Plasma Diagnostics Along Solar Coronal Structures & the Relationship to Coronal Heating

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We believe that it is important to be able to detect spatial variations in density (and temperature) **along** atmospheric structures. If fluctuations in the density can be observed then theoretical profiles can be fitted to match the observations which relate to the energy deposition within the structure. Hence it will start to become clear how these coronal features are being heated.

Using current instrumentation such as CDS, EIT and TRACE, numerous difficulties have been found in determining densities along coronal structures. CDS and EIT have limited spatial resolution (if we want to distinguish the believed fine plasma strands within loop structures) and temporal resolution (i.e. the time that it takes CDS to raster across an active region or the time lapse between EIT exposures). It is important to use the improved, suggested instrumentation onboard Orbiter (an order of magnitude better spatial resolution than CDS and better temporal resolution) to try and distinguish if fine plasma threads exist and do indeed make up the structures observed already.

By analysing these elemental strands within atmospheric structures it will be possible to obtain the individual density measurements **along** the strands. Therefore, rather than seeing the global average measurements of a feature the actual variation in density along the features will be found, which is what is required to relate the density diagnostics to coronal heating.

EUS instrument requirements

1. Emission line requirements

We would employ diagnostics of the atmosphere including transition region and chromospheric lines as we want to determine whether cooler structures do exist within active regions in the corona. Band 7a and Band 1 seems like a good choice for this purpose. Although Band 5 contains both TR and coronal lines there are no useful density diagnostic lines in this band.

Band 1 contains the Fe X 175.3/174.5 and Fe XI 182.2/180.4 ratios for density diagnostics at coronal temperatures. Bands 7a and 7b are useful to put the emphasis on cooler lines, there is a very good coverage of TR lines, there is also the Mg X 625 coronal line and the C III 977/1176 ratio for estimating electron densities at TR temperatures. To look at coronal heating, however, would require the presence **a few** strong coronal lines and therefore Band 7 cannot be used alone.

2. Spectral resolution requirements

The line profile needs to be resolved in order to undertake line ratio diagnostics.

3. Spatial coverage

Small scale whole loop structures (around <10 Mm) would be ideal but it may take too long (compared to the dynamic changes; see next point) to raster across the structure. However, we could just concentrate upon specific features of the structures such as the loop base or apex.

4. Time resolution (incl. count rates)

Needs to be of the order of seconds at the very least. We will want to use a sit and stare mode for some of the density diagnostics to be able to see the variation in the density over time at the apex or the base of a loop structure.

5. Requirements for other instruments

Imaging capability for coronal and transition region temperatures is important for placing the spectroscopic images in context. EUI would also be useful for observing the global dynamic changes in the area being studied over the observational period. Coincident magnetograms from VIM is a crucial component in understanding the magnetic skeleton through the atmosphere.

6. Other requirements

N/A

Relation to Solar Orbiter science goals

Indicate how your science fits in with the four Orbiter science goals. Simply type “N/A” if it’s not applicable to a science goal.

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

Determining the density profiles of coronal structures is extremely important for finding out how the solar corona is being heated, whether it be through the structure’s footpoints from the photosphere or from magnetic reconnection events above the structures or by some other mechanism.

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

Using a range of wavelengths available it should be possible to view the magnetic plasma structures from the corona down through the transition region and chromosphere. If we can accurately link these observations and provide detailed density analysis from the top of the structures down to the chromosphere, modelling the movement of energy throughout the atmosphere will become more feasible and the high temperatures seen in the corona maybe explained.

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

N/A