Element abundances in the low transition region

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Measuring the abundances in the solar atmosphere is of maximum importance to understand the composition of the solar atmosphere and its effects on many phenomena. It has long been known that abundances in the solar atmosphere are not the same everywhere; also, abundances in the solar corona (except in coronal holes) of elements with first ionization potential (FIP) smaller than 10 eV are different than their photospheric values, while those of elements with FIP>10 eV stay constant. Because of this variability, element abundances can be used as a tracer of the source regions of the solar wind (e.g. Feldman et al. 2006), and to validate flare models, as they can also help discriminate the origin of the flare-heated plasma – chromospheric, as required by most standard models, or coronal, as SUMER measurements imply?

A key question to be answered before using abundances as tracer of wind and flare plasma is at what temperature do element abundances of the solar atmosphere depart from their photospheric values, and whether this critical temperature changes between different structures in the solar atmosphere.

To determine the element abundances at low temperatures it is necessary to observe a large number of lines emitted in the 10,000-300,000 K temperature range from elements with FIP higher and lower than 10 eV. CDS and Solar-B/EIS do not have the necessary temperature coverage, while SUMER only allows studies either of very small fields of view, or of a limited number of lines. Only EUS will provide the necessary spectral lines and spatial coverage and resolution to track element abundances from the corona to the chromosphere.

The most suitable wavelength ranges to carry out these studies are 7a, 7b and 8.

EUS instrument requirements

1. Emission line requirements

Strong lines formed between 10,000 and 300,000 K from ions with FIP>10 eV AND ions with FIP<10 eV are necessary. Plasma diagnostics capabilities are highly desirable. Many ions in each FIP class are 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, or quiet Sun and coronal hole areas large enough to image the network-cell patterns. Spatial resolution of at least 1 arcsec is desirable to study abundances from individual structures in active regions and in the cell-network areas in the quiet Sun.

4. Time resolution (incl. count rates)

Fast cadence is not key for this study, so the ability of scanning a few arcminutes square in say 10 minutes would be OK. Faster cadence (say 1 minute) can be used to monitor individual quiet Sun plasma structures, whose dimensions are of the order of 20-30 arcsecs. 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 provide context images.

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 allow us to understand element fractionation in the solar atmosphere and its relation to the problems of flare initiation and solar wind source regions, and will have a strong impact on theoretical models attempting to understand and predict how flare explode and where and how the solar wind is accelerated into the heliosphere.

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 element composition of plasmas in all solar structures, and to relate them to the energetics and the evolution of active and quiet Sun structures.

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

N/A