Temperature, Density, and Heating Profiles of Coronal Loops

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Introduction

- Code for interactive analysis of coronal loops using EIS and AIA data:
 - Automated coalignment of EIS rasters with AIA
 - Interactive selection of loop and footpoint coordinates
 - Extraction and background subtraction of selected loops
 - Temperature (AIA DEM) and density (EIS line ratio) estimation
 - 3 dimensional length estimation using footpoints and loop coordinates
- ► PL/T³_{max} scaling factor then indicates loop heating distribution.
- Simple enough for an undergraduate to analyze an active region (EIS raster) in an hour.

Loop 1 Context & DEM



Figure: Left: AIA Context image showing loop coordinates. Right: Loop DEM, background subtracted.

Loop 1 Density & Pressure



Figure: Left: Density, estimated from EIS line ratios. Right: Pressure, estimated from density and AIA DEM temperature.

Loop 1 Heating Function



Figure: Left: Temperature fit to heating function. Right: Normalized heating rate.

Loop 2 Context & DEM



Figure: Left: AIA Context image showing loop coordinates. Right: Loop DEM, background subtracted.

Loop 2 Density & Pressure



Figure: Left: Density, estimated from EIS line ratios. Right: Pressure, estimated from density and AIA DEM temperature.

Loop 2 Heating Function



Figure: Left: Temperature fit to heating function. Right: Normalized heating rate.

Loop 3 Context & DEM



Figure: Left: AIA Context image showing loop coordinates. Right: Loop DEM, background subtracted.

Loop 3 Density & Pressure



Figure: Left: Density, estimated from EIS line ratios. Right: Pressure, estimated from density and AIA DEM temperature.

Loop 3 Heating Function



Figure: Left: Temperature fit to heating function. Right: Normalized heating rate.

Results & Conclusions

Loop Properties:

Name	Loop 1	Loop 2	Loop 3
Pressure ($\operatorname{erg} \operatorname{cm}^{-3}$)	0.55 ± 0.01	0.50 ± 0.01	0.27 ± 0.01
T_{max} (MK)	2.01 ± 0.21	1.57 ± 0.11	1.53 ± 0.06
L _{half} (Mm)	130 ± 14	70 ± 7	152 ± 5
PL/T ³ _{max} (CGS units)	$(7.8 \pm 2.3) imes 10^{-10}$	$(10\pm3)\times10^{-10}$	$(13\pm3)\times10^{-10}$
α (heating parameter)	-2.0 ± 0.3	-2.2 ± 0.2	$\textbf{-2.34}\pm0.08$

Heating Model Comparison & Conclusions:

- Footpoint heating ($\alpha < 0$) strongly preferred.
- ▶ Joule heating (α = −1.5) most consistent; Most other mechanisms appear inconsistent

Future work: Refine heating model and loop fitting , apply code to large number of loops (REU project?)

Loop 2 Hi-C Image



Figure: Hi-C image of Loop 2 shows multistranded details.

Scaling Factors



Figure: Dependence of PL/T_{max}^3 on α . Joule heating corresponds to $\alpha = -1.5$, velocity filtration to $\alpha = -1.0$, uniform heating to $\alpha = 0$, ion-acoustic to $\alpha = 0.5$, and phase-mixing to $\alpha = 2.5$.