On M22.2 Solar Flare and CMEs Observations on 26 November, 2000 from NOAA AR 9236

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Introduction

A solar flare is a large explosion in the Sun's atmosphere that can release as much as 6×10^{25} joules of energy (Kopp et al, 2005). Solar flares affect all layers of the solar atmosphere (photosphere, corona, and chromospheres), heating plasma to tens of millions of Kelvin and accelerating electrons, protons, and heavier ions to near the speed of light. They produce radiation across the electromagnetic spectrum at all wavelengths, from radio waves to gamma rays. Major goals of solar flare research is to determine the origin and evolution of the energetic electrons accelerated during impulsive phase of the solar flares. These particles are most directly observable through their gyrosynchrotron radiations at MW frequencies and emission of HXR through collisional bremsstrahlung (Holman et al, 1984).

Most flares occur in active regions around sunspots, where intense magnetic fields penetrate the photosphere to link the corona to the solar interior. Flares are powered by the sudden (timescales of minutes to tens of minutes) release of magnetic energy stored in the corona

Aim of Study

The aim of the present study to understand the solar flare phenomena and other related phenomena, in the light of multi-wavelength observations of the Sun.

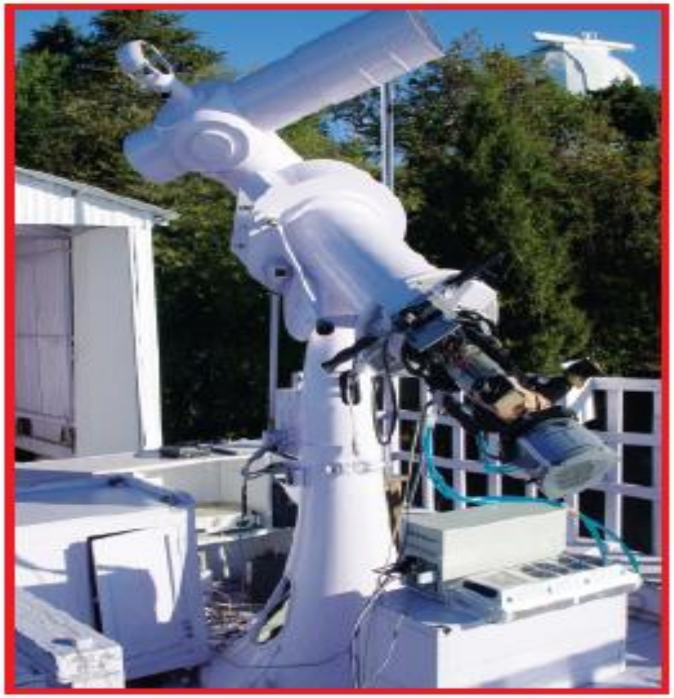
The solar data for flare that occurred in AR NOAA 9236 on 26 November 2000 around 02:47 UT are used to understand the flare phenomena. The multi-wavelength solar flare data used in present study are Hα data, EIT data, LASCO CMEs data, 10830 coronal hole data, MDI sunspot magnetic field data GOES soft X-ray data, radio data, microwave data and hard X-ray data.

Observational data

Hα observations of flare

On 26Nov.2000 while monitoring the Sun through 15 cm f/15 and a 0.7 ^{o}A pass band Hα filter, we noticed a solar flare in AR 9236 around 02 47UT on the north-west area of solar disc. The temporal changes in solar flare region were recorded with high speed CCD camera (Verma, 1998).

Solar telescope



MDI, EIT and HXR Data

- To understand the magnetic complexity of the active region and its role for flare trigger, we use SOHO/MDI, EIT 195 ^{0}A and HXR data. The magnetic field data was taken from the SOHO/MDI instrument which has cadence of images is 96 minute and the pixel resolution is 1.98''. SOHO/EIT 195 ^{0}A observe the full disk sun with a cadence of 12~min and pixel resolution of 2.5''. We also use the X-ray data from the Czech-made Hard X-Ray Spectrometer (HXRS) instrument on board the Multispectral Thermal Imager (MTI) satellite(Farnik et al., 2001).

Observations of Hα Flare

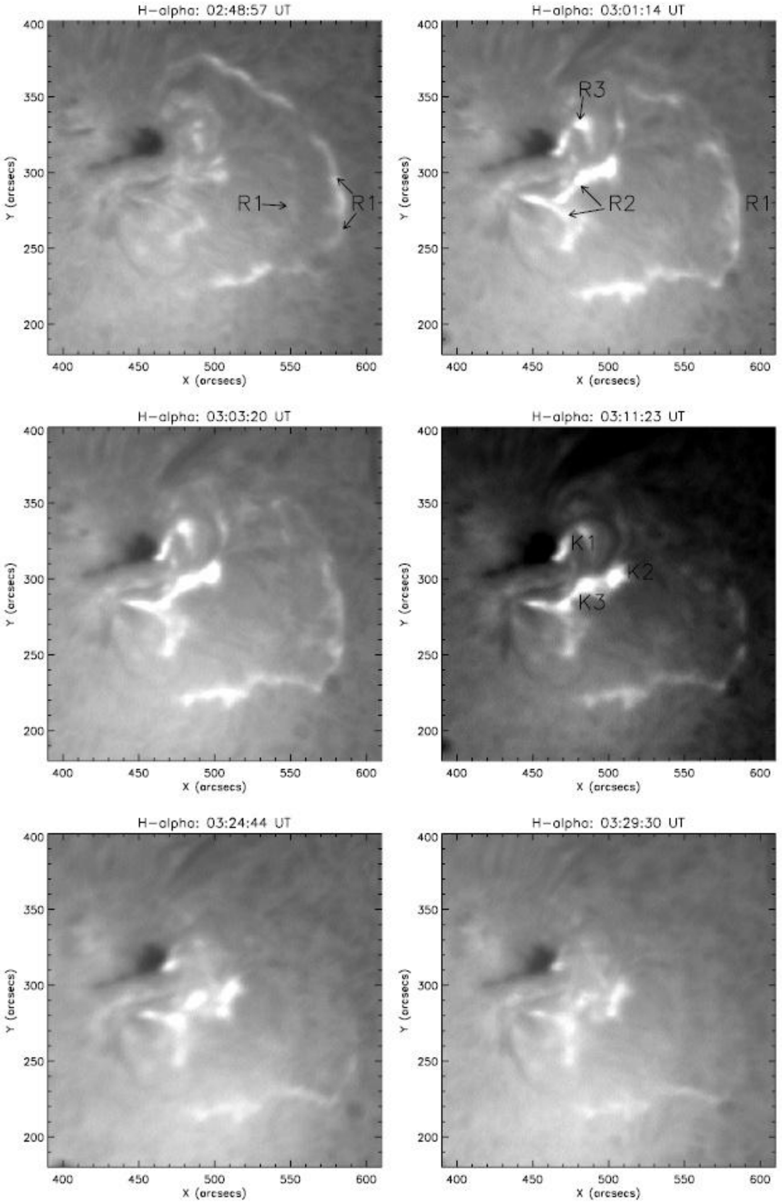
Start: 02 47 ; Peak : 03 08 ; End : 03 22 T Time

Resolution: ~1- 10s

Loc.: N19 W30; Opt.: 1F.

First outer ribbon appear, then the main main flare site brighten.

•Initially the outer ribbon moves outwards with a speed of 20 km/s afterwards its shows contraction.



Multi-wave Observation

Temporal evolutions : 02:45- 03:42 UT.

Figure shows time vs. flux in following order (top):

SXR; HXR ; Hα Kernels' K1 and K3

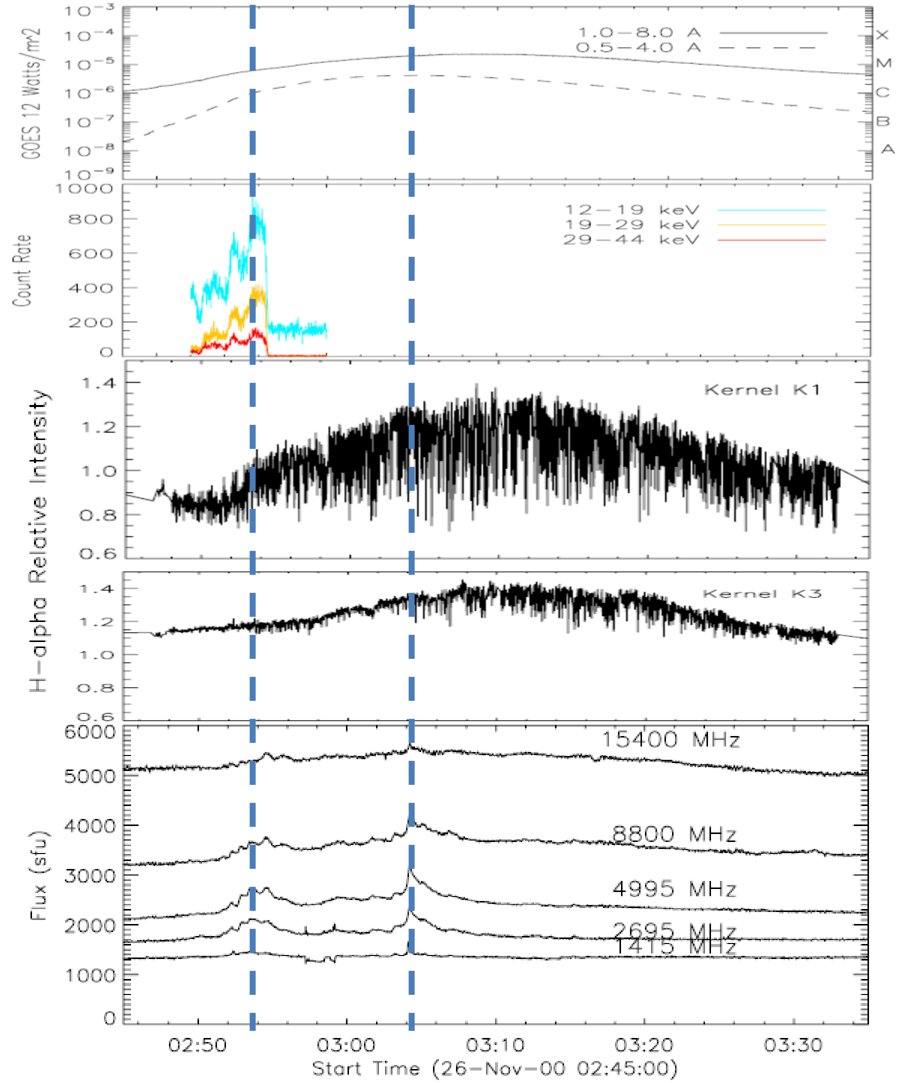
MW: 15400 MHz

MW: 8800 MHz

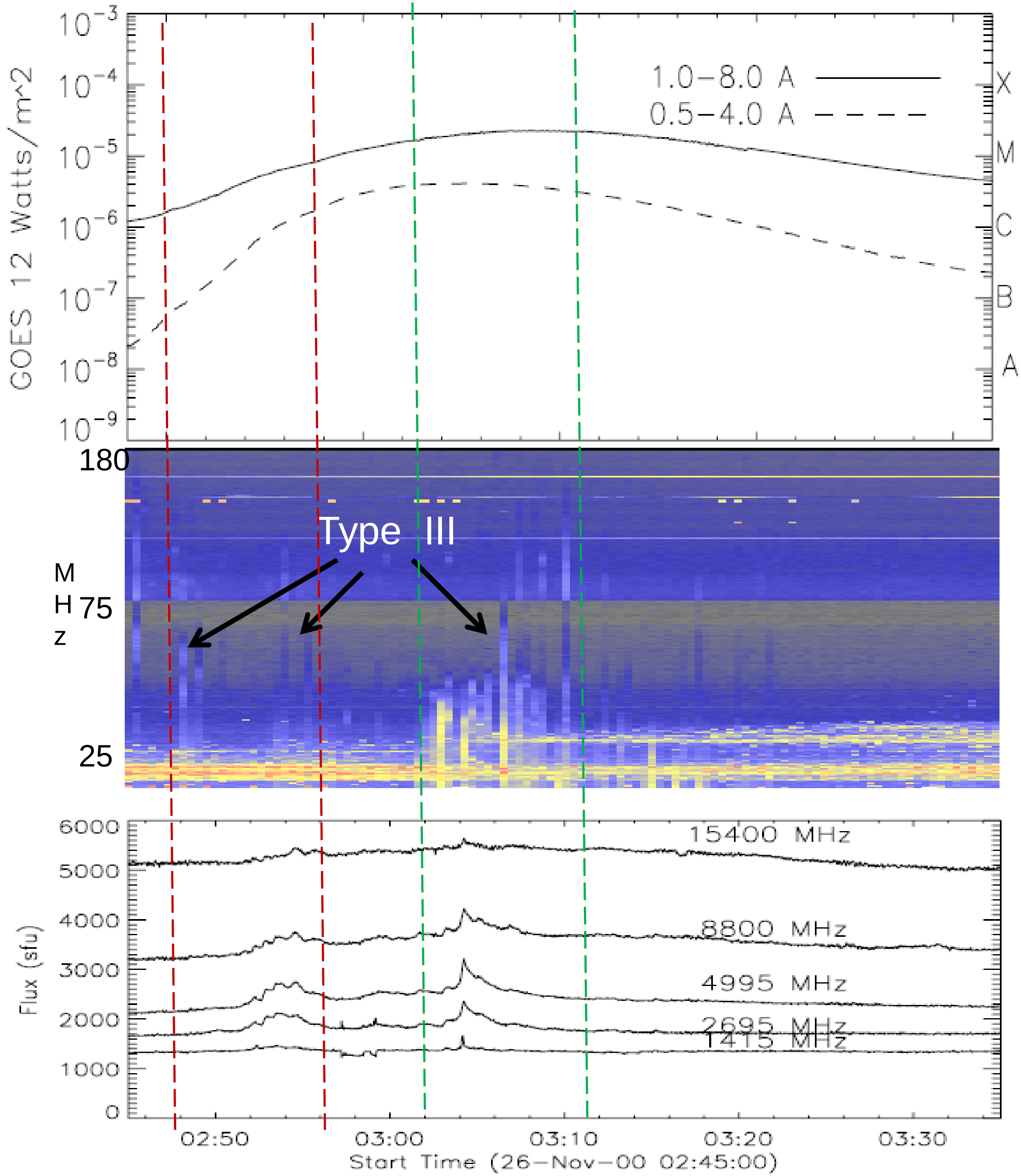
MW:4995 MHz

MW: 2695 MHz

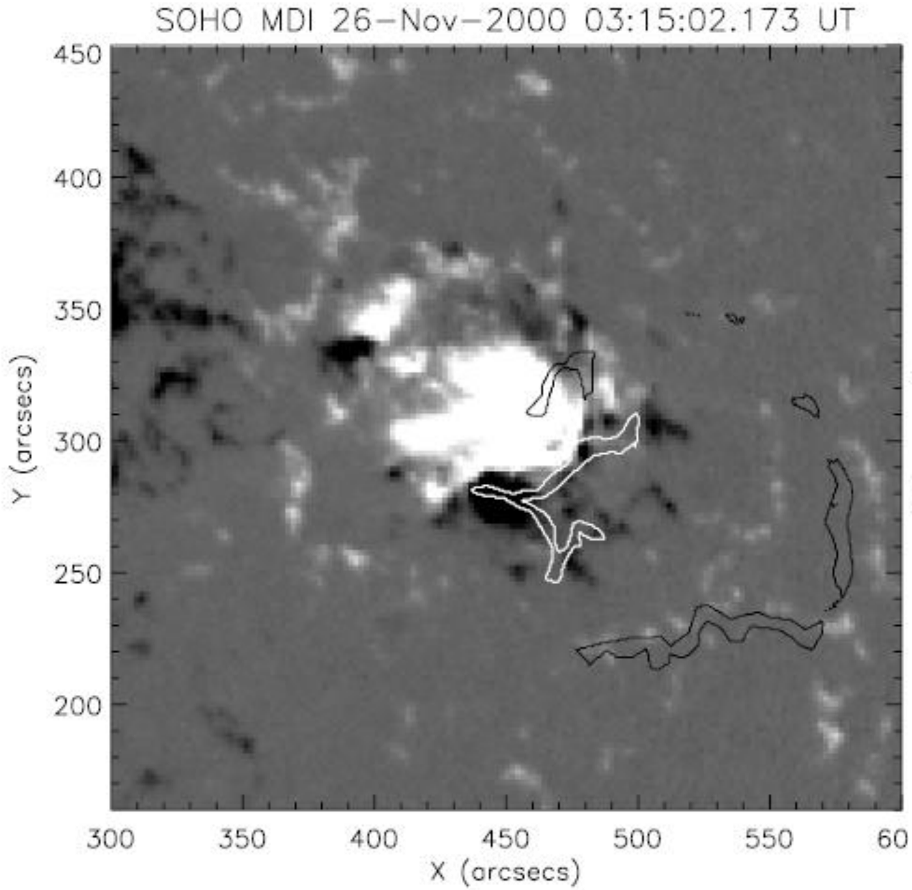
MW: 1415 MHz

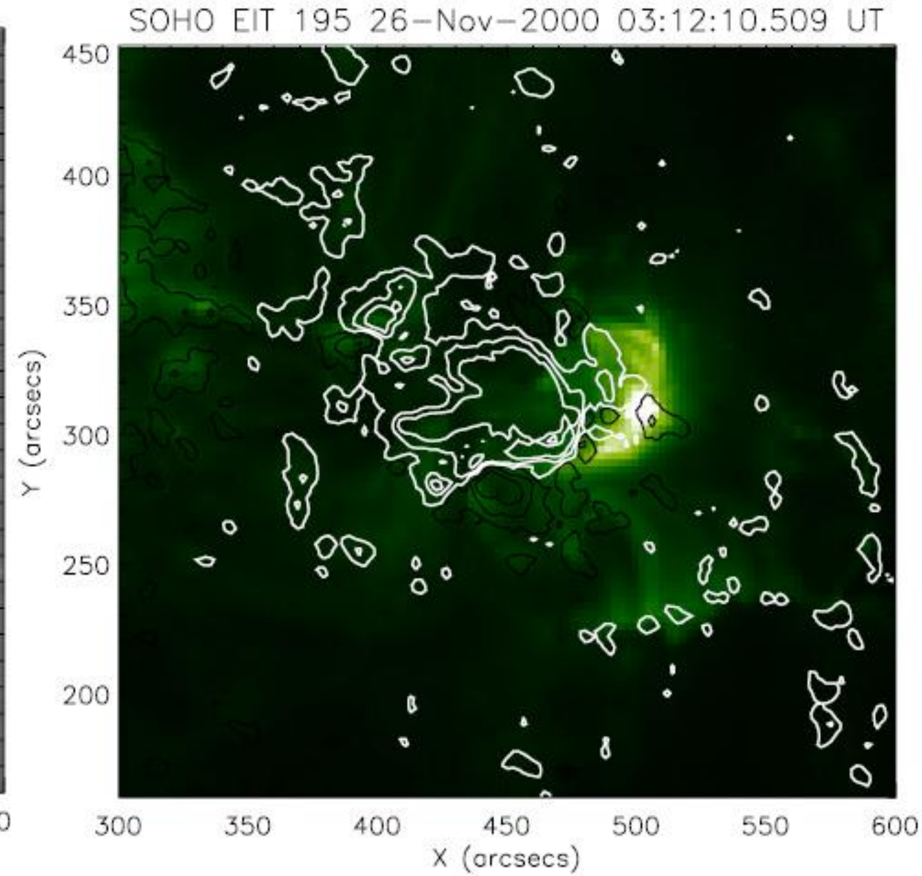


Type III radio bursts and its relation with GOES X-ray and radio observations



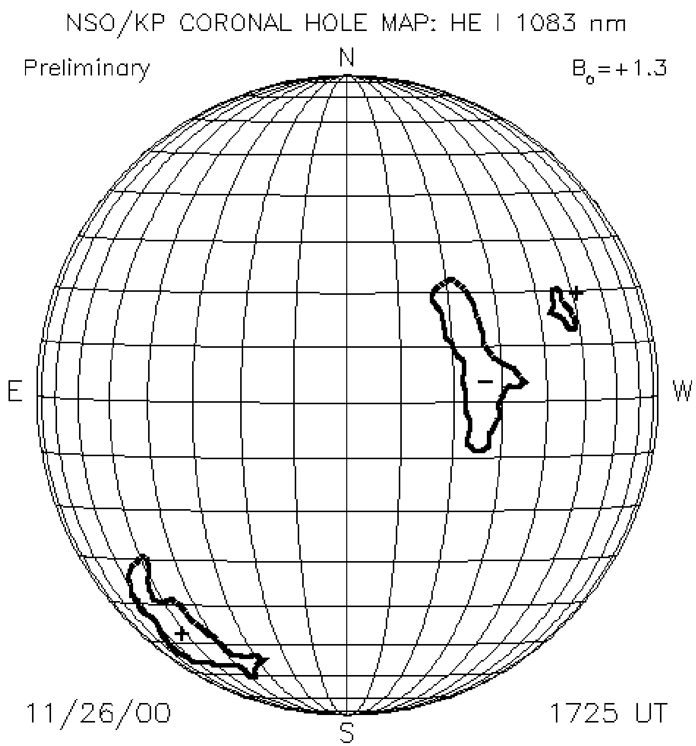
Magnetic field overlaid by H-alpha ribbons contours (left) and SOHO/EIT overlaid by magnetic field contours (right)



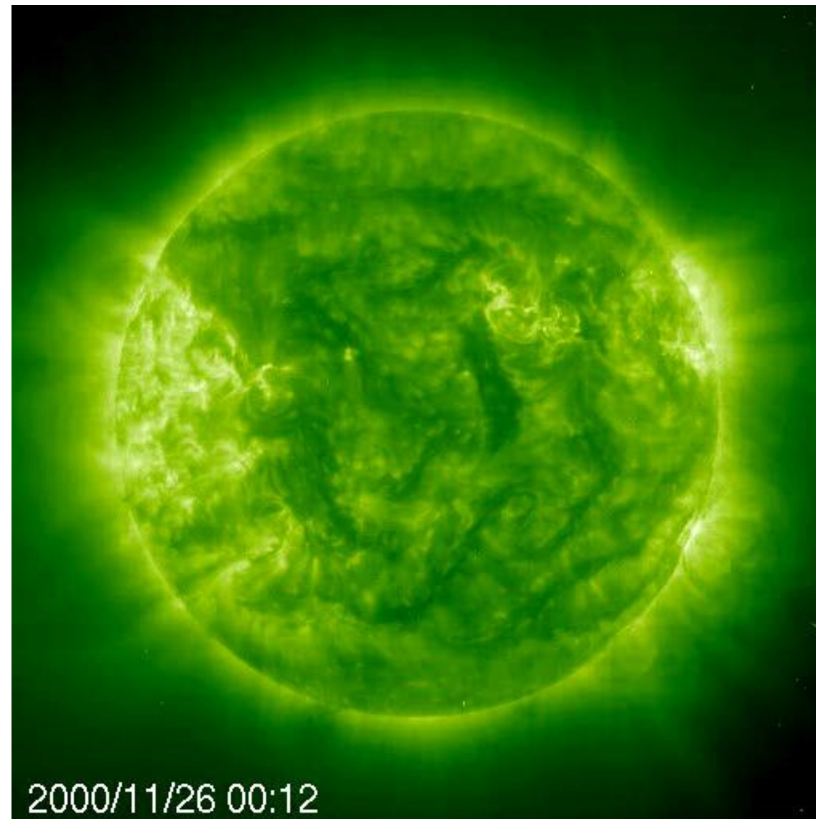


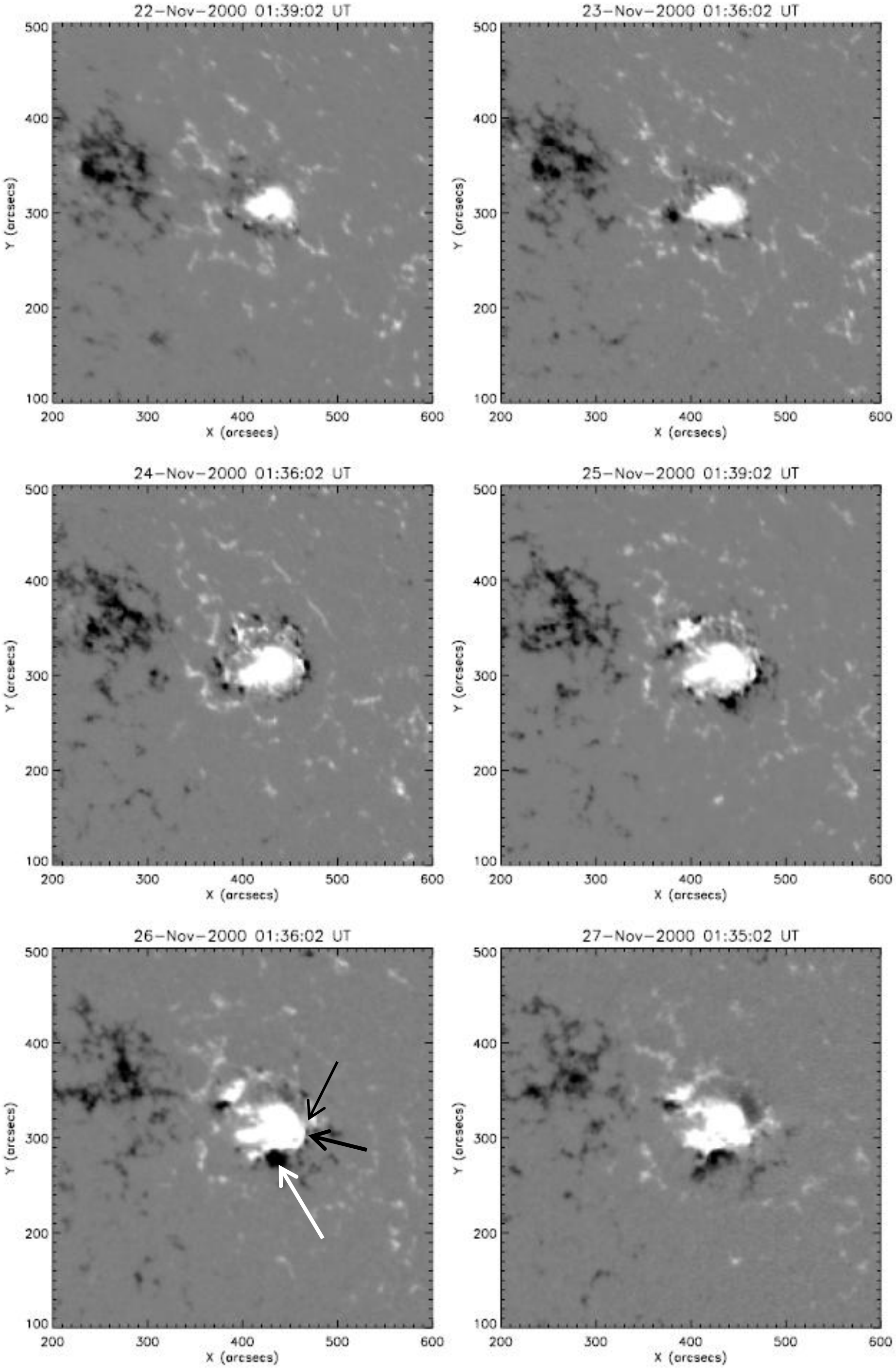
Coronal Holes & EIT movie of flare

10830 ^{0}A daily maps



EIT Movie 26 Nov. 2000

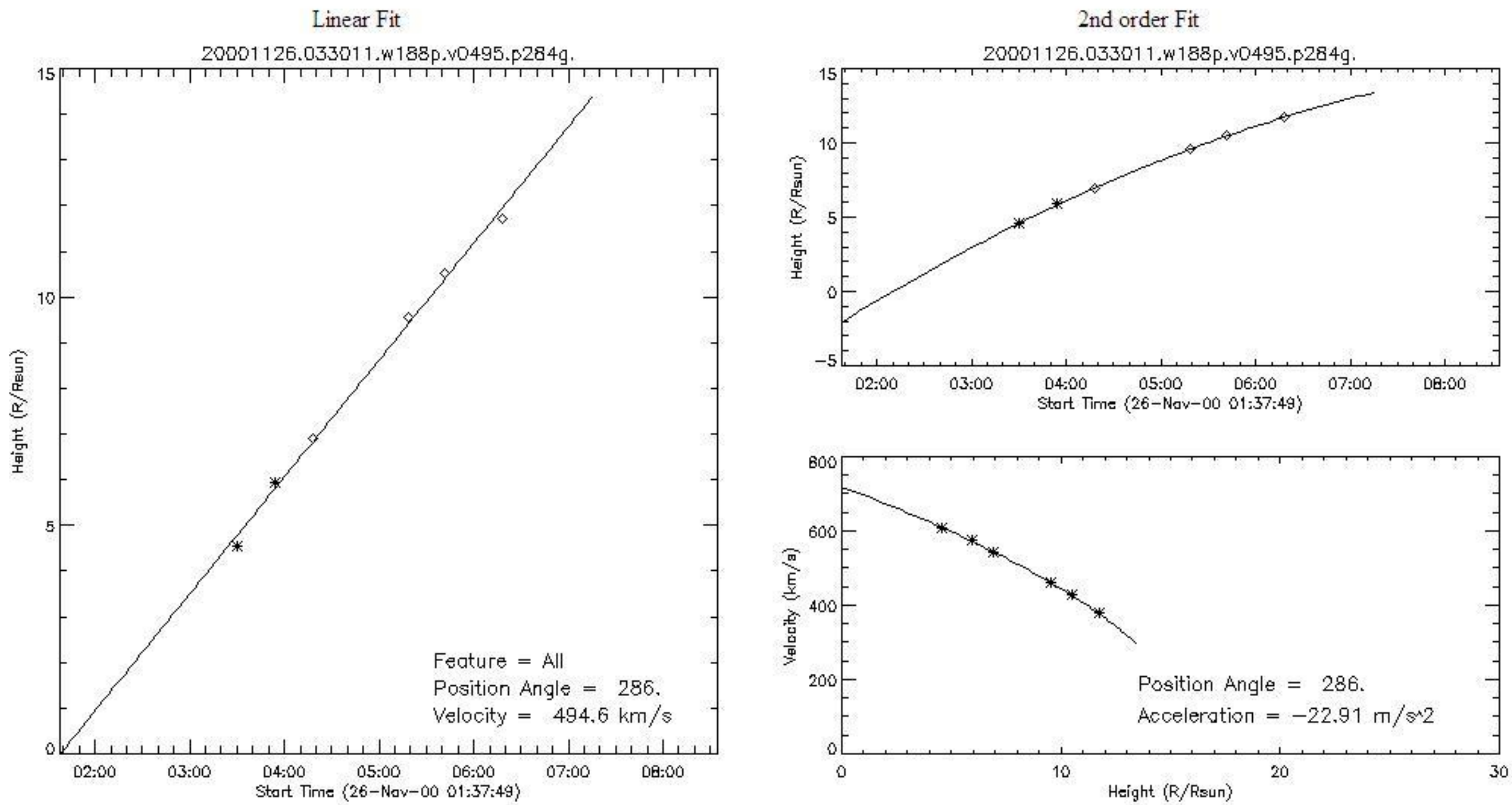




Evolution of magnetic field in the NOAA AR 9236

White arrow: Flux emergence
Black arrow: Flux cancellation site

Flare associated CMEs was after 03:00 UT and height time plot are shown below



Summary

The solar active region NOAA AR 9236 was one of the most flare productive active region of solar cycle 23 and it has a large positive polarity spots surrounded by small positive and negative emerging polarities. The SOHO/MDI observations show the emergence of positive and negative polarities around the main positive polarity in the flaring active region, which might make this active region more flare productive. Here, we present a study based on the high cadence (~ 1 sec) CCD observations of solar flare (M2.2 class) in Hα emission on 26 November, 2000 from NOAA AR 9236. The solar flare was observed by various ground based observatories (Hα, radio) and space borne instruments (SOHO, HXRS, GOES) on 26 November 2000 in time interval between 02:30 UT to 04:00 UT. The flare started with long arc-shape outer ribbons. Afterwards, the main flare starts with two ribbons. Initially the outer ribbons start to expand and later it also shows contraction. An appearance of flare ribbons shows that the flare was initiated by the magnetic breakout mechanism (Antiochos, DeVore and Klimchuk: 1999).

Summary (Cont.)

The H-alpha emissions from the different ribbons of the flare in the chromospheres, which are the footprints of overlying active region coronal loops. This most likely supports the periodic reconnection scenario in the higher corona and precipitation of the energetic particles in the chromospheres. The solar flare was associated with the coronal mass ejection (CME) which has a maximum speed of 494 km/sec and also accompanied by solar energetic particle (SEPs). This small flare occurs in an area closed to a coronal hole (within 10^o) which guides the triggered CME implying the scenario of the reconnection/interaction between closed magnetic field lines related to the flaring active region and open field lines of the coronal hole as earlier reported by Verma (1998). In conclusion, we have presented a detail analysis in the light of multi-wavelength (Hα, radio, HXR and SXR) observations of solar flares and discussed the observations in view of latest scenario of solar flares and CME triggering mechanisms.