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Temperature Diagnostics of a Solar Active Region Using a Single-Filter Observation of Hinode/XRT

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Abstract. Broad-band X-ray observations can provide limited temperature diagnostics through filter ratios. A high cadence observation of an active region made with a single Hinode/XRT filter allows us to use an alternative approach in which we measure the time fluctuations of the pixel count rate and use the variance as temperature proxy. We show the results and discuss limitations of method.

1. Data Analysis

A high cadence observation of an active region made with a single-filter Hinode/XRT allows us to use a new method of single filter temperature diagnostics (Labonte & Reardon 2007), measuring the time fluctuations of the pixel count rate and using the variance as temperature proxy. The data that we used was collected from the *X-Ray Telescope* (XRT) onboard on the HINODE satellite. The data set under analysis consists of 265 couples of 384x384 pixels images, taken in the Ti_poly filter band (Fig.1, left panel). The data set have a cadence of 15 seconds, with short exposure times (~ 0.73 sec) for a total coverage of ~ 60 min. The active region was observed in 2010 April 1, starting at 15:04:19 UT.

Pixel-by-pixel we measure the amplitude of the fluctuations of the count rate, with respect to the linear fit to the light curve in unit of the width of the photon noise distribution for that pixel, that is the standard deviation of the distribution (Terzo et al. 2011). The method is so based on measuring the fluctuations of the pixel light curves and assuming that they are entirely due to the photon noise. This is reasonable because all relevant physical processes are expected to occur on time scales longer than the data cadence. For each pixel, we measure the standard deviation of the fluctuations around the linear best fit of the light curve (σ_p), i.e. the width of their distribution.

If the fluctuations are due to the photon noise they depend on the photon rate and therefore on the average DN rate I_0.

$$\sigma_{DN}(x, y, t) = \sqrt{K_i[T(x, y, t)]\, I_0(x, y, t)} \quad (1)$$

where $K_i[T(x,y,t)]$ is the conversion factor from DN to photon counts, which depends on the underlying spectrum and therefore on the temperature T of the emitting plasma, and I_0 is the measured DN. σ_{DN} is already in units of DN. The conversion factor $Ki^{(2)}$ from DN rate to photon rate depends on the spectrum and therefore on T (Katsukawa & Tsuneta 2001).

2. Results

We derived temperature distribution by a single filter observation (Ti_poly) by inverting the formula above (eq.1). In the Figure1 (right panel) we report the result of the method, we show the resulting temperature histogram of the valid pixels, of the central part of the active region (see Fig.1, left panel). The temperature values are in the range $6.0 \leq \log T \leq 6.5$. The peak is at $\log T \sim 6.2$. The applicability of this method is liable to high cadence observations ($dt \leq$ plasma times). In a multi-thermal line of sight we are sampling the EM where the filter is more sensitive (hard filter in this case). The method is easy to apply to constant or linear light curves, and it should be robust because we expect a little depending on the filter calibration.

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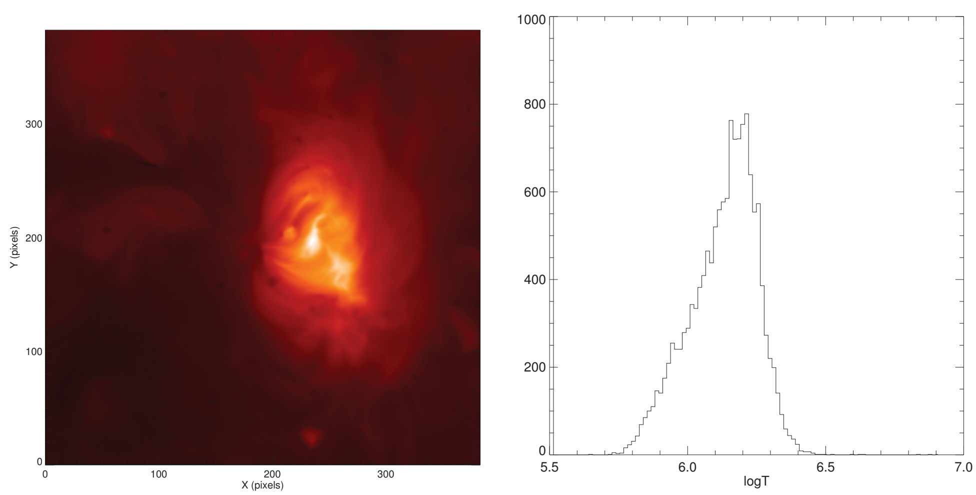

Figure 1. Left Panel: Active region observed with the Hinode/XRT Ti_poly filter on 01 April 2010 at 15 UT. Right Panel: The histogram shows that the temperature is in the range $6.0 \leq logT \leq 6.5$. The peak is at $\log T \sim 6.2$.