Extreme Ultraviolet Spectroscopy of the Solar Corona

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Abstract

New Extreme Ultra-Violet (EUV) observations of the solar corona, obtained by the Coronal Diagnostic Spectrometer (CDS) instrument on board the NASA/ESA Solar and Heliospheric Observatory (SOHO) are presented. The CDS instrument for the first time has provided the opportunity of observing a large number of emission lines from a wide range of ions of different elements. The spectral and spatial resolution of the CDS instrument has allowed the simultaneous application of a wide range of spectroscopic diagnostic techniques to determine the temperature distribution, densities and elemental abundances in the solar plasma. A differential emission measure (DEM) diagnostic technique has been used to infer the temperature structure and the element abundances. The importance of including DEM effects in the element abundance analysis is demonstrated. A complete in-flight cross-calibration between all the CDS detectors (NIS and GIS, 150-785 Å), is presented here for the first time. The level of accuracy and completeness of the CHIANTI atomic database, used throughout this thesis, has allowed the identification of the many hundreds of spectral lines observed in the CDS spectra, resulting in several new line identifications. An assessment of the GIS solar spectra is presented, showing that, in spite of complexities, GIS spectra are useful for diagnostic analyses. Many discrepancies (in particular with the Li-like ions) between theory and CDS observations are highlighted. It is shown that some of these may be explained by inaccurate ionization equilibrium calculations. Coronal hole densities, temperatures, $DEMs$, and relative element abundances from both off-limb (plume and inter-plume regions) and on-disc observations are derived and compared with quiet sun values. These included (August 1996) a large equatorial hole, the Elephant's Trunk, probably the best example of a coronal hole observed by SOHO. Coronal hole densities in both coronal ($N_e \simeq 1\text{x}10^8$ cm^{-3}) and transition region ($N_e \simeq 1\text{x}10^{10}$ cm^{-3}) plasma were found to be about a factor of 2 lower than in the quiet sun, with much lower emission measures at temperatures above 10^6 K. Moreover, in the transition region, the cell-centres in both coronal holes and quiet sun regions show consistently higher densities (factor of 2) compared to those in the network. Relative element abundances show approximately photospheric values for the coronal holes, with an indication of element abundance variation (neon in particular) with the supergranular structure. On-disc EUV observations of coronal hole plumes have been performed. This allowed a spectroscopic characterisation of plumes to be obtained for the first time, leading to the first identification of a low-latitude plume near sun-centre. Plumes are shown to be quasi-isothermal structures, with temperatures $T \simeq 7 - 8\text{x}10^5$ K. Abundance analyses (using transition region lines) reveal a small FIP effect in these plumes, together with a decreased Ne/O abundance ratio (compared to photospheric).

Contents

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