_be and
Al_poly, Bc of 10 G

Results

- Power-law index was raised slightly
- Overall trend is similar



Expanded selected regions in HMI data

Discussion

- Data points below 10^{21} Mx shows different trend. This could be caused by data selection bias
- Comparing results with Yoshimura et al. (2024) the change of the power-law index in our study is smaller
- Fisher et al. (1998) reported a power-law index of 1.19 and Pevtsov et al. (2003) reported a power-law index of 1.15 while ours was able to cover the same region with increasing Bc
- The general trend of the power-law index appears to be decreasing with increasing Bc regardless parameters chosen but its rather stable staying around 1

Future of Project

- Consider projection effect between XRT and HMI images
- Integrate over a different wavelength range for X-ray luminosity
- Check solar cycle dependency

References

Fisher et al., 1998, ApJ, 508, 885

Pevtsov et al., 2003, ApJ, 598, 1387

Takeda et al., 2016, Sol.Phys., 291, 317

Yoshimura et al., 2024, TESS 2024 Meeting at Dallas, TX, USA

Acknowledgements

I would like to thank

Dr. Keiji Yoshimura

Dr. Aki Takeda

Rhiannon Fleming

The faculty and students with the solar/space physics REU program

This work is supported by the NSF REU program (2244344) at Montana State University