# TRANSIENT EVENTS AND THEIR SOLAR MAGNETIC FIELD

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Excellent review papers have been presented in this session by S. Solanki (Manifestations of solar magnetic fields), K. Dere (Coronal Mass Ejections and interplanetary ejecta) and W. Droege (Particle acceleration by waves and fields) and the relevant texts can be found in this volume.

The Joint Discussion benefited from three contributed papers: X-Ray/Radio network flares of the quiet Sun by A.O. Benz, S. Krucker, L.W. Acton, and T.S. Bastian (presented by A.O. Benz)
Radio observations of coronal X-ray jets by M.R. Kundu
A giant prominence eruption observed by Nobeyama radioheliograph and YOHKOH spacecraft, by N. Gopalswamy, Y. Hanaoka, M.R. Kundu, K. Shibasaki, H. Koshishi, S. Enome, and J.R. Lemen (presented by Y. Hanaoka)

## 1. Contributed papers

The temporal variations in the soft X-ray (SXR) emission and the radio emission above the solar magnetic network of the quiet corona have been investigated using Yohkoh SXR images with deep exposure and VLA observations in the centimetric radio range. The SXR data show several brightenings with an extrapolated occurrence probability of one brightening per 3 seconds on the total solar surface. During the roughly 10 minutes of enhanced flux, the total radiative losses of the observed plasma are between 0.6 and $2.4{\cdot}10^{26}$ erg per event. These events are more than an order of magnitude smaller than previously reported X-ray bright points or active region transient brightenings. For all of the four events with simultaneous radio observations, a corresponding radio source correlating in space and time can be found. There are several similarities between these SXR/radio events and regular solar flares. These events thus appear to be flare-like and are called network flares.

Coronal line (Fe IX and Fe XII) observations by the Extreme ultraviolet Imaging Telescope (EIT) onboard the SOHO satellite have also been made. They detect plasma in the temperature range around 1.3 $10^6$ K, previously measured in the Yohkoh SXR in the quiet sun. Thus the coronal EUV lines are a very sensitive measure of variations in the content of coronal plasma. The thermal emission of the quiet corona is detected to fluctuate in time and space, presumably the result of localized heat inputs. Significant fluctuations are found in 85% of all pixels. The more prominent enhancements are identified with previously reported X-ray network flares above the magnetic network of the quiet Sun chromosphere. In coronal EUV lines they are amenable to detailed analysis suggesting that the brightenings are caused by additional , dense plasma injected from below and heated to slightly higher temperature than the preexisting corona. An associated radio enhancement at 3.6 or 6 cm wavelength is found in most cases. About half of them show decreasing spectra indicating gyrosynchrotron radiation. Such radio signature is suggestive of non-thermal electrons well-known as an important constituent of regular flares. Therefore we propose that these enhancements are indeed microflares produced by a reconnection process in the corona. Assuming that these findings apply to all observed EUV enhancements, their energy input would correspond to a consideral part of the heating requirement of the quiet corona. These observations give convincing evidence for the first time that microflare heating is a significant process in the quiet sun.



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The X-Ray jets observed by the Yohkoh-SXT experiment consist of highly collimated plasma structures originating in active regions or X-Ray bright points. They evolve dynamically on time scales of the order of minutes to tens of minutes; and they are visible in soft X-rays because of density and temperature enhancements relative to the surrounding coronal material. Most jets are associated with small flares.

We have made radio observations – both metric and microwave in conjunction with the X-ray jets. Type III bursts have been detected in association with dynamic coronal X-ray jets observed by Yohkoh/SXT. The type III bursts are spatially and temporally coincident with the X-ray jets. The radio locations at different frequencies are aligned along the length of the jets. The observation of type III bursts in association with X-ray jets implies the acceleration of electrons to several tens of keV, along with the heating responsible for the production of soft X-rays. This association implies the existence of open field lines in dense coronal structures identified on the Sun's disk, along which type III emitting nonthermal electrons propagate.

We have searched for nothermal radio signatures in the form of metric type III bursts in conjunction with two-sided-loop type X-ray jets observed by the Yohkoh/SXT experiment. We have found no evidence of type III bursts in association with this particular type of X-ray jets in contrast to the positive evidence of type III's in association with anemone type X-ray jets. This result is consistent with the simulation results of Yokoyama and Shibata (6), which show that anemone type jets are produced by vertical/oblique plasma flow whereas the two-sided-loop type jets are produced by horizontal plasma flow.

We also detected microwave emission at 17 GHz in association with coronal X-ray jets. We usually see 17 GHz emission from the upper part of the jet base (active region loop or loops), but no emission from the collimated X-ray jet itself, implying that it must be optically thin at 17 GHz. In one event, we see the base of the jet as well as the bottom part of the jet itself, implying that the optical depth is higher at the bottom part (obviously because of higher electron density) than at the top. We believe that the 17 GHz emission is thermal because it is gradual and unpolarized and that the heating process that gives rise to the jet X-ray plasma also results in the 17 GHz emission.

Quiescent prominences are large-scale cool structures overlying photospheric neutral lines separating opposite magnetic polarity regions. Prominence eruption is the most common signature of coronal mass ejections (CMEs) near the solar surface. X-ray and microwave observations can provide information on eruptions close to the solar surface, which is difficult to obtain from coronagraphic observations. After the advent of the Yohkoh/Soft X-ray Telescope and the Nobeyama radioheliograph, it has become possible to study the near surface manifestations of CMEs in detail. The giant prominence eruption of 1994 April 04-05 is one such event studied using soft X-ray and radio data. Prior to the eruption, the prominence could be observed on the disk for several days starting from March 25, 1994 as a long north-south filament. The prominence was above the west limb on April 04, 1994 and started to rise around 23:00 UT with an acceleration of 11 m $s^{-2}$. The prominence attained a speed of only about 70 km $s^{-1}$ when it reached the edge of the field of view around 05:30 UT on April 05. During the eruption, some amount of material could be seen falling back to the solar surface. The X-ray images taken around this time showed nothing spectacular. However, in X-ray difference images, a large depletion above the prominence was found, similar to the "coronal dimming" events. When the radio prominence was superposed on the X-ray difference image it was found that the depletion had a much larger radial extent and a comparable lateral extent. There was no depletion in earlier difference images. The depletion was clearly well ahead of the erupting prominence, and occupies a volume much larger than that of the prominence itself. The coronal depletion above the rising prominence is a clear indication that the corona overlying the erupting prominence had been dynamic even before the prominence lift-off. There was another X-ray signature in X-rays associated with the eruption: At the bottom of the coronal dimming and underneath the erupting filament was an arcade formation that remained for several hours. This arcade was parallel to the limb in projection and occupied an area roughly similar to that occupied by the prominence.

## 2. Posters

Fourteen posters have been presented during this short session. Five posters concerned eruptive prominences and coronal mass ejections. The analysis of Type II and IV radio bursts connected with CMEs has evidenced fiber structures (Chernov and Markeev). The initiation of the CME is now better understood with the combination of EIT and LASCO on SOHO : the association with an eruptive prominence is well established (Dere et al.). The Nobeyama radioheliograph images at 17 GHz indicate that the eruptive prominence material starts to be heated at the very beginning of the eruption (Kanaoka and Shinkawa). The eruption itself as observed with MDI, EIT, SUMER and LASCO on SOHO, is interpreted as the consequence of magnetic field lines reordering occurring in the corona (Schmieder et al.). The large scale of filament eruption is shown by the combination of optical (Halpha) and radio (Nobeyama) observations of a big event; large horizontal velocities are noted (Shinkawa et al.). Could they be the signature of Moreton waves? Two posters addressed the issue of prominence diagnostic. The RATAN polarization measurements in the range 0.9-18 GHz provide a wealth of information, including temperature and magnetic field; weak and strong field values (up to 100 G) are found (Bogod, Garaimov and Grebinskii). The plasma diagnostic performed in strong lines in moving structures such as eruptive prominences is made difficult by NonLTE radiative transfer but worth to be done from SOHO (Vial et al.). Four posters dealt with flares. The initiation of a flare observed in Halpha, magnetic field and soft X-ray shows that a double system of loops interacts to form a single loop in accordance with a coalescence model (Liu, Akioka and Yan). The evidence of plasma ejection in some impulsive flares has been brought by YOHKOH in soft X-ray; this ejection is part of the very early phase of the flare (Ohyama and Shibata). Three gamma-ray flares have been studied with YOHKOH data (Mosalam Shaltout). The precipitation of electrons has been studied for different configurations, including magnetic field convergence; this time-dependent study matches the signatures (spectral indices and fluxes) observed with SMM and YOHKOH (Zharkova and Syniasvskii). One poster was connected with surges: from Halpha evolution and magnetic field extrapolation, it is shown that the coronal interaction between a small and a large loop is the key for the surge initiation (Akioka and Liu). One poster presented two-dimensional simulation on helmet streamer formation. From the emergence of an arcade-type magnetic field, an equilibrium involving low-lying loop and high-lying cusp arcades is formed (Setiahadi et al.). Finally a poster described the Solar Mass Ejection Imager which, with its very wide-angle cameras, should image transient structures in the heliosphere such as CMEs and shocks (Jackson et al.).

## 3. Discussions

Following all presentations, discussions followed on:

1. The magnetic triggering mechanisms of eruptive prominences and CMEs. Further measurements of the magnetic field vector, the filling factor and mass flux are needed. Disk vs. limb observations were discussed. The important role of MDI on SOHO was stressed.
2. The micro-heating related to micro transients (from mesoscales to nanoscales).
3. The future observations whose importance increases with cycle 23; with SOHO, YOHKOH, ULYSSES, and in a near future, TRACE, solar and heliospheric physicists are in a unique position to address long-standing issues.
4. Future instrumentation: the approval of Solar-B was seen as a good omen.