SPECTROSCOPIC DIAGNOSTICS OF THE UV EMITTING PLASMAS IN SOLAR FLARES OBSERVED FROM SMM

Chung-Chieh Cheng
E.O. Hulburt Center for Space Research
Naval Research Laboratory
Washington, DC

E. Tandberg-Hanssen
NASA Marshall Space Flight Center
Huntsville, AL

INTRODUCTION

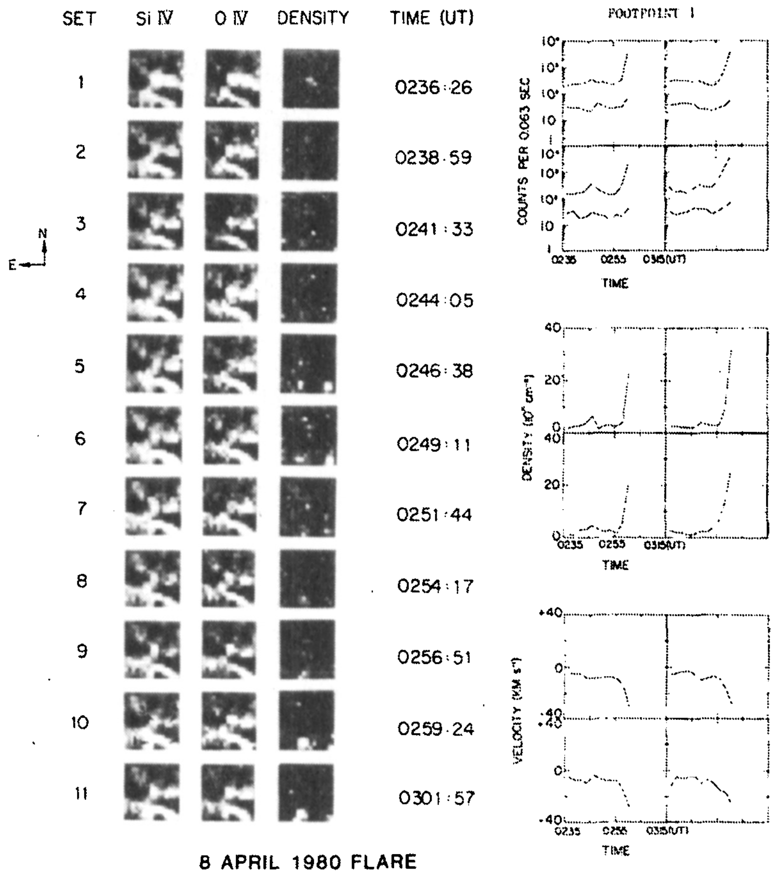
The transition region exhibits dynamic changes during solar flares. To understand the energy release and transport processes in solar flares, it is important to determine observationally the physical conditions in the flare transition region plasmas, which emit in the UV wavelength ranges. During the Solar Maximum Mission (SMM) we observed many flares in the UV emission lines of Si IV (1402 Å) and O IV (1401 Å) using the Ultraviolet Spectrometer and Polarimeter (Woodgate et al. 1983). In this paper we present the Si IV/O IV flare observations, in particular the dynamic evolution of the transition zone plasmas (~ 10^5 K). We also studied the temporal and spatial correlations between the impulsive UV and hard X-ray bursts.

DIAGNOSTICS OF THE FLARE TRANSITON-ZONE PLASMAS

The O IV 1401.2 Å line is an intersystem line and the Si IV 1401.8 Å line is a resonance line. Their intensity ratio is sensitive to densities > 5 x 10^{10} cm^{-3}, and is particularly useful for density determination in the flare transition zone plasmas of temperatures ~ 10^5 K (for details, see Cheng et al. 1982). Figures 1 and 2 show the application of the Si IV/O IV plasma diagnostics to the 8 April and 22 November 1980 flares respectively, using the raster-through-the line (RL) mode of the UVSP. Use of the RL mode consists of making spectroheliograms in a number of wavelength positions successively for the two lines so that line profiles can be constructed for each individual pixel in the raster. We find that the Si IV/O IV burst in the 8 April flare occurred in a low-lying transition-zone temperature loop. At the onset of the flare, the footpoints, particularly the eastmost one, brightened up impulsively. The density at this flare footpoint increased from its preflare value of ~ 10^{11} cm^{-3} to 3 x 10^{12} cm^{-3}, and the plasma there had a downflow velocity of 20-40 km s^{-1}. The situation was the same for the 22 November 9180 flare, which was located outside the main sunspot regions. The Si IV/O IV emission was concentrated in small kernels, located at the footpoints of interacting loops, one of which was a large loop observed in soft X-rays (Cheng and Pallavicini 1984). At the flaring UV bright points, the density increased to ~ 2 x 10^{12} cm^{-3}, and there was a downflow of ~ 20 km s^{-1}.

https://doi.org/10.1017/S0252921100085560 Published online by Cambridge University Press

FIG. 1


SET
Si IV
O IV
DENSITY
TIME (UT)
0236:26
0238:59
0241:33
0244:05
0246:38
0249:11
0251:44
0254:17
0256:51
0259:24
0301:57
COUNTS PER 0.063 SEC
TIME
DENSITY
TIME
VELOCITY (KM s⁻¹)
TIME
8 APRIL 1980 FLARE

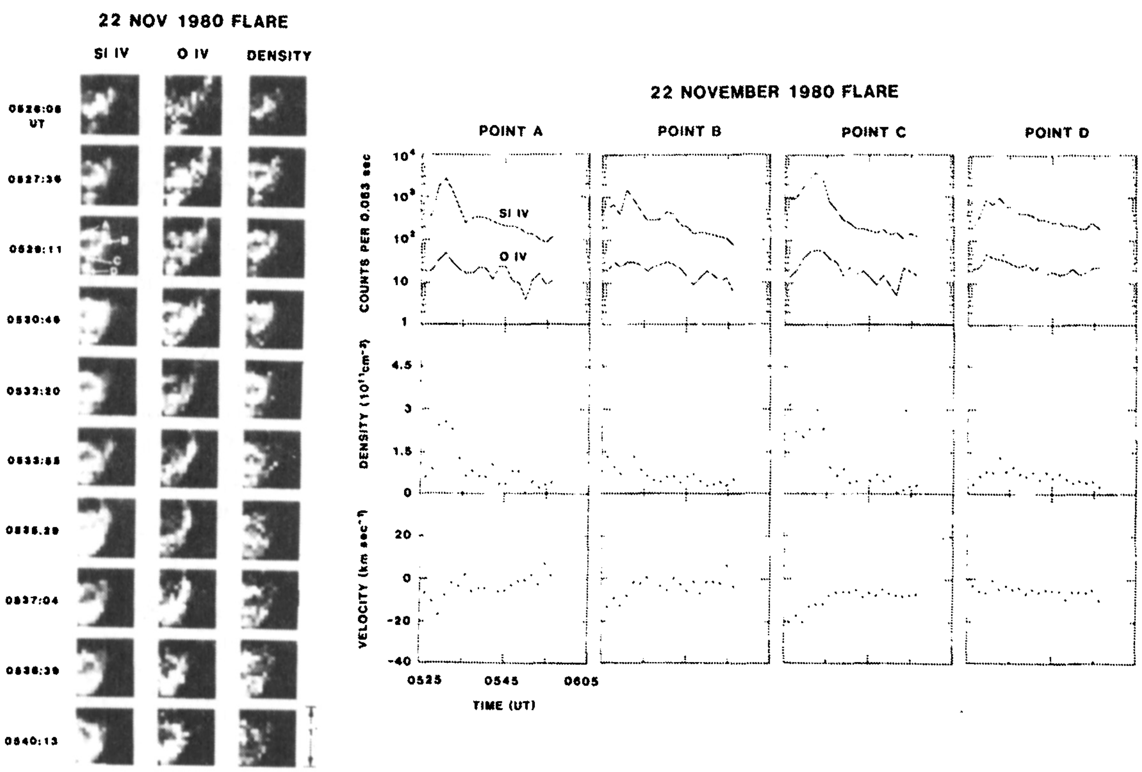

22 NOV 1980 FLARE
SI IV
O IV
DENSITY
22 NOVEMBER 1980 FLARE
POINT A
POINT B
POINT C
POINT D
COUNTS PER 0.063 sec
DENSITY
VELOCITY
TIME (UT)

FIG. 2

Correlations between the impulsive hard X-ray bursts and the spatially-resolved Si IV/O IV observations enable us to deduce the spatial structures of the impulsive hard X-ray bursts. Figure 3 shows one example of Si IV/S IV observation of the impulsive phase in solar flares (Cheng et al. 1981). As can be seen from the figure, the Si IV/S IV bursts occurred at discrete kernels of size 3"-4". The impulsive UV and hard X-ray bursts were temporally correlated, and individual hard X-ray peaks were associated with brightenings in individual UV kernels. Sometimes, however, one hard X-ray peak may correspond to many UV brightenings in different kernels. These observations show that the impulsive UV and hard X-ray bursts originate in small regions of high density, and that the emission regions have considerable spatial structure (Cheng, Tandberg-Hanssen, and Orwig 1984).

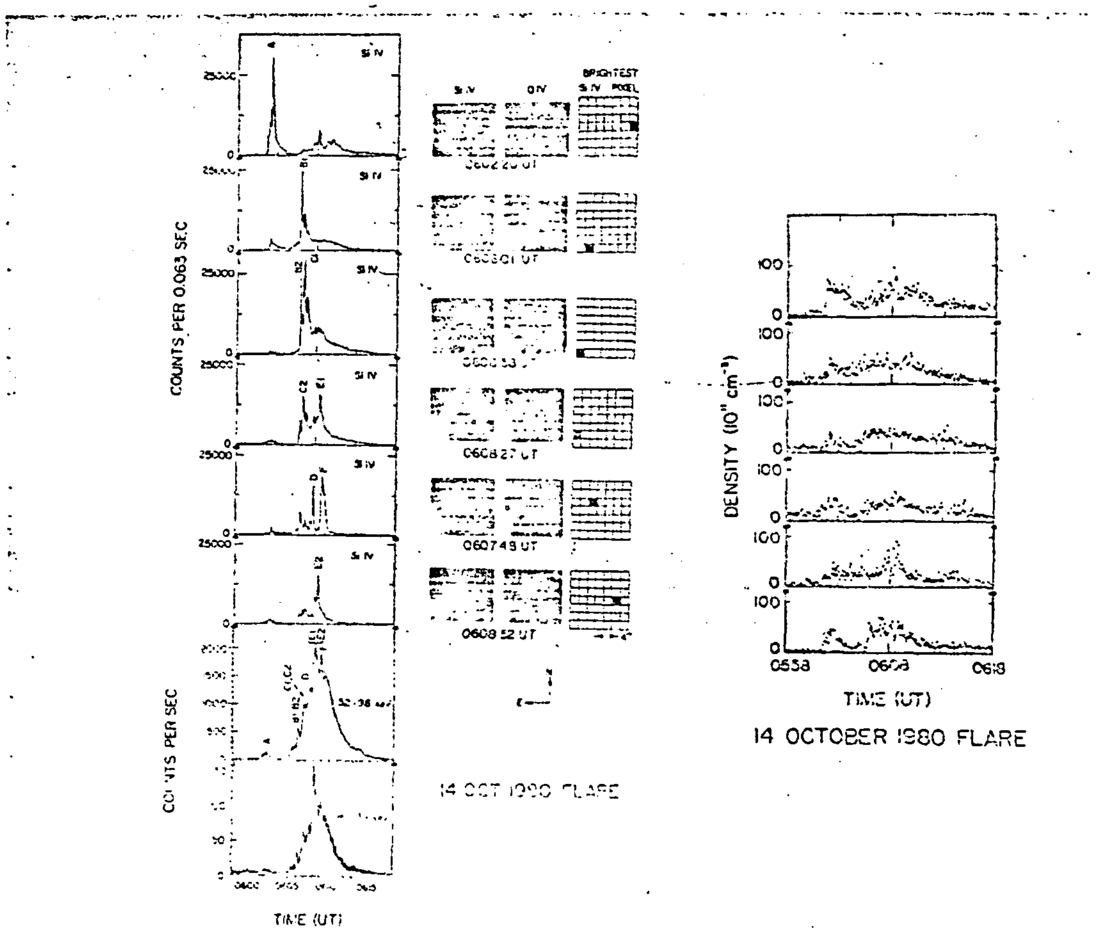


FIG. 3

https://doi.org/10.1017/S0252921100085560 Published online by Cambridge University Press

CONCLUSIONS

The Si IV and O IV lines proved to be useful diagnostic tools for studying the flare transition zone plasmas. As a result of these observations, we now know more about the temporal and spatial structures of the impulsive UV and hard X-ray bursts. The observations show that there is considerable spatial structure in the emission regions of these impulsive components. For a proper understanding of the energy release and transport processes in flares, it is necessary to include the spatial structure in modeling the impulsive bursts.

We sincerely thank all the people who have contributed to the successful operations of SMM. The work was supported in part by NASA under contract DPR W-15367.

REFERENCES

Cheng, C.-C. et al. 1981, Ap. J., (Letters), 248, L39.
Cheng, C.-C. et al. 1982, Ap. J., 253, 353.
Cheng, C-C. and Pallavicini, R. 1984, Solar Phys., (in press).
Cheng, C.-C., Tandberg-Hanssen, E., and Orwig, L.E. 1984, Ap. J., 278, 853.
Woodgate, B.E. et al., 1980, Solar Phys., 65, 73.