COMMON ORIGIN FOR UV AND RADIO FLUCTUATIONS?

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(Received 28 June; in revised form 3 November, 1979)

Abstract. Brightness temperature fluctuations induced by a shock wave transit through the solar transition region are computed at several decimetric wavelengths. A simplified method previously used to reproduce the observed UV line intensity fluctuations is shown to give oscillation amplitudes which are consistent with experimental results. The detectability of shock-induced radio fluctuations is briefly discussed, to check the possibility of a common origin for the observed UV and radio phenomena.

1. Introduction

Since the discovery of the 5-min oscillations in photospheric regions (Leighton et al., 1962) much work has been developed to obtaining information regarding the presence of waves at higher levels in the solar atmosphere.

In recent studies, periodic chromospheric oscillations have been found using OSO-8 UV data (see for instance Chapman et al., 1972; White and Athay, 1978; Bruner, 1978; Chapman, 1977), while aperiodic oscillations have been reported in transition zone lines, as observed by Skylab (Vernazza et al., 1975). At still higher levels, contradictory results come from soft X-ray observations from Skylab (Teuber et al., 1978) and from Solrad-9 (Jakimiec and Jakimiec, 1974), while in the Fe xiv 5303 Å line the 5-min oscillations have still been recognized (Tsubaki, 1977).

In the last decade a number of authors made radio observations in an attempt to find further evidence of the wave-associated oscillations. Most observations have been made in the centimetric and millimetric range, namely at wavelengths originating from regions where the presence of the waves was established beyond any doubt from optical measurements.

However, observations with simple antenna beams suffer from low spatial resolution, while it is difficult, when interpreting better resolution interferometer data, to distinguish between real and apparent time fluctuations which can be induced by changing source structure or instrumental effects.

Radio data have therefore led, so far, to contradictory results; different interpretations have been advanced and even the significance of the reported variations has sometimes been questioned. (Yudin, 1968; Duravo et al., 1971; Simon and Shimabukuro, 1971, Shuter and McCutcheon, 1973; Wefer, 1975; Lang, 1974; Kundu and Alissandrakis, 1975; Graf and Wernecke, 1976; Grebenkemper and Graf, 1975; Avery, 1976; Sentman and Shawhan, 1974; Kobrin et al., 1976).

The radio measurements would be most valuable at longer wavelengths, where they could help in establishing the level in the solar atmosphere where the presence

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of the waves could still be detected. Actually in the only two decimetric measurements (Pakhomov and Snegirev, 1977; Pakhomov et al., 1973) so far reported in literature, short-period fluctuations have been detected.

On the theoretical side, very few authors have investigated the possibility that radio fluctuations could be ascribed to the temperature and density modifications induced by the passage of waves through the solar atmosphere. Lang (1974) interpreted the observed oscillations as induced by small amplitude acoustic waves travelling upward in an isothermal atmosphere, while Shuter (1976) suggested that large scale oscillations, such as those reported by Hill and Stebbins (1975), could be responsible for the observed phenomena. This interpretation has been questioned by Kobrin et al. (1976) on the grounds of the variability of the observed fluctuations compared with the high stability of the natural solar radial oscillations. More recently Butz et al. (1979) considered the spectrum of fluctuation frequencies of the radio flux from limited solar regions and showed it to be compatible with longitudinal waves propagating towards the observer in a medium of constant temperature and density.

Evidence of the presence of acoustic waves in the lower and middle chromosphere comes also from the oscillations observed with OSO-8 at a number of UV wavelengths. Radio and UV fluctuations from these atmospheric layers, therefore, appear to be originated by the passage of upward propagating sound waves, even if no attempt has, up to now, been made to fit both of them in an unique frame model.

However, at higher levels of the solar atmosphere, the sound waves are expected to steepen into shocks. Actually OSO-8 oscillations in C IV may be interpreted as indicating the presence of weak shocks while the Harvard observations of aperiodic fluctuations from transition region lines have been shown to be compatible with the modifications induced in the physical parameters of the line emitting region by an upward transit of shock waves (Poletto, 1979).

The purpose of this paper is to investigate if also the radio brightness fluctuations, at wavelengths originating from the transition region, can be ascribed to the same shock induced phenomena. The method will be applied, which has been previously proved to successfully reproduce the UV line intensity fluctuations from the chromosphere-corona transition region.

If the shock wave transit will also induce radio brightness fluctuations and if their detectability could be proved, the likelihood of a common origin for radio and UV brightenings, already indicated by Pramesh Rao and Kundu (1978), will be highly increased. Further evidence will thus be added for interpreting radio observational results as simply mirroring the optical and UV behaviour.

The problem of the periodicity, if any, of the fluctuations will not be dealt with in this paper but the effect of a single shock pulse only will be considered. Their periodicity will imply only that interaction effects between successive shocks are negligible.