Multi-Wavelength Study of M-5.4 Class Solar Flare and Associated Phenomena

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The Anatomy of the Sun

Temperature and Density Variations

Mega-kelvin Atmosphere above Cool Photosphere !!!

Credit : Hardi Peter
Combined effect of differential rotation and dynamo action transport complex magnetic field from the Sun’s interior to its exterior. The key behind the different types of dynamics and transient events in the solar atmosphere is its complex magnetic field.
Three major types of solar corona: Active Regions; Quiet Sun; Coronal Holes

Credit: XRT/Hinode
The solar magnetic field in time: The magnetic maps of the Sun’s surface were recorded with the Vacuum Tower Telescope at the Kitt-Peak National Solar Observatory from 8 January 1992 (lower left) to 25 July 1999 (lower right). Note the variation in pattern and strength of the field from one image to the next (taken one half to one year later than the previous). The variations in the magnetic field reflect the 11-year solar sunspot cycle.
Solar Flares/CMEs [Large Scale Transients]

AR Sunspot Groups

Flare

CME

Credit: SoHO
Standard Flare Model

Magnetic energy = thermal + Particle acceleration

- Magnetic reconnection
- Loop footpoints
- Non-thermal electrons
- Evaporation
- Release of flare energy
- Radiation
- Accelerated particles
- Magnetic loop
- Hard X-rays
- Gamma ray emission from nuclear processes
- Plasmoid/filament
- Chromosphere
- Neutral line
- Sun
Multi-wavelength Study of M5.4 Solar Flare from NOAA AR 11121

GOES plot for this flare

- M5.4 Flare Peak
- Decay Phase
- Primary Energy Release in Decay Phase
- Secondary Energy Release in Decay Phase

Shows magnetic structure of the active region

SDO/HMI and HINODE/SOT images
Of flaring site

Two twisted filaments are interacting, and loop strands are also overlying these filaments.

Flare energy release due to interaction between unstable filament-loop systems and newly formed loop system.
2. In SDO/AIA 304 angstrom

Transition Region view of the same flare process

Remote brightening is clearly evident in 15:37UT Snapshot

SDO/AIA Images in the 304 angstrom
3. Magnetic field contours overlaid the flaring region

Shows filament-loop system interactions

Ribbon separation are evident in various phase of the flare in Hinode Ca II H (3986 A) that shows the ongoing reconnection process in the coronal atmosphere.

Magnetic field is not changing during course of the flare, which means that the flare is due to coronal activity above the active region.

HMI magnetic field contours overlaid images and in last row magnetic field of active region
4. H Alpha Observation

Sequence of H Alpha images captured by NSO-GONG.

Both filament are clearly evident.

Filament 2 has been disappeared during flare process that probably launch the weak eruption of the plasma in the outer corona.
Coronal View of primary energy release in the decay phase of the Flare.

PFLs are changing their location.

Some connectivity of the loop strands, which generates new PFLs.
PFLs are already formed

Heating in the PFLs are clearly evident

Old and new PFLs are crossing each other

SDO/AIA image of the primary energy release in 304 angstrom
Shows CaII H lines during the primary energy release in the decay phase of the flare.

New ribbon at another site of filament
[C] Secondary Energy Release Process in the Decay Phase of Flare

SDO/AIA image sequence during the secondary energy release in decay phase of flare

Filament activation and eruption

Coronal material is heated upward
SDO/AIA 304 A images for the secondary energy release

Similar scenario like 171
Top panel display the chromospheric part during the secondary energy release by using Hinode/SOT CaII H lines.

H alpha images revel formation of the new shape of flare ribbon during this process.
Generally CME is associated with flare.

There are a slow CME is associated with this flare but in the form of flux-tube (loop) expansion in outer atmosphere.

Speed of this CME is 172 Km/sec

Credit: SoHO/LASCO

* Note: We are still in the way to going to add some information about it.
Conclusions

1. Unique Observational Evidences of multiple energy releases in this event.

2. Main flare takes place due to loop-filament interaction.

3. Primary energy and secondary energy releases in the decay phase.

4. A slow CME is also associated with this flare.
THANK YOU VERY MUCH