TYPE II BURST-SOURCES AS LOW-V_A REGIONS IN THE CORONA 'ILLUMINATED' BY FLARE-INDUCED MHD SHOCKS

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Abstract (*Solar Phys.*). The author has proposed a hypothesis that the type II burst-sources may be due to the local enhancement of the flare-produced MHD fast-mode shock wave on encountering the pre-existing low Alfvén velocity regions in the corona (Uchida, 1973). The purpose of the present paper is to show that this may actually be the case by comparing the behavior of the computor-simulated propagation and strengthening of MHD fast-mode (weak) shock with the observed characteristics of type II burst-sources.

The computation was performed as an extention of a previous treatment which interpreted the Moreton's wave phenomenon as a sweeping skirt of the flare-produced coronal MHD wavefront (Uchida, 1968; Uchida *et al.*, 1973). The behavior of the wavefront and the shock strength over the wave surface were computed by using eiconal characteristic approximation in the HAO model coronal magnetic field (Altschuler and Newkirk, 1969) and model coronal density (Perry and Altschuler, 1972) for the days for which these models as well as the type II burst data (Culgoora or Boulder) without severe refraction-effect are available (Figure 1).

It is actually seen in the calculated events (May 23, 1967; October 3, 1969; and October 13, 1969) that the projection on the plane of the sky of the calculated distribution of low Alfvén velocity regions in the corona in the vicinity of the flare coincide roughly with the observed position and shape of type II burst-sources. Furthermore, as the result of the computation of the wave behavior in the three-dimensional distribution of the propagation velocity in the corona in these cases, it is clearly seen that the wavefront tends to converge to the low Alfvén velocity regions lying in the corona. This converging effect, together with the local propagation effect of low Alfvén velocity in such regions itself, causes a considerably sharp build up in the Alfvén Mach number of the wave at such particular locations. The enhanced effect of the shock wave, and therefore such phenomena as the electron acceleration in the shock front, may be expected preferentially at these locations, since the Alfvén Mach number of the material flow behind the front (whose initial value is the ratio of the flare explosive velocity of the order of two or three hundred km s^{-1} at most, over the Alfvén velocity in the active region corona of the order of several thousand km s^{-1}) otherwise stays

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small. This explains, therefore, the observed rather irregular appearance of type II burst sources in which, for example, a distant point is brightened up in some events without any brightening at plasma level closer to the flare. It may be remarked that this anisotropic appearance of the burst sources is expected in our hypothesis even for an assumption of an isotropic emission of the wavefront from the flare explosion,

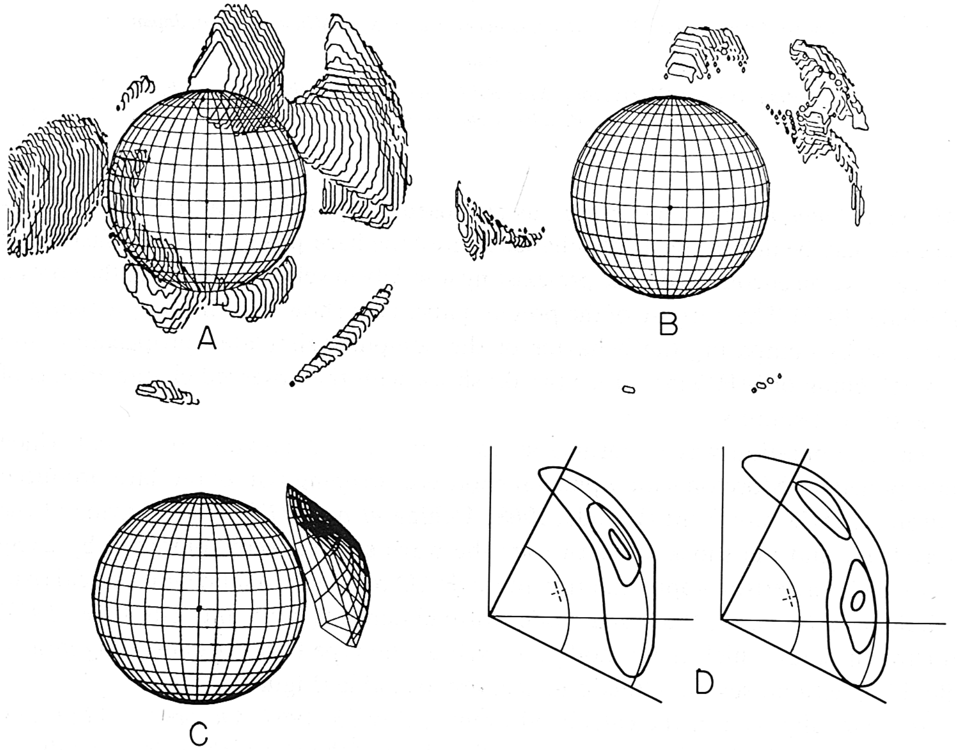

Fig. 1. Several features of the October 13, 1969 event as an example: (A) Three-dimensional representation of the regions where V_A is less than a_0. (B) Region where V_A is less than a_0 on the shell of 40 MHz plasma-level. (C) The wavefront after emission from the flare position in the corona. (D) Equal intensity contours of the observed type II burst from Dulk and Smerd (1971). The maps are rotated by the inclination angle of the solar axis: *Left* $23^h41^m51^s$ UT; *Right* $23^h43^m41^s$ UT.

which is a reasonable first order guess for a short rise time explosion in a medium with $(V_A/a_0)^2 \gg 1$, where the propagation of the MHD fast mode wave is isotropic in its nature (V_A = Alfvén speed and a_0 = sound speed). Even if there is an intrinsic directivity in the emission of the wavefront, the situation is similar except that some of the pre-existing low Alfvén velocity regions falling outside of the wave cone are not 'illuminated'.

One of the predictions to be made in the present hypothesis is that such properties as the drift velocity, or the time lag of the first appearance of the burst after the impulsive phase are expected to be fairly independent of the flare importance. Even the chance of association of type II bursts with a flare depends on such circumstantial situations as the existence of the low Alfvén velocity region within the reach of the wave. It is, thus, understandable that some large flares are not accompanied by a type II burst while much smaller flares may be accompanied by one. The probability of the association may increase with the flare importance because a more complex structure of the magnetic field and density is associated for the occurrence of a large flare. A similar explanation applies for the association and non-association of type II bursts with Moreton wave events, although we believe both are due to MHD wave emitted by the flare explosive phase (Uchida, 1973).

References

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DISCUSSION

Rosenberg: Do you think that the type II radiation is due to the focussing effect to the low V_A region, or to the fact that in such a region the shock attains a higher Mach number?

Uchida: Due to both. The shock attains a high Alfvén Mach number exclusively at such locations, and produces accelerated electrons and therefore the radio emission there.

Sturrock: What kind of disturbance is needed to set this off?

Uchida: An impulsive disturbance. I assumed a simple pressure pulse.

Smerd: What shock strengths do you find in the region of the type II's?

Uchida: This depends upon the initial shock strength. For a v_0 of 200 to 300 km s^{-1}, the Mach number will be 2 to 5.

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