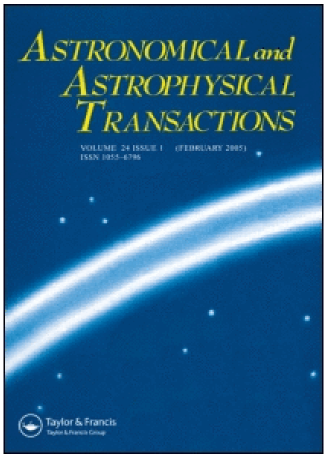

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WHAT IS THE NATURE OF DIMMING?

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It is very likely that, due to the substantial role of scattering in the formation of lines, the observation of dimming in SOHO EIT 171 and 195A filtergrams demonstrates the high-speed, dense clouds of solar coronal mass ejection matter.

Keywords: Scattering; Doppler shift; Passband

The dimming is the diminution of the emission intensity in some parts of SOHO/EIT 195 and 171A and soft X-ray Yohkoh filtergrams during onset of a coronal mass ejection (CME) from the Sun.

Study of the dimming shows that this phenomenon results from matter ejection (Hudson, Acton and Freeland, 1996) and is a part of the so-called sigmoid structure, often observed during CME (Sterling and Hudson, 1997; Zarro *et al.*, 1999). Although the relation between the dimming and matter ejection during CME was proved, it is commonly supposed now that the dimming is associated with matter depletion (Pick *et al.*, 1999). The aim of the present note is to demonstrate a possible alternative, namely, that dimming corresponds to clouds above the undisturbed corona.

Schrijver and McMullen (2000) studied the properties of resonance coronal lines of iron with high oscillator strengths, observed in the passbands of EIT and TRACE. Their studies demonstrated that the fraction of photons subject to scattering in these lines should be substantial and can be estimated to equal about 50% for 171A passband and 10–30% for 195A passband. The contribution of scattering to radiation is proportional to the density squared. The oscillator strengths for the absorption in 171 and 195A lines are not small (3.05 and 0.76 respectively), and the optical thickness of the corona in the above-mentioned lines can be as large as 3 and 1. According to Schrijver and McMullen (2000), a resonant scattering in the weakly-emitting loops, filling the most part of the corona, must be a primary source of the background haze.

Let us remember that H_α filaments appear, as dark lines in ground-based observations with a H_α birefringent filter. As is known, the scattering effect (no decreasing density) causes this fact. A historically strong argument for this was observations of filaments as bright prominences near the solar limb. In the article about SOHO results Thompson B. J., St. Cyr O. C.

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et al. (1999) give the example the off-limb dimming (plate 4, the difference image 195A, 5 October, 1996 CME) as bright structure. The essentiality of the scattering mechanism for the line formation gives the possibility to declare that the dark dimming in 171 and 195A filtergrams are images of compact clouds above undisturbed solar corona.

The usual plane-of-sky speed of CME equals about 400–500 km s^{-1} (LASCO C2, C3). So, the Doppler shift in the lines 171 and 195A corresponding to such speeds is about 0.2–0.3A. A full width at half-maximum (FWHM) of a thin optical line is given by the expression:

$$\mathrm{FWHM} = \left[\Delta\lambda_1^2 + 4\ln 2\left(\frac{\lambda}{c}\right)^2\left(\frac{2\mathrm{k}T_e}{M} + \xi_0^2\right)\right]^{1/2},$$

where $\Delta\lambda_1$ is the instrumental width, λ is the wavelength, c is the speed of light, k is Boltzmann constant. M is the ion mass, and ξ_0 is the most probable velocity of the random mass motion. In the case of FeXII line 1242A in a quiet corona the values of FWHM equal 0.20–0.24A (Cheng, Doschek and Feldman, 1979) and change only slightly with increasing limb height from 0 to 20 arc sec. Consequently, it should not exceed 0.2–0.3A for the line 195A of the same ion FeXII. As a result, the matter motion with speed 500 km s^{-1} will shift the emission wavelength by a value little more than the FWHM.

The wavelengths of the strongest coronal resonance lines of iron within the passbands of EIT and TRACE 171 and 195A are 171.08A FeIX, 174.53A FeX, 177.24A FeX and 193.51A FeXII, 195.12A FeXII, and 197.43A FeXIII. It should be mentioned that the difference between the wavelengths of neighboring lines in each of the two passbands always exceeds 0.3A. The Doppler shift of emission in one of these lines toward its red or blue wing by the above-mentioned value cannot result in overlapping with the next line. So, the shifted emission must change the continuum intensity. In the frequency band under consideration, the continuum intensity of a background quiet corona is very small in comparison with the intensity in the lines (Allen, 1973) even at the SOHO/EIT passband width, which equals approximately 10A (Delaboudiniere *et al.*, 1995).

Certainly if the cloud is lifting from solar surface with speed 500 km s^{-1} its emission must be inside such a passband. After the EIT filters, the undisturbed corona 171 or 195A filtergrams are combined, the white light filtergrams with the cloud image. Because the white light intensity is very small for these wavelengths we shall see only an undisturbed corona and coronal clouds at high speed as well as at low speed.

Thus it is quite likely that, due to substantial role of scattering in the formation of lines, the observations of dimming in SOHO EIT 171 and 195A filtergrams demonstrate the high-speed clouds of CME matter. The estimate of their density needs to be done by means of a new ‘clouds model’.

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