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Using the Time Lag Analysis to Diagnose Coronal Heating in a Survey of Active Regions

In this paper we examine 15 different active regions observed with the Solar Dynamics Observatory and analyze their nanoflare properties using the time lag method. The time lag method is a diagnostic of whether the plasma is maintained at a steady temperature, or if it is dynamic, undergoing heating and cooling cycles. An important aspect of our technique is that it analyses both observationally distinct coronal loops as well as the much more prevalent diffuse emission surrounding them. We find that widespread cooling is a generic property of both loop and diffuse emission from all 15 active regions. Only occasionally, however, is there full cooling from above 7 MK to well below 1 MK. More often the plasma does not fully cool below 1 MK before being reheated by another nanoflare. Warren et al. (2012) first studied these same 15 active regions, and measured their emission measure distribution. We find that the degree of cooling is not well correlated with the reported slopes of the emission measure distribution. We show that these apparently contradictory observations can be reconciled with the presence of a distribution of nanoflare energies and frequencies along the line of sight, with the average delay between successive nanoflare events being comparable to the plasma cooling timescale.