Understanding Coronal Heating through Time-Series Analysis and Nanoflare Modeling

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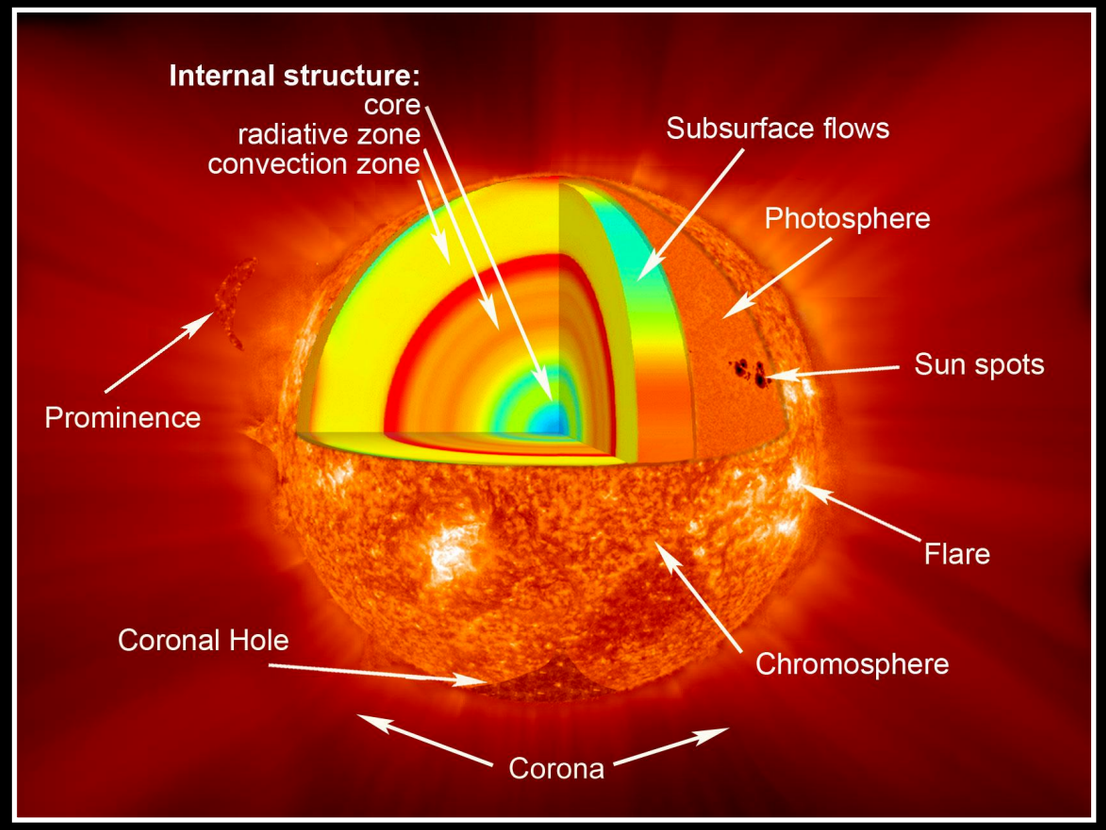
Background image courtesy of NASA/SDO and the AIA, EVE, and HMI science teams.

Basic solar anatomy

- Solar surface features caused by the Sun's magnetic field

- Temperature of photosphere: ~ 5800 K

- Temperature of corona: 1 - 3 MK



Credit: NASA / Jenny Motar

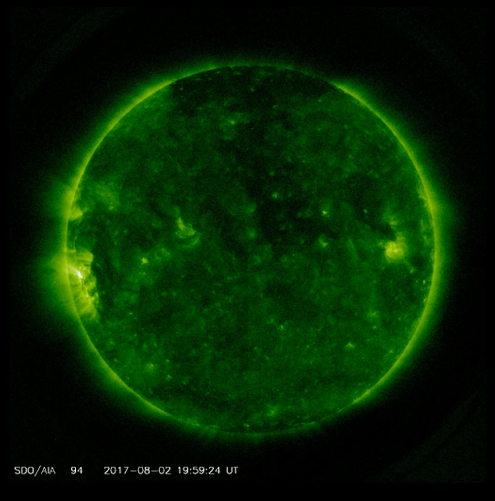
Source: https://www.nasa.gov/sites/default/files/images/462977main_sun_layers_full.jpg

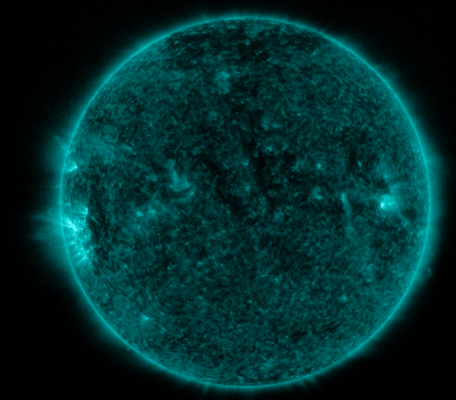
Why is the corona so hot?

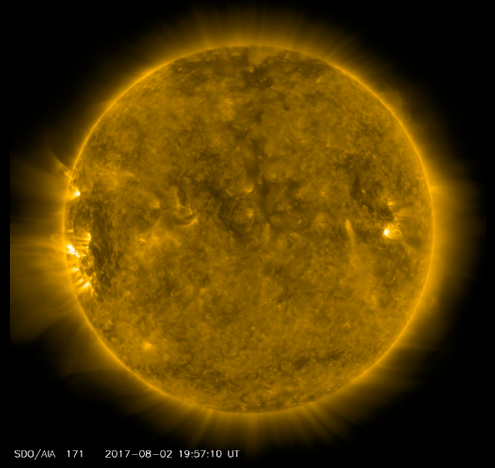
(Answer: We don’t know!)

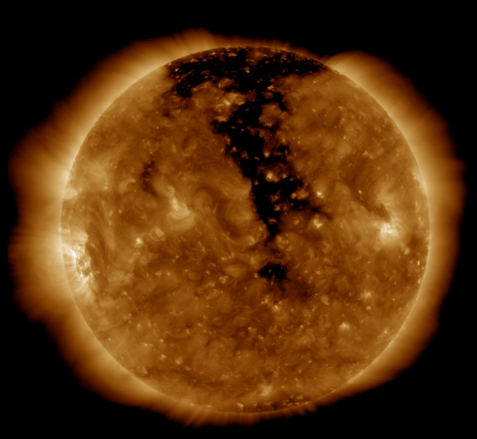
Image: https://apod.nasa.gov/apod/ap060407.html

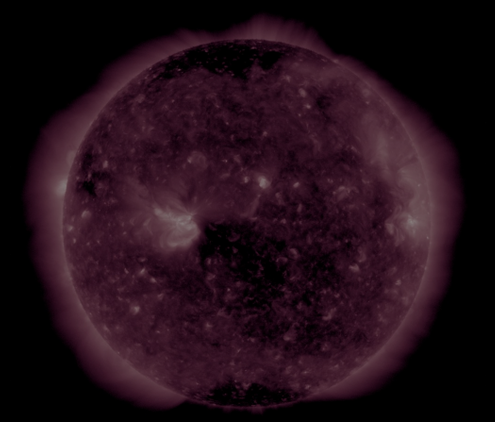
How do we study the corona?

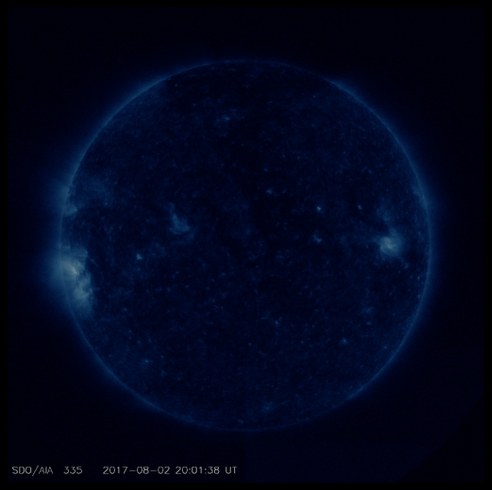










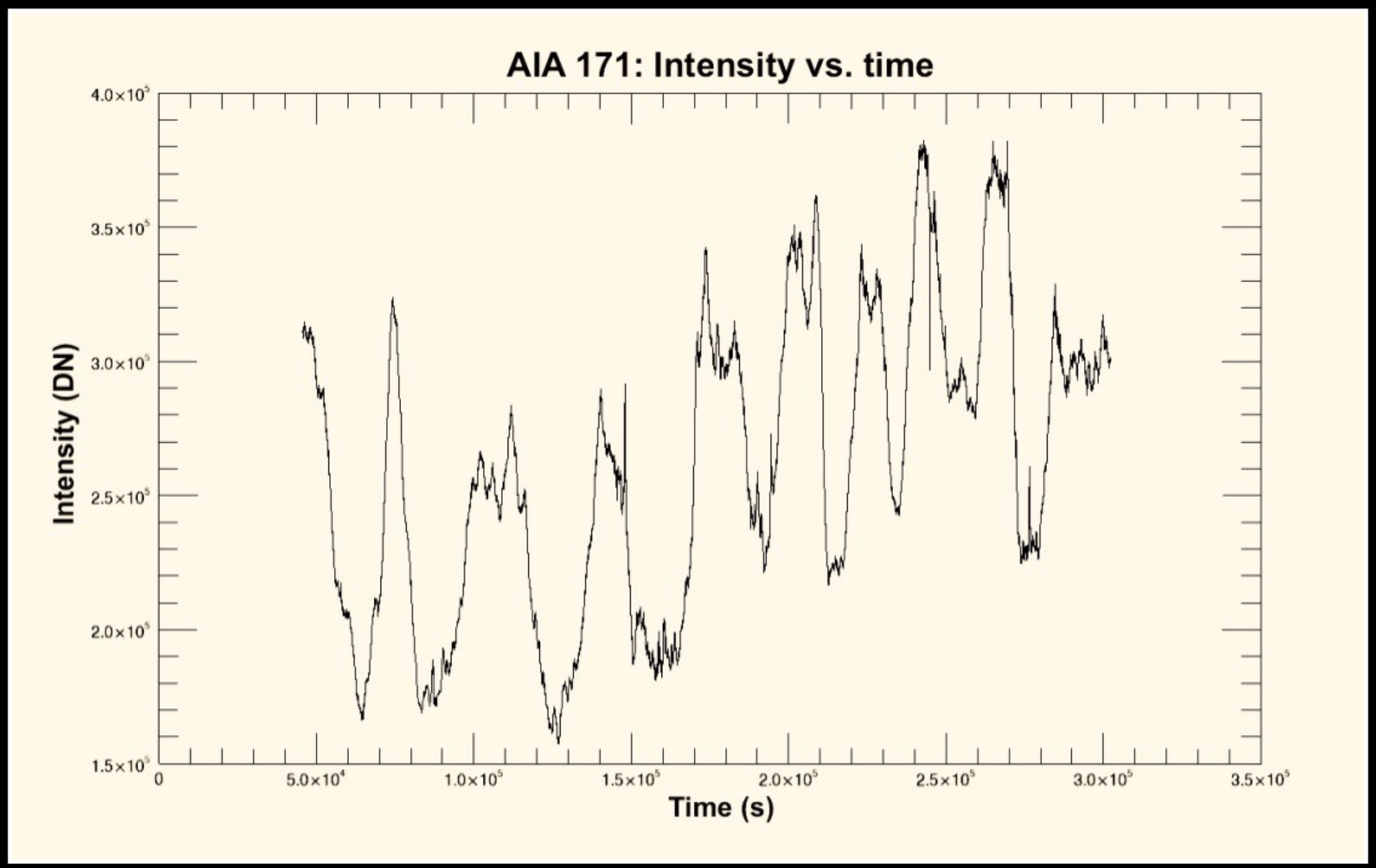


The Atmospheric Imaging Assembly (AIA) aboard NASA's Solar Dynamics Observatory spacecraft continually monitors the corona across a variety of wavelengths.

Each channel is sensitive to a different temperature.

All images courtesy of NASA/SDO and the AIA, EVE, and HMI science teams.

Intensity fluctuations:
a signature of temperature evolution



(June 5-8, 2012)

Nanoflares

- Impulsive bursts of energy release in the solar atmosphere — too small (and too numerous) to resolve using current instruments

- EBTEL (*E*nthalpy-*B*ased *T*hermal *E*volution of *L*oops) simulates plasma response to energy input

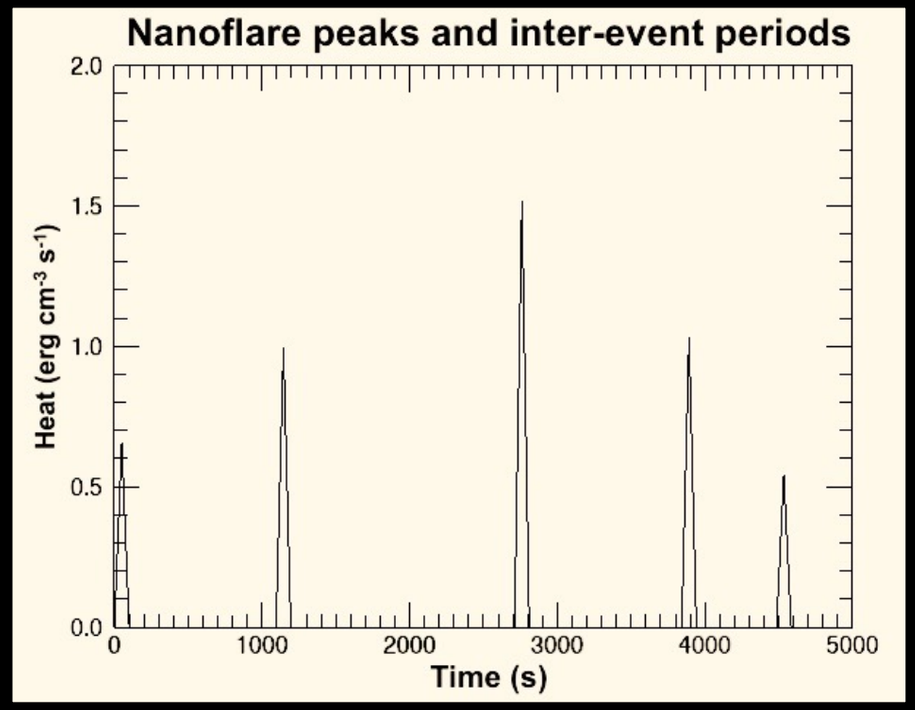
- My job: model nanoflares, run through EBTEL, compare with real data

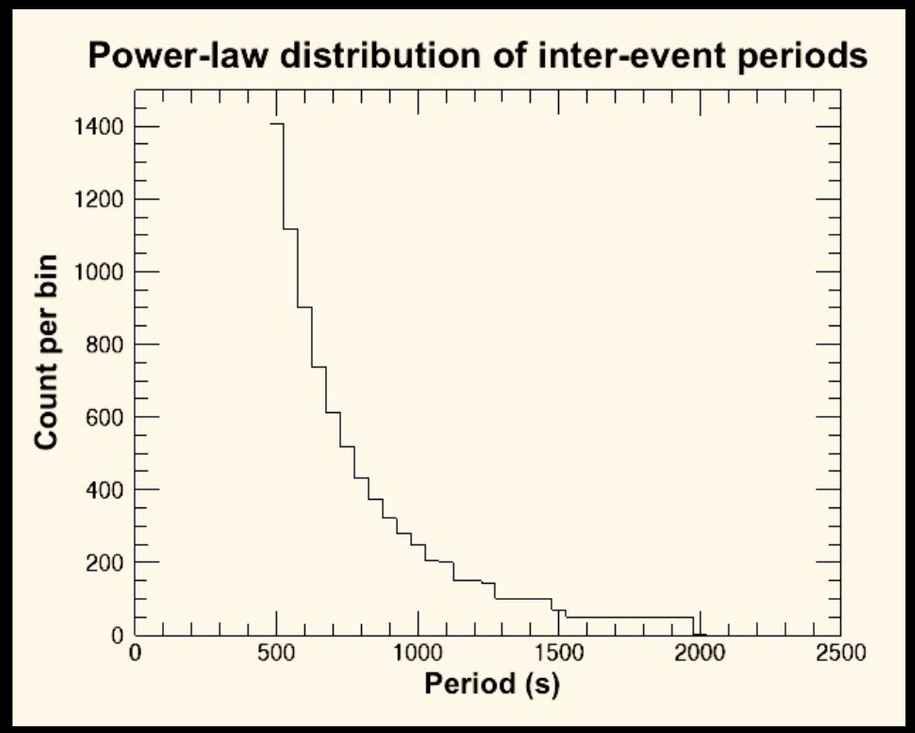
Modeling nanoflares

- Individual nanoflares represented as triangular bursts (duration: <100 s); energy in each burst = area of triangle

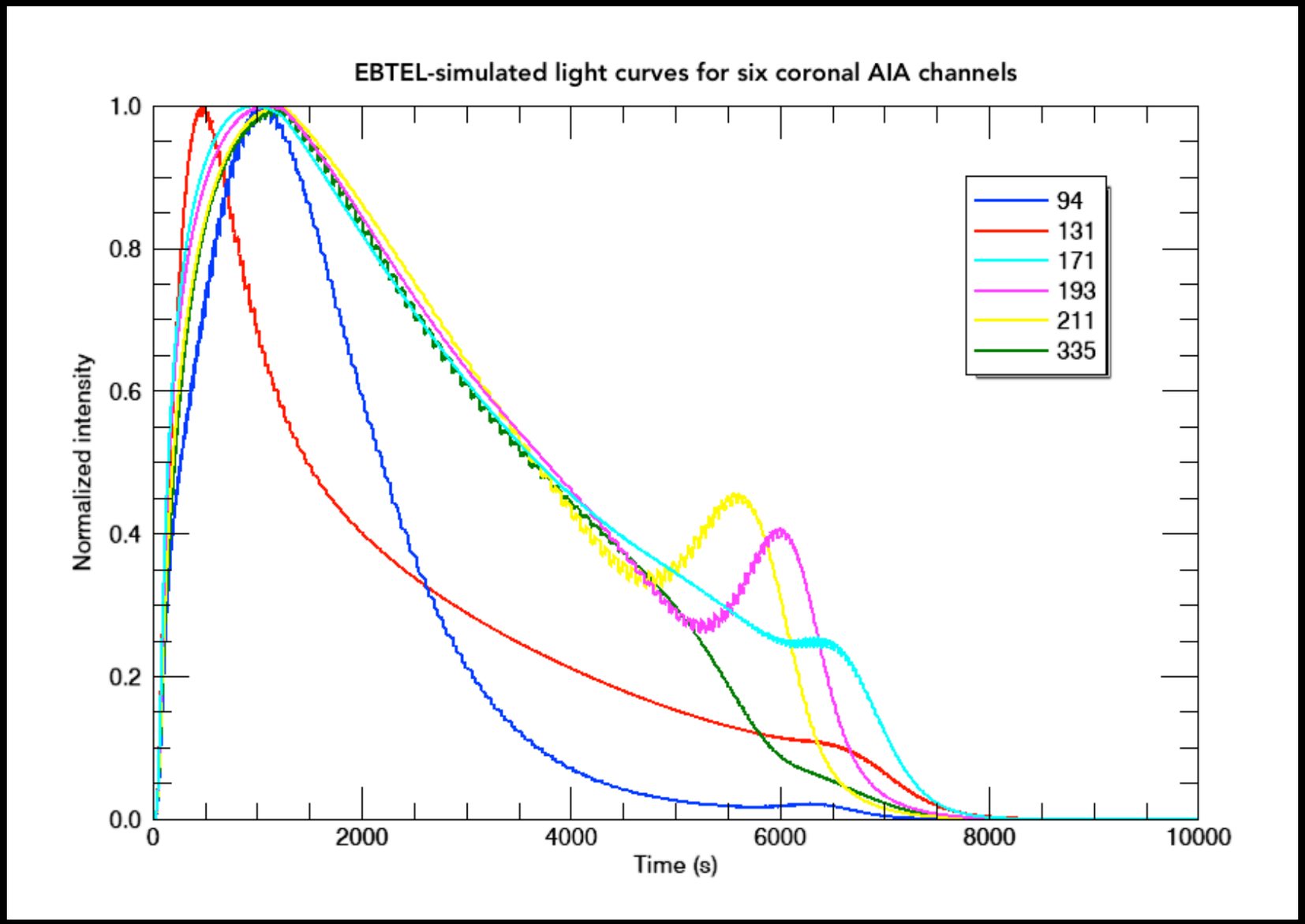
- Distribution follows a power law

Hudson (1991), Cargill (2014), Bradshaw & Viall (2016)



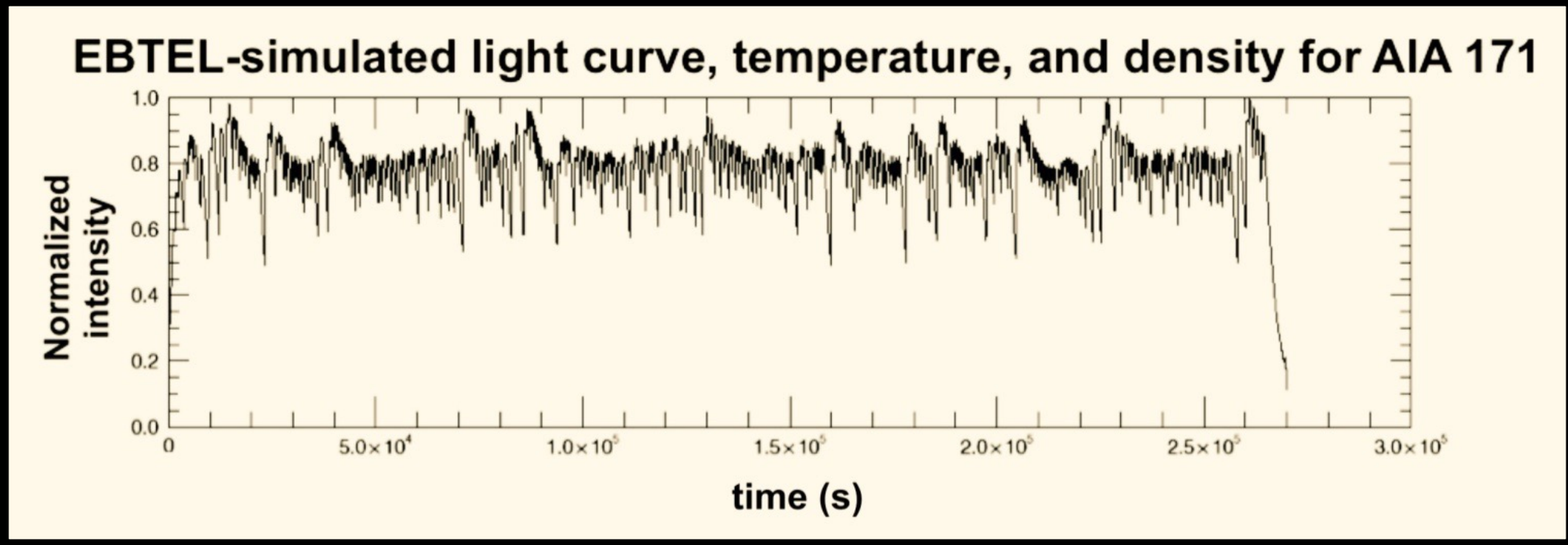


EBTEL: single nanoflare

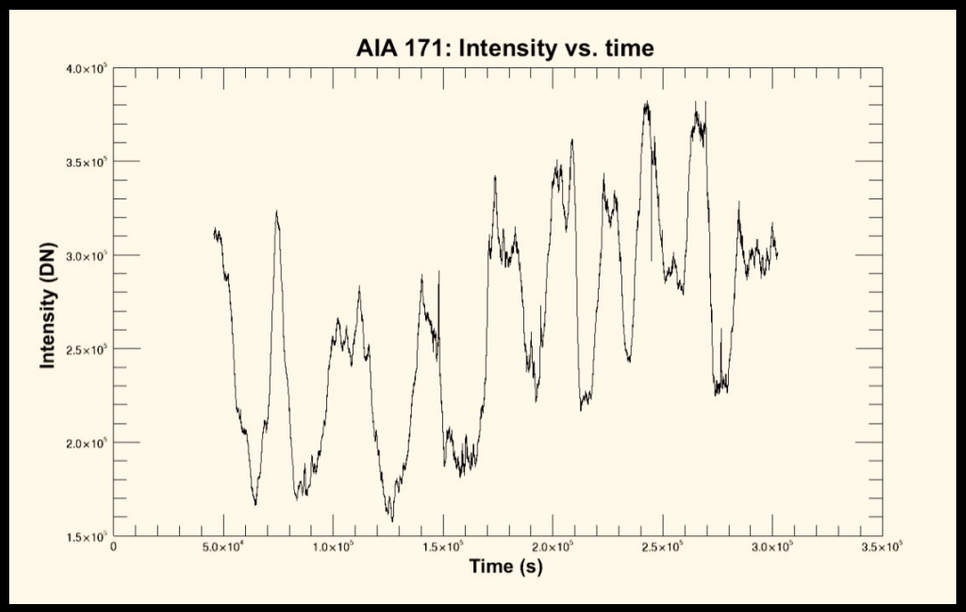


Klimchuk *et al.* (2008), Cargill *et al.* (2012)

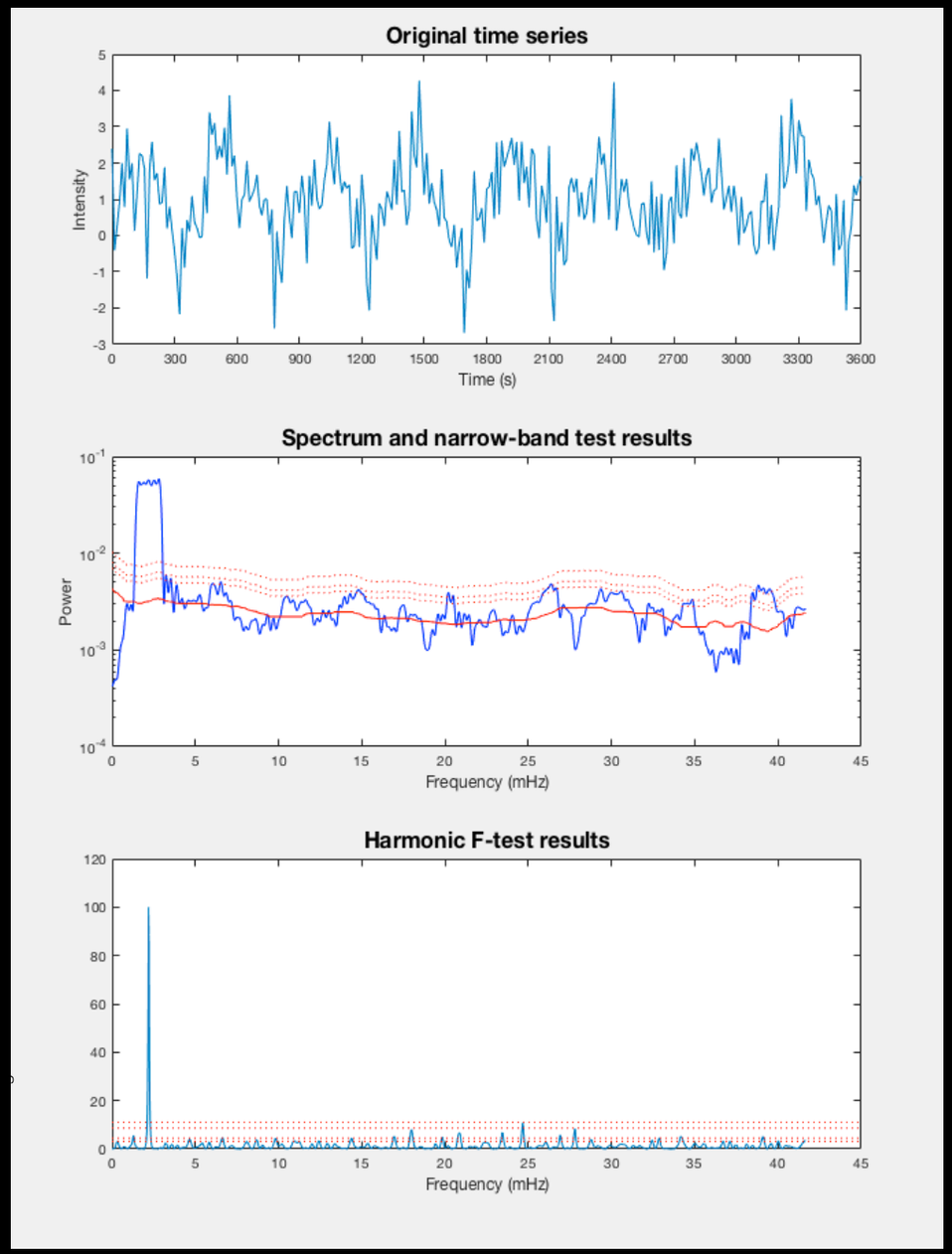
EBTEL: sequence of nanoflares



Compare with real data: if nanoflares cause the intensity fluctuations, results should be similar.



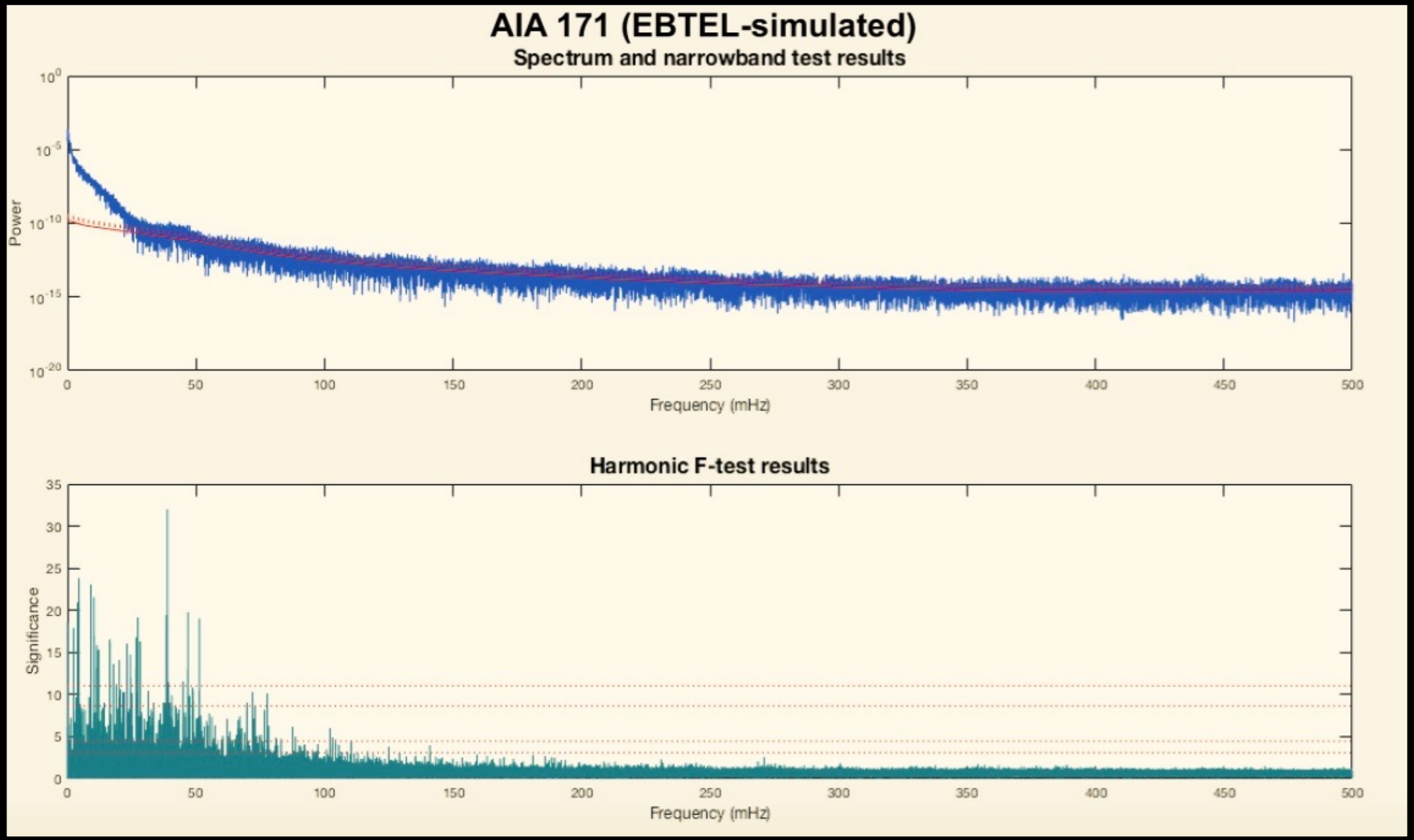
Fourier analysis: time → frequency



- Basic idea: every time series can be expressed as the sum of embedded sinusoids

- Helps us identify patterns in data

Preliminary results



Conclusion

We have developed a method of approximating the energy released by a sequence of nanoflares.

Our simulations can help determine the characteristics of the nanoflares that are responsible for heating the corona.

Background image courtesy of NASA/SDO and the AIA, EVE, and HMI science teams.

Acknowledgments

- AIP/SPS
- GSFC: Nicholeen Viall, Larry Kepko, Jim Klimchuk, Emily Mason
- The SDO/AIA science team

Questions?

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https://www.spsnational.org/programs/internships/2017/kristine-romich

Image: https://apod.nasa.gov/apod/ap060407.html

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