NANO-FLARE HEATING IN SMALL COOL LOOPS

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Recent observational advances (e.g.: Feldman et al 2001) have revealed a wealth of dynamic fine-scale structure at transition region temperatures that provide most of the quiet solar VUV output at temperatures well below 1 MK, demonstrating that such cool structures are the basic components of the quiet transition region, rather than the footpoints of large coronal loops.

Moreover, theoretical investigations (e.g.: Spadaro et al. 2006) have shown that transient, nanoflare-level heating localized near the chromospheric footpoints of small magnetic loops, with durations of the order of 10 to 100 s and repeat times of a few hundred seconds, can successfully reproduce the emission measure versus temperature distribution and the temperature dependence of the persistent redshifts observed in the quiet-Sun transition region.

In order to investigate these aspects in more detail and confirm or not the role of such fine-scale magnetic structures, spectroscopic observations with spatial resolution capable to disentangle plasma elements of the order of 100 to 200 km, such as that expected for the Solar Orbiter spectrometer, are critically needed to truly isolate cool loop emissions from their high-temperature surroundings and possibly locate the regions of heating release within the loop.

EUS instrument requirements

1. Emission line requirements

Bands 6, 7a and 7b, described in the wavelength selection documents, contains strong lines formed from 10^4 K to few 10^5 K plus the C III 97.7/117.6 nm density diagnostic at transition region temperatures. A selection of lines would include, H I Lyman-α or -β (2×10^4 K, morphology and link with the imager, EUI), Si II 126.5 nm (2×10^4 K), C III 97.7 nm (8×10^4), O VI 103.2 nm (3×10^5), Ne VIII 77.0 nm (6.3×10^5 K). The C III 117.6 nm multiplet should also be included for density diagnostic. Moreover, we could introduce the N V 123.8 nm (1.5×10^5), in order to have a better temperature coverage of the TR.

2. Spectral resolution requirements

Profile needs to be resolved in order to study line shifts and widths. A spectral resolving element of 0.005 nm/pixel is required (2 km/s in $1/7^{th}$ of pixel at 97.7 nm). Spectral windows must be at least 0.2 nm large (40 pixel with 0.005 nm/pixel), to fully resolve the dynamics of the impulsive events. If it will be possible to select spectral windows of variable width, and since the H I Lyman-α line in this study is required only for morphology and alignment with the imager, a smaller window (15 or 20 pixels) for this line could be employed.

3. Spatial coverage

The typical scale on which to observe includes one supergranular cells ($L \approx 30$ Mm). This requires at least a 300"×300" raster (at 0.22 AU). However, unless precise pointing on single supergranular cells will be available, rastering should cover at least the size of two cells, or 600×300" at 0.22 AU.

4. Time resolution (incl. Count rates)

The timescales to be resolved are of the order of 10 s. Required count rates: at least 100 counts in 10 s. In the quiet Sun such count-rates are achieved by all the listed lines, with the possible exception of Ne VIII 77.0 nm, where we should anyway expect an average of at least 80 counts in 10 s. The produced data rate (12 bps) for the seven selected lines and for spectra covering 300" (300 pixels) along the slit, would be 7×300×40×0.1×12=100.8 kbps, roughly 6 times the available rate. Some amount of data compression may be needed.

5. Requirements for other instruments

Imaging capability at coronal and transition region temperatures is important to place the spectroscopic measurements in their context and to study the morphology and evolution of the selected active region. EUI images required: Lyman-α and Fe IX 17.1 nm. VIM magnetograms will allow structures to be related to photospheric magnetic features.

6. Other requirements

N/A.

Relation to Solar Orbiter science goals

1. Determine the properties, dynamics and interactions of plasma, fields and particles in the near-Sun heliosphere

N/A

2. Investigate the links between the solar surface, corona and inner heliosphere

The transition region is the route through which energy flows from the photosphere to the corona. Understanding its structure and dynamics is crucial for a global comprehension of the solar atmosphere energetics and dynamics.

3. Explore, at all latitudes, the energetics, dynamics and fine-scale structure of the Sun's magnetized atmosphere

Now that the importance of extended regions of plasma below 1 MK for the structure and emission of the quiet transition region has definitely come to the foreground, a better understanding of the energetics and dynamics of cool magnetic loops is even more essential.

4. Probe the solar dynamo by observing the Sun's high-latitude field, flows and seismic waves

N/A

References

Feldman, U.; Dammasch, I. E.; Wilhelm, K. 2000, Space Science Reviews, v. 93, 411-472

Spadaro, D., Lanza, A.F., Karpen, J.T., & Antiochos, S.K. 2006, ApJ, 642, 579