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Numerical simulation of a coronal loop: response to impulsive heating with a power-law energy distribution

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We conducted one-dimensional numerical simulations of a 40 Mm length coronal loop heated by impulsive heating events (nanoflares) with a power-law energy distribution. The solar flares have a very wide energy range of about 10 orders of magnitude. There are a number of statistical studies on the occurrence frequency of solar flares so far, from which it has been concluded that the energy distribution of solar flares obeys to a power-law distribution (Lin et al. 1984, Shimizu 1995, Parnell & Jupp 2000). If the power-law index has a value which exceeds 2, numerous smaller flares, often called "nanoflares", contribute to the coronal heating instead of large, violent flares (Hudson 1991). Focusing on this point related to the longstanding enigma of coronal heating (see the review: Klimchuk 2006), many authors have investigated the power-law index of the energy distribution of solar flares. When putting it all together, their results indicate an index of 1.5-1.8 (Aschwanden & Parnell 2002). Therefore, in consideration of this result from previous studies, so called "nanoflares" cannot contribute to the heating of the solar corona. However, previous studies have implicitly assumed that the increment of thermal energy derived from observational data is same as the input energy to the solar corona. If this assumption is not correct, that is, there are discrepancies between the power-law index of input and that of observations, we must re-examine the interpretation of previous studies. In this study, synthetic observational data of a coronal loop heated by numerous impulsive heating events (nanoflares) with a power-law energy distribution are made by taking account of the filter response of Transition Region And Coronal Explorer (TRACE) satellite. We have analyzed synthetic data by the same method as previous studies and concluded that energy distribution derived from synthetic data differs from input power-law energy distribution in its shape, that is, convex upward distribution. This result is similar to the result of Antolin et al. (2008). The derived energy distribution can be fitted better by a double-power law than a single-power law. When the intervals of time between nanoflares are sufficiently long, the derived energy distribution appears similar to the input energy distribution.

Keywords: sun, corona, nanoflares