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Solar limb brightening observed with SOHO/UVCS

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Summary. — A model of the ultraviolet emission from chromospheric and transition region solar plasma is necessary for a correct interpretation of the measurements of the resonantly scattered spectral lines in solar corona and to determine the stray light correction needed to subtract non-coronal signal from coronagraphic data. That model is useful for analysis of SOHO/UltraViolet Coronagraph Spectrometer (UVCS) observations and for the incoming future missions for coronal study in UV spectral range. Escape probability techniques avoid the need for a full solution of the radiative transfer equation and reduce the question to a geometrical problem. In this paper we use UVCS observations to calculate a simple function to approximate a radial limb brightening.

1. – Introduction

The coronal spectral lines observed by UVCS are contaminated by the additional spurious contribution of solar chromospheric radiation, which is not fully suppressed by the coronagraphic assembly, referred to as stray light. The evidence of this contribution is demonstrated by the presence in UVCS coronal spectra of uniform emission along the slit from chromospheric lines such as Si III (1206), C III (1175) and C III (977). Coronal observations of the low and intermediate corona, such as observations of the solar plumes (see [1], [2]), need to be corrected for a non negligible stray light contribution, which subtraction can affect the application of some diagnostic techniques, as in the case of the Doppler Dimming (see *e.g.* [3]). The stray light removal in the case of UVCS is based on the calculation of the stray light factor of a monitoring line emitted by chromosphere and appearing in the solar corona spectra. To improve the technique we analyzed line intensity profiles along the UVCS slit, in H Ly α and OVI channels, observed on 31 March 1996 and 22 October 1996 on the Sun disk, and found an empirical function approximating the limb brightening.

2. – The empirical function

The spectral emission from a plasma is governed by two sets of coupled equations, describing the radiative transfer. The solution of the radiative transfer for a constant source function in the case of an optically thin emitting layer is proportional to the optical depth and it usually requests to solve the equation of statistical balance. Considering the escape probability (see [4]) , we can adopt a constant source function and assuming also constant density we describe the emitting layer as a spherical shell. We obtain two empirical functions for the intensity I_j (where j is the index of the spectral line), one for a thin optical layer, for distances from the Sun center $0 \leq r < R_{min}$ (see eq.1), and one for thick optical layer between $R_{min} \leq r \leq R_{max}$ (see eq.2). The free parameters R_{min}, R_{max}, k_j^0 and k_j^1 are then determined by fitting the disk and limb observations of UVCS.

$$(1) \qquad I_j = k_j^0 + k_j^1(\sqrt{R_{max}^2 - r^2} - \sqrt{R_{min}^2 - r^2}), \qquad 0 \leq r < R_{min}$$

$$(2) \qquad I_j = k_j^0 + 2k_j^1\sqrt{R_{max}^2 - r^2}\ cos(sin^{-1}(\frac{\sqrt{3}}{2}\frac{r}{R_{min}})), \qquad R_{min} < r \leq R_{max}$$

3. – Observations

Two valuable data sets were recorded on 31 March and 22 October 1996, during the solar minimum, by offset pointing UVCS over the solar disc. In the first data set the UVCS slit was parallel to the North-South direction, at three different distances, 0.33, 0.54 and 0.84 $R_\odot$ from the Sun center, with respect to the Est limb. In the second data set the UVCS slit was parallel to the solar equator, in the North hemisphere and at a distance 0.48 $R_\odot$ from the Sun center. We assumed a radial symmetry and used the UVCS data taken on 31 March 1996 in the H Lyman α channel, and on 22 October 1996 in the O VI channel, to fit the parameters of the functions (1) and (2), for the different lines we observed.

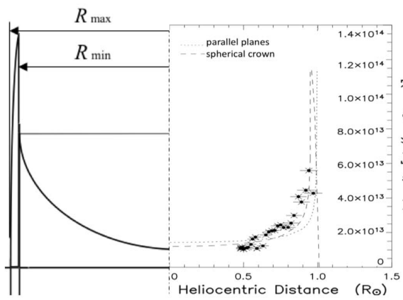

Fig. 1. – Spherical shell model compared with the observed limb brightening on OVI (1037) during 22 October 1996.

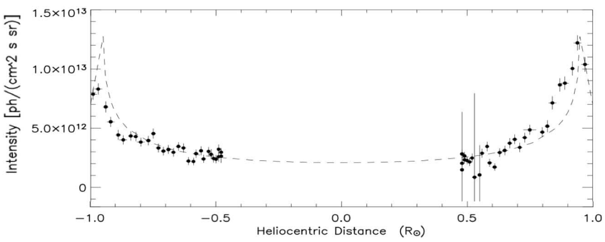

Fig. 2. – Limb brightening profile observed in N III (991), on 22 October 1996.

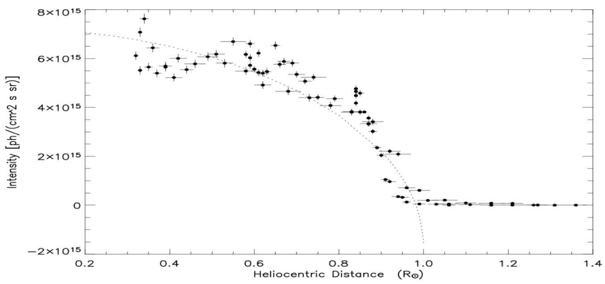

Fig. 3. – Limb darkening profile observed in HI (1215), on 31 March 1996

4. – Results and Conclusions

The parameters of the empirical functions (1) and (2), fitted to the intensity profiles of different spectral lines, are summarized in Table 1. In the case of H Lyman α, β, and γ lines, no limb brightening was not found. For the other emission lines, we observed the foreseen limb brightening. The functions (1) and (2) fit pretty well the data of the more intense lines, as the O VI doublet, C *III* (977), observed on 22 October.

TABLE I. – *Parameters of the limb brightening empirical functions for different spectral lines.*

Spectral line (Å)	k^0_J ph/cm^2 s sr	k^1_J ph/cm^2 s sr	R_{min} $R_\odot$	R_{max} $R_\odot$
Fe XII(1242)	-1.75 10^{13}	8.03 10^{13}	0.88	1.01
N V(1238)	4.80 10^{12}	2.58 10^{13}	0.86	1.01
CIII(1175)	-2.09 10^{13}	2.80 10^{14}	0.86	1.01
OVI(1037)	-7.91 10^{11}	1.02 10^{14}	0.93	1.05
OVI(1031)	1,46 10^{12}	1.62 10^{14}	0.93	1.05
NIII(991)	-9.83 10^{11}	3.06 10^{13}	0.95	1.05
CIII(977)	6,67 10^{12}	2.44 10^{14}	0.87	1.05
SiXII(521)	-2.03 10^{11}	2.93 10^{12}	0.90	1.05
SiXII(499)	1.82 10^{11}	1.33 10^{12}	0.93	1.02

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