Investigating Solar Lx-B Relation with Hinode/XRT and SDO/HMI

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Background

The temperature of the steady component of the solar corona ranges from 150 to 300 times hotter than the solar photosphere. The physical mechanism responsible for this heating is still largely unknown. It is widely accepted that emerging magnetic fields from within the solar interior play a major role in heating the corona. In this project, we inspect the relationship between coronal X-ray luminosity and photospheric magnetic flux, particularly with X-ray bright points and quiet Sun regions, to compare with the results of the previous studies performed for the full-Sun integrated signals and active regions.

Data & Methods

Data Sets

- Hinode/XRT soft X-ray images taken with Aluminium-Polyimide and Aluminium-Mesh filters were used to identify X-ray bright points and measure emission.
- SDO/HMI magnetograms were used to measure and calculate unsigned photospheric magnetic flux.
- CHIANTI Atomic Database version 11.02 used for calculating isothermal coronal spectrum (assuming CHIANTI 2021 coronal abundance, ionization equilibrium as of July 2026).

Data Selection Process

- Bright points were outlined and circled so that both the X-ray and magnetic field components of the points were included.
- A large, circular region centered at the middle of the solar disk was selected as a boundary and only bright points that lie within said disk were used in order to minimize stretching effects that are seen further from the center.
- Dates were selected which had data for both XRT filters, HMI data, and low solar activity.
  - After the first round of data processing, dates which took place during the minimum of the solar cycle were exclusively selected because of less scattered light.

X-ray Luminosity & Magnetic Flux Calculations

- Temperature and emission measure were derived from XRT filter ratios (using the two filters mentioned above) and used to calculate luminosity over 2.8-36.6 Å.
- Unsigned magnetic flux was summed up from HMI magnetograms after projection and pixel-area corrections were performed.

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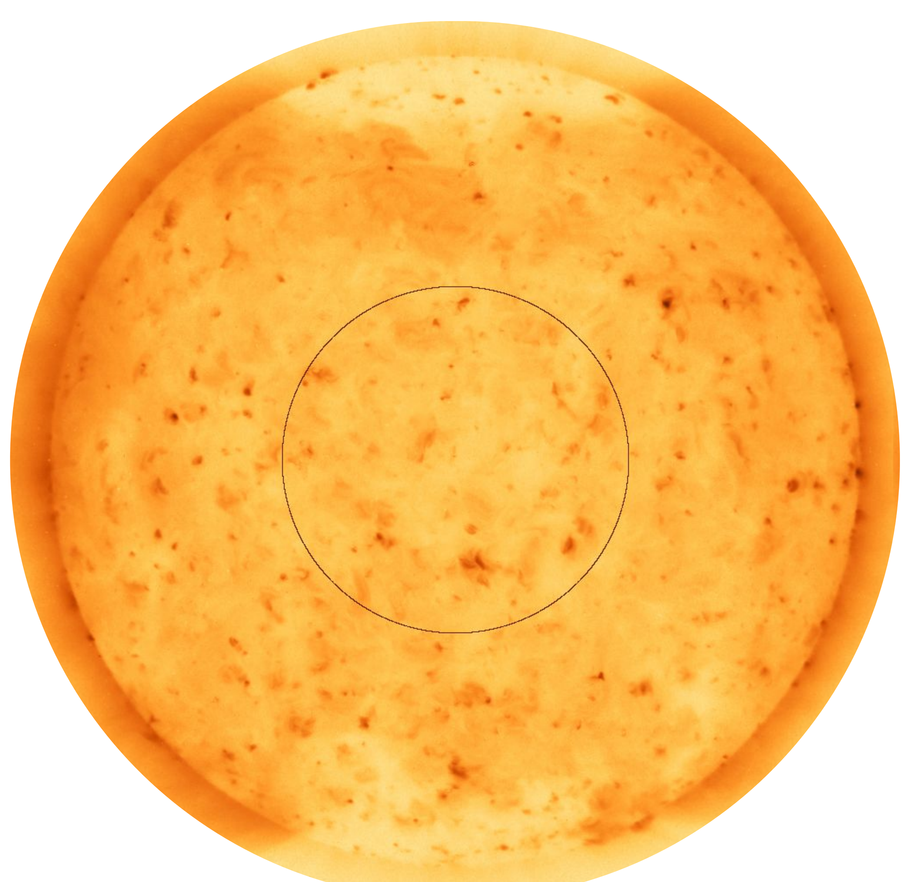
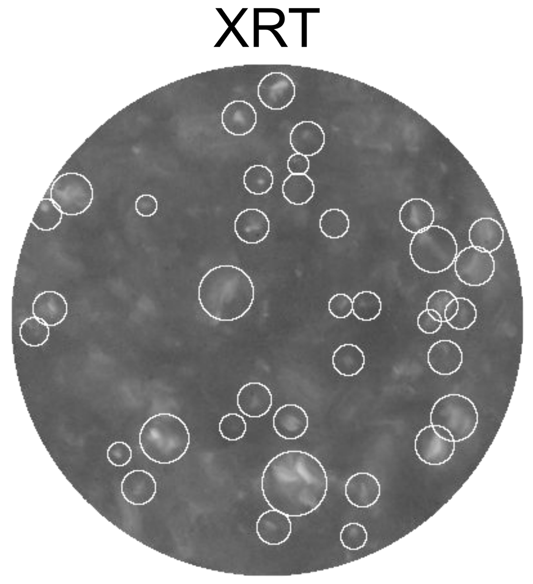
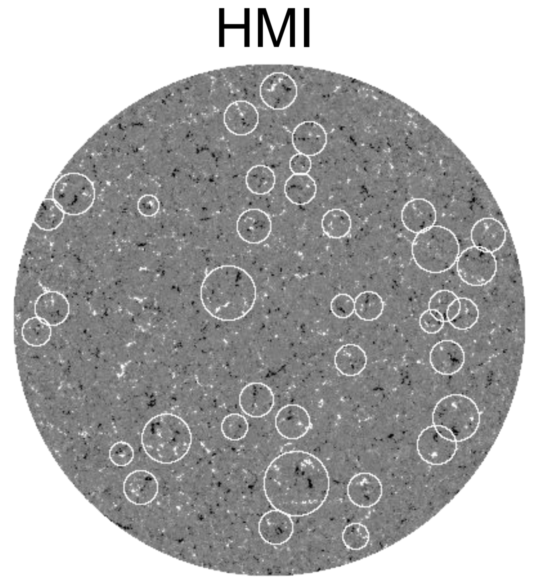


XRT

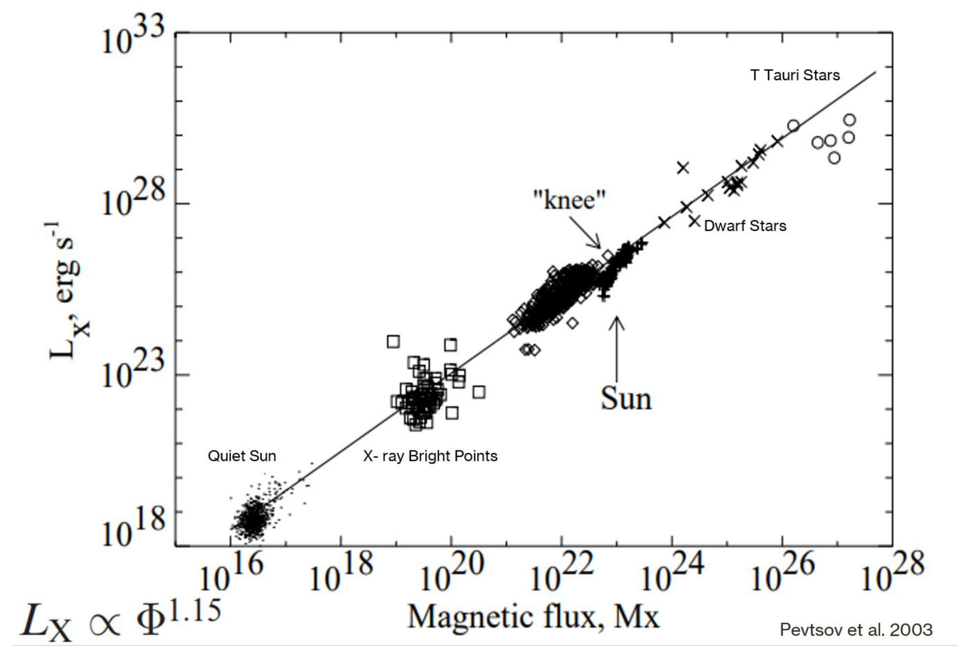


HMI



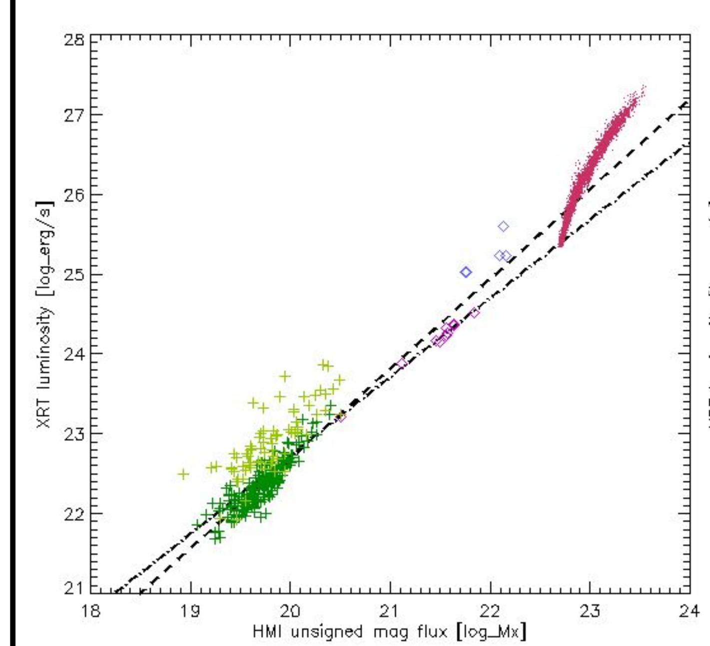
Analysis & Results

A previous study by Pevtsov et al., 2003, found that X-ray luminosity is proportional to magnetic flux by a power law of 1.15. The last study used the Yohkoh/SXT and Kitt Peak magnetogram, and this study uses Hinode/XRT and SDO/HMI.

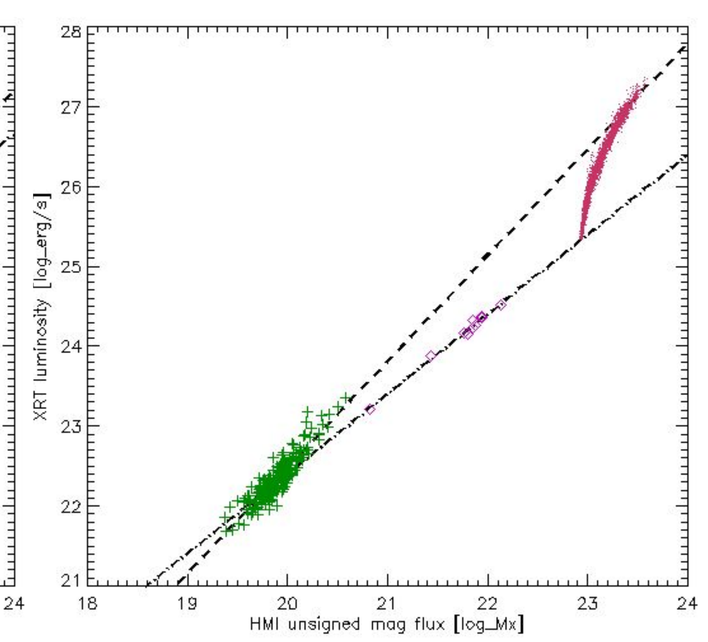


The below Lx-B graphs consist of our bright point, quiet Sun, and full Sun data: Solar Minimum Bright Points (+), Active Period Bright Points (+), Solar Minimum Quiet Sun (◇), Active Period Quiet Sun (◇), Full Sun (●). The dashed line is fitted through the bright points and the dotted-dashed line is fitted through the solar minimum quiet Sun.

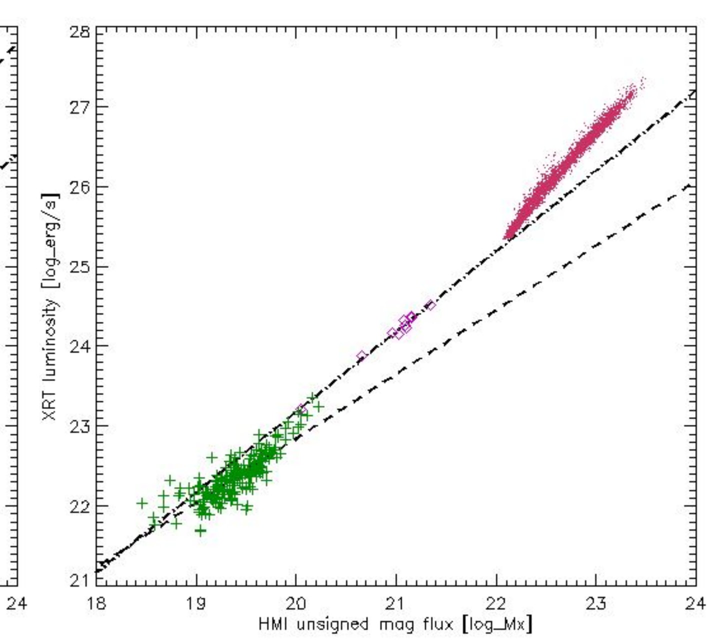
10G Cutoff



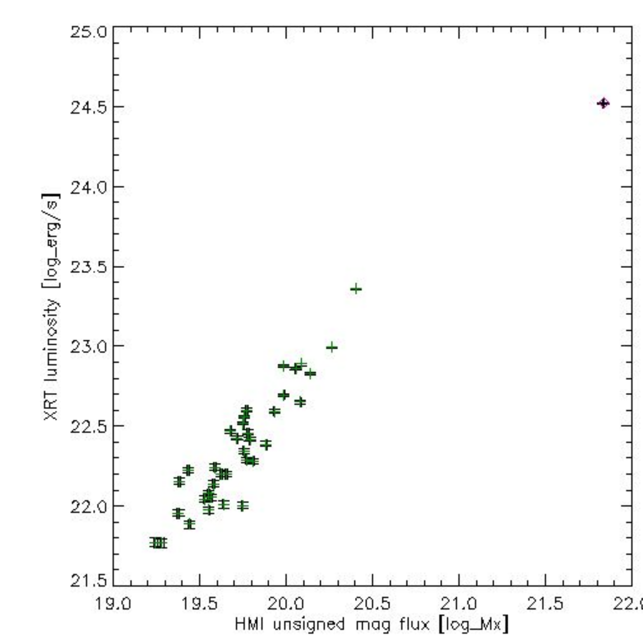
0G Cutoff



45G Cutoff

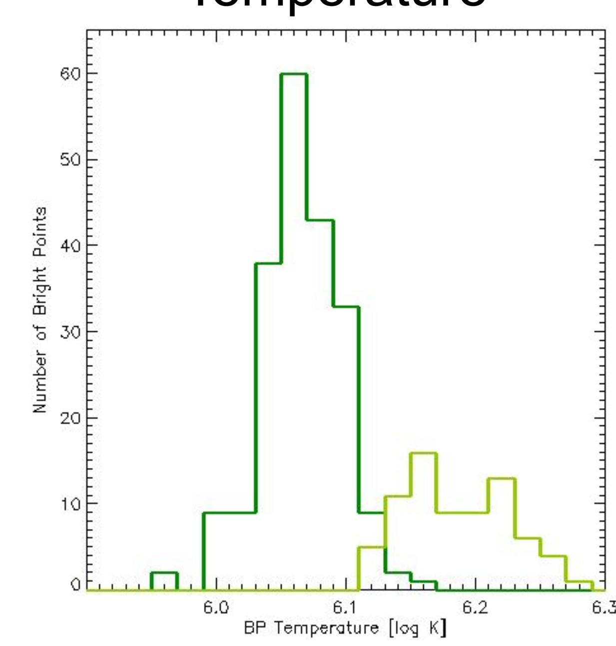


Single Day Uncertainties

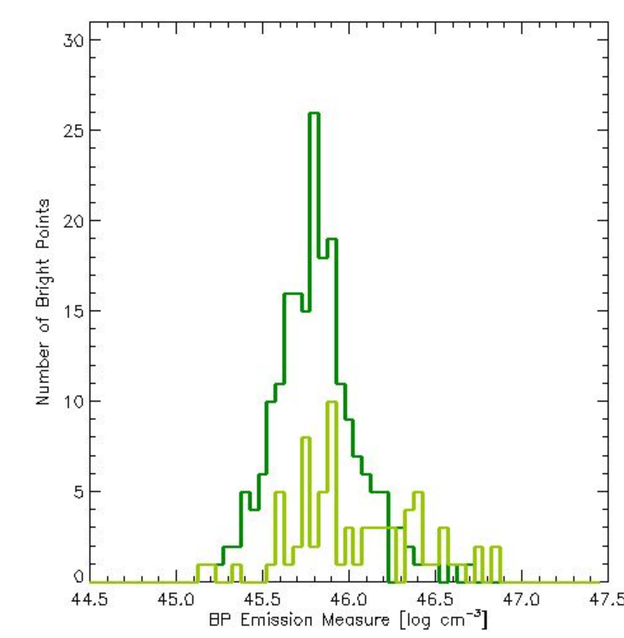


To the right are temperature and emission measure histograms of our bright point data, as well as an uncertainty plot: Solar Minimum & Active Period.

Temperature



Emission Measure



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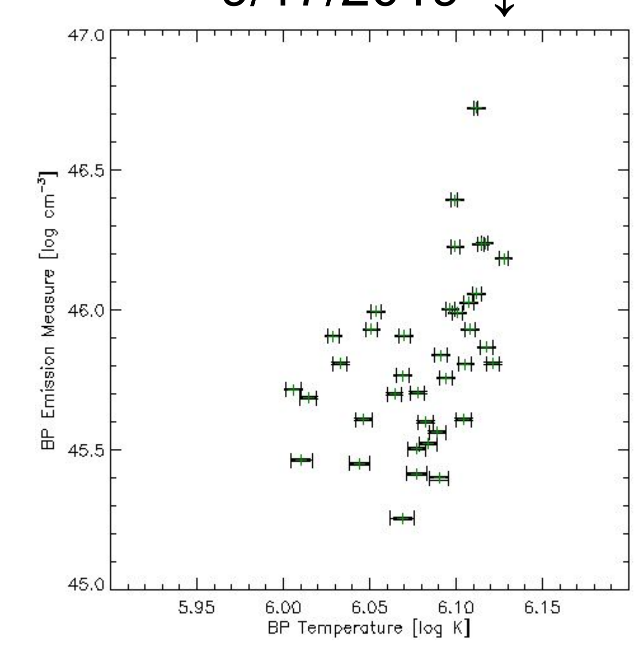

Conclusion

(1) We can see that the solar minimum quiet Sun consistently points to the very bottom of the full Sun plot on all three cutoffs. (2) On the other hand, we cannot confirm nor deny whether or not bright points directly contribute to the knee-structure of the full Sun data. (3) We can see in the bright point temperature histogram that the solar minimum bright point average temperature is around 1.2 MK, which is noticeably cooler than those from more active periods, which have an average of around 1.6 MK.

References:
Yoshimura, K., Takeda, A. and Longcope, D.W. (2025) ApJ, 992, 165
Pevtsov, A.A., Fisher, G.H., Acton, L.W., et al. (2003) ApJ, 598, 1387
https://solar.physics.montana.edu/HINODE/XRT/SCIA/

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