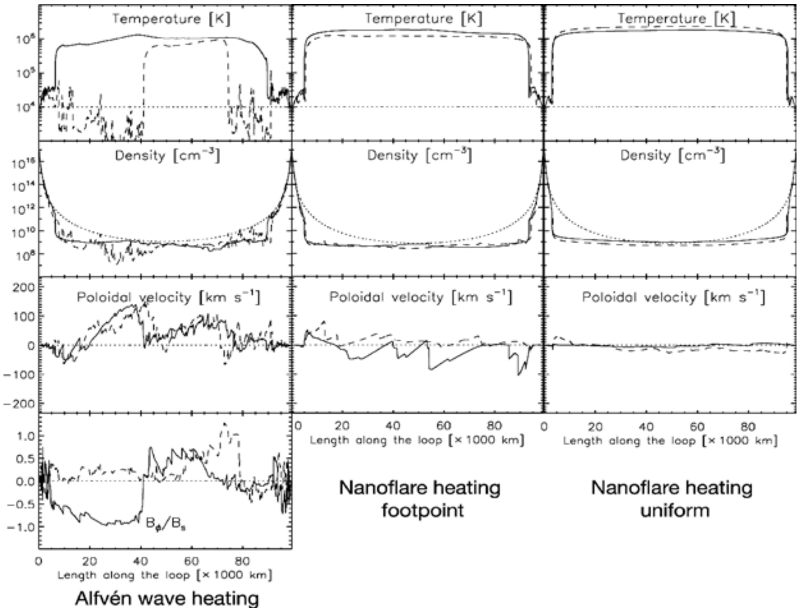
Predicting observational signatures of coronal heating by Alfvén waves and nanoflares

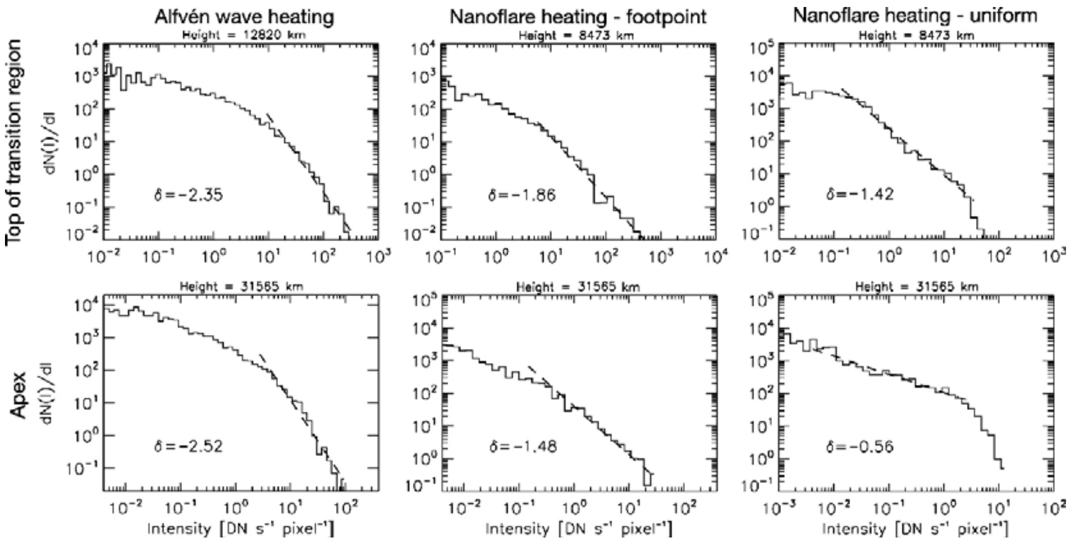
Alfvén waves can dissipate their energy by means of nonlinear mechanisms, and constitute good candidates to heat and maintain the solar corona to the observed few million degrees. Another appealing candidate is the nanoflare-reconnection heating, in which energy is released through many small magnetic reconnection events. Distinguishing the observational features of each mechanism is an extremely difficult task. On the other hand, observations have shown that energy release processes in the corona follow a power law distribution in frequency whose index may tell us whether small heating events contribute substantially to the heating or not. In this work we show a link between the power law index and the operating heating mechanism in a loop. We set up two coronal loop models: in the first model Alfvén waves created by footpoint shuffling nonlinearly convert to longitudinal modes which dissipate their energy through shocks; in the second model numerous heating events with nanoflare-like energies are input randomly along the loop, either distributed uniformly or concentrated at the footpoints. Both models are based on a 1.5-D MHD code. The obtained coronae differ in many aspects, for instance, in the flow patterns along the loop and the simulated intensity profile that Hinode/XRT would observe. The intensity histograms display power law distributions whose indexes differ considerably. This number is found to be related to the distribution of the shocks along the loop. We thus test the observational signatures of the power law index as a diagnostic tool for the above heating mechanisms and the influence of the location of nanoflares.



Profiles of quantities along the loop at various times for a loop heated by Alfvén waves (left panels), and a loop with heating events simulating nanoflares concentrated at the footpoints (center panels) or uniformly distributed along its length (right panels).

Heating model	Flow pattern	Mean velocities $\langle v_p \rangle$ [km s^{-1}]	Max velocities $\langle v_p \rangle$ [km s^{-1}]	Intensity flux pattern	Mean power law index
Alfvén wave	non-uniform, alternating	~ 50	> 200	bursty everywhere	$\langle \delta \rangle <$ -2
Nanoflare footpoint	uniform, simultaneous	~ 15	> 200	bursty close to TR	$-1.5 > \langle \delta \rangle >$ -2
Nanoflare uniform	uniform, simultaneous	~ 5	< 40	flat everywhere	$\langle \delta \rangle \sim$ -1

Observational signatures for coronal heating mechanisms. In the first column from top to bottom we have the heating model: Alfvén wave heating, nanoflare-reconnection heating with the heating events concentrated towards the footpoints or uniformly distributed along the loop. The second column denotes the pattern of the flows along the loop obtained with each heating model. 'Alternating' and 'simultaneous' correspond, respectively, to flows from one footpoint to the other that alternate in time or are rather simultaneous. Flows are 'uniform' when their paths can be traced easily along the loop. The mean and maximum flow velocities found in each heating model are written in the 3rd and 4th columns, respectively. The intensity flux pattern in the 5th column refers to the shape of the intensity flux time series, which can be bursty or rather flat, and which can change with position along the loop. The mean power law index in the last column denotes the mean obtained for many positions along the loop from the transition region to the apex.



Intensity histograms constructed from the intensity flux time series constructed from Hinode XRT response function (Thin Al mesh filter).

Reference: Antolin et al. 2008 ApJ., 688, 669.

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