MULTI-WAVELENGTH OBSERVATION OF A MORETON WAVE ON NOVEMBER 3, 1997

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ABSTRACT

We report the observation of a Moreton wave in Hα at 4:37–4:41 UT on November 3, 1997. The same region was simultaneously observed in soft X-rays and EUV, and wave-like disturbances ("X-ray wave" and "EIT wave") were also found. The propagation speed of the X-ray wave (630 km/s) is almost the same as the Moreton wave (490 km/s). The EIT wave (170 km/s) is much slower than the Moreton wave. Assuming that the X-ray wave is the MHD fast shock, we can estimate the propagation speed of the shock, based on the MHD shock theory and the observed soft X-ray intensities. It is found that the estimated fast shock speed is 400–760 km/s, in rough agreement with the observed propagation speed of the X-ray wave. The fast mode Mach number of the X-ray wave is also estimated to be about 1.15–1.25. These results suggest that the X-ray wave is an MHD fast shock propagating through the corona and hence is the coronal counterpart of the Moreton wave, but the EIT wave is not.

Introduction

Moreton waves are flare-associated waves observed to propagate across the solar disk in Hα, especially in the wing of Hα (Moreton, 1960). They propagate in somewhat restricted solid angle at the speed of 500–1500 km/s with arc-like fronts, and are often associated with coronal EIT waves. Moreton waves have been identified as the intersections of a coronal MHD fast-mode shock front and the chromosphere (Uchida, 1968). This model predicts the existence of a coronal counterpart of the chromospheric Moreton wave. The purpose of this paper is to examine the basic question whether the EIT wave and the X-ray wave are the coronal counterpart of the Moreton wave, i.e., a coronal MHD fast-mode shock, or not.

Observation and Result

In this paper, we study three kinds of flare-associated waves, chromospheric Moreton wave, coronal EIT wave and coronal X-ray wave accompanied by the C-class flare occurred in NOAA 8100 at S20, W13 on November 3, 1997 (Fig. 1). The flare started at 04:32 UT and peaked at 04:38. The Moreton wave was

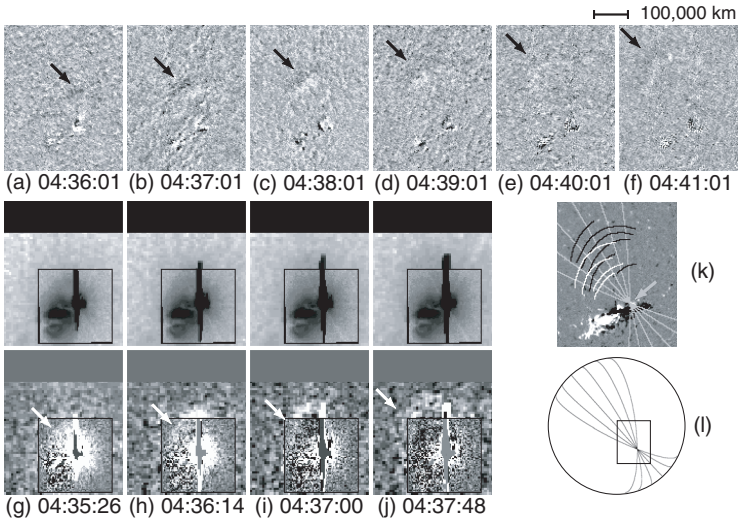

Fig. 1. Observed images on November 3, 1997, at NOAA 8100. Top panels are Hα +0.8 Å "running difference" images of a Moreton wave (black arrows). Middle and bottom panels are soft X-ray and "running difference" images of an X-ray wave (white arrows) taken with Al-Mg filter, respectively.

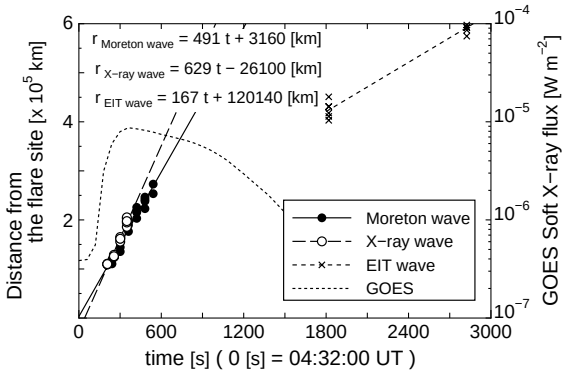

Fig. 2. Propagation of the Moreton wave (closed circles), the X-ray wave (open circles) and the EIT wave (crosses). First-degree polynomial fits of the Moreton wave (solid line), the X-ray wave (dashed line) and EIT wave (short dashed line) are shown. Dotted line shows soft X-ray flux observed by GOES 9 satellite.

observed in Hα (line center and +/− 0.8 Å), most clearly in Hα +0.8 Å, with the Flare Monitoring Telescope (FMT) at the Hida Observatory of Kyoto University, the X-ray wave with the Soft X-ray Telescope (SXT) on board the *Yohkoh* and the EIT wave with *SOHO*/Extreme-ultraviolet Imaging Telescope (EIT).

The position of the X-ray wave front as well as the direction of propagation of the X-ray wave roughly agree with those of the Moreton wave. The propagation speeds of the Moreton wave and the X-ray wave are about 490 km/s and 630 km/s, respectively. The EIT wave propagates at a speed of 170 km/s (Fig. 2).

Discussion

Let us now examine whether the EIT wave and/or the X-ray wave are the coronal counterpart of the Moreton wave or not. The EIT wave propagates at a speed of 170 km/s, which is much slower than the Moreton wave, 490 km/s. Hence, the EIT wave is not the coronal counterpart of the Moreton wave.

The X-ray wave propagates at a speed of 630 km/s, and the position of the wave front as well as the direction of propagation of the X-ray wave roughly agree with those of the Moreton wave. Assuming that the X-ray wave is the MHD fast shock, we can estimate the propagation speed of the shock, based on the MHD shock theory (Priest, 1982) and the observed soft X-ray intensities. It is found that the estimated fast shock speed is 400–760 km/s, in rough agreement with the observed propagation speed of the X-ray wave. The fast mode Mach number of the X-ray wave is also estimated to be about 1.15–1.25 (Narukage et al., 2002). These results suggest that the X-ray wave is an MHD fast shock propagating through the corona and hence is the coronal counterpart of the Moreton wave.

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