Hot X-ray onsets of solar flares

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Hudson et al.
MNRAS, v. 501-1, Feb 2021
https://doi.org/10.1093/mnras/staa3664

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What is the Hot Onset?

initial temperature values measured from a flare: 10-15 MK

EM starts low (log EM 46) increasing 10-fold during this onset
GOES Temperatures: first detection at 10-15 MK

**Strong & Slow**
SOL2010-11-05T13:29 M1.0

**Weak & Slow**
SOL2011-02-14T01:37 B9.4

**Weak & Fast**
SOL2012-05-14T13:38 C1.1

**Strong & Fast**
SOL2014-01-07T10:13 M7.3
GOES Temperatures: first detection at 10-15 MK

Strong & Slow
SOL2010-11-05T13:29
M1.0

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SOL2011-02-14T01:37
B9.4

Weak & Fast
SOL2012-05-14T13:38
C1.1

Strong & Fast
SOL2014-01-07T10:13
M7.3
Sources of the Hot Onset: AIA imaging

Hot emission: 94 Å (Fe XVIII/XX, 8-10 MK) and 131 Å (Fe XXI/XXIII, ~12 MK) (e.g. O'Dwyer et al. 2010)
Chromospheric emission: 1700 Å (C I, He II, Al II + lines, ~10^{4.5} K) (Simões et al. 2019)
Sources of the Hot Onset: AIA imaging (2)

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Sources of the Hot Onset: Loop vs. footpoint emission

AIA 131 A diff. SOL2011–02–14 (B9.4)

(map: 14–Feb–2011 01:34:09.620

AIA 131 A [10^6 DN/s]

~30%

AIA 1700 A diff. SOL2011–02–14 (B9.4)

(map: 14–Feb–2011 01:34:07.710
ref: 14–Feb–2011 01:32:55.710)

AIA 1700 A [10^6 DN/s]

~40%

131 A onset

94 A onset

FP/Loop emission

FP

loop

total
Verification: limb-occulted flares

AR 11748 rotates into the disk

Onset is now visible at $T = 10-15$ MK

footpoints behind the limb $T = 15-20$ MK
Summary

GOES temperatures start at 10-15 MK B to M classes
Onset temperatures confirmed with RHESSI data

Very small amounts of plasma: log EM ~ 46 to 47 cm$^{-3}$

SDO/AIA imaging: localized near footpoint regions & low-lying faint loops

Flare models? Regulated 10-15 MK while EM increases 10-fold

Ubiquitous? Are there hints to flare magnitude here?

Future work

Alasdair Wilson (Glasgow): DEMograms
Douglas Silva (CRAAM/Mackenzie): statistical analysis of GOES temperatures
Poster by Hugh Hudson: GOES-R data

More details:

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Verification: RHESSI Temperatures

Strong & Slow SOL2010-11-05T13:29 M1.0: 12 MK

Weak & Slow SOL2011-02-14T01:37 B9.4: 16 MK

Weak & Fast SOL2012-05-14T13:38 C1.1 12 MK

Strong & Fast SOL2014-01-07T10:13 M7.3 15 MK
GOES Temperatures: background (pre-flare) subtraction

background subtraction can be tricky but it does not affect the determination onset temperature too much