Diagnostics of loop structure and heating

Enrico Landi, Clarence Korendyke[1]

[1]Naval Research Laboratory

Contact: [landi@poppeo.nrl.navy.mil]

Plasma loops are the building blocks of the solar corona and are involved in most phenomena taking place in the solar atmosphere. Despite their importance, little consensus has been found on the mechanism(s) that form them and heat their plasma (steady state or nanoflare heating?), on their structure (size of individual strands? Uniform or variable cross-section?), and on why they are isothermal along their length.

Recently, evidence has been brought (Landi & Feldman 2005) that the loop cross-section is not uniform, but it decreases sharply with temperature in the transition region: these variations help explaining the weak loop emission in transition region and chromospheric lines, and the constant loop temperature in the corona. Also, a big controversy has flared on the basic physical properties of loops.

To determine the variation of the cross-section with temperature many lines emitted by plasmas with temperatures between 10,000 and 1,000,000 K need to be observed at high spatial resolution; the physical properties of the whole loop structure at all temperatures need to be measured using a variety of line intensity ratios.

Current spectrometers (CDS and SUMER on SOHO) do not have the diagnostic capabilities, the spatial resolution and/or the temperature coverage to provide reliable measurements of the loop cross-section with temperature. Solar-B/EIS will be confined mostly to coronal temperature. EUS will be the only instrument which will be able to provide the necessary data. The spectral bands best suited for this study are band 5 (515-635 A) and 6 (700-800), as a compromise between wide temperature coverage and diagnostic capabilities.

EUS instrument requirements

1. Emission line requirements

Strong lines formed at 10^4 K, 10^5 K and 10^6 K are necessary for mapping the loop shape with temperature and compare their intensities with models; density and temperature diagnostic at transition region and coronal temperatures are also necessary.

2. Spectral resolution requirements

Need to measure unblended lines, a standard SUMER-like spectral resolution, or better would do.

3. Spatial coverage

The field of view needs to be able to observe a complete active region, in order to track active region loops along all their length and relate them to footpoints.

4. Time resolution (incl. count rates)

Very fast cadence is not key for this study, so the ability of scanning an entire active region in say 5-10 minutes would be OK. Good signal to noise is required for plasma diagnostics, let's say 50 counts (S/N=7 assuming Poisson statistics) at each position are needed for medium-strength lines.

5. Requirements for other instruments

Support from imagers is desirable at cadence of 30s-1min. to monitor the stability and the evolution of the active region loops that EUS is scanning. Magnetographs can help correlating the loop emission at low temperatures with magnetic field concentrations.

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

This study will determine the amount of connection between coronal loops and colder plasma in the photosphere and chromosphere, and the relation between the emission below and above 40,000 K.

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

This study will allow us to understand the structure and heating of active region loops, and their evolution with time.

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

N/A