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Solar-B – The Next Japanese Solar Mission –

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Abstract

Our view of the solar corona has been revolutionized by *Yohkoh*. *Yohkoh* has shown that the hot corona is extremely dynamic, with magnetic reconnection, rapid heating, and mass ejection being common phenomena. The next vital step is to understand magnetic origins of coronal dynamics and heating. Solar-B, Japan's next solar physics mission, is designed to study the connection of the dynamics and heating observed in the corona with the magnetic field at the solar surface. Solar-B will carry a medium-sized optical telescope capable of measuring vector magnetic fields on the solar surface, together with two X-ray/EUV imaging instruments for the solar corona. The Solar-B program is now in the conceptual design study phase. ISAS, in collaboration with NASA (U.S.A.) and PPARC (U.K.), plans to launch Solar-B as its 22nd science satellite in summer 2004.

Key words: Sun: Corona – Sun: Magnetic field – Sun: Photosphere – High resolution, Space Observation

1. Introduction

Many interesting results from *Yohkoh* motivated us to plan the Solar-B mission with the current design concept, which will be described in the subsequent sections. The *Yohkoh* satellite has made significant advances in understanding solar flares and the corona and revolutionized our view of the hot corona. *Yohkoh* has shown that the hot (> 3 MK) corona is extremely dynamic, with rapid heating, plasma ejection, and coronal restructuring being common phenomena. *Yohkoh* also discovered several pieces of evidence which support the idea that magnetic reconnection plays a vital role of energy release in solar flares. More recently, the SoHO and TRACE satellites have observed lower temperature (< 2 MK) plasmas in the corona and revealed that the low-temperature corona is also dynamic.

It has been believed that magnetic fields play important key roles in the dynamical nature of the corona, and they are deeply rooted into the photosphere and controlled by plasma convective motions there and beneath. To better understand the dynamical nature of the corona, we need to understand the nature of magnetic fields in the corona and photosphere as a unified system. The Solar-B mission aims to unveil the magnetic connection between the corona and photosphere and hence the origin of hot atmosphere of the Sun and the basic mechanisms involved in magnetic energy release in the corona.

This paper describes the current design concept of the Solar-B mission (§3) and discusses scientific objectives of Solar-B (§4). In §2, some key findings by *Yohkoh*, which are a guide to Solar-B science, are summarized.

2. Highlights of *Yohkoh*: A Guide to Solar-B Science

Yohkoh observations present pieces of evidence which support the idea that magnetic reconnection plays an important role in magnetic energy release in solar flares. Some key findings from *Yohkoh* observations regarding solar flares are summarized below:

1. Hard X-ray sources in solar flares show a strong tendency to occur in simultaneous pairs. The double sources match the photospheric footpoints of a flaring loop, establishing that non-thermal electrons transport the impulsive-phase energy along the flare loops (Sakao et al. 1992; Hudson et al. 1992, 1994; Canfield et al. 1992).

2. A cusp-shaped soft X-ray structure was found in long duration flares (Figure 1a). The temperature map deduced from *Yohkoh* SXT shows the tendency for highest temperatures to occur in the periphery of the cusp structure, suggesting that magnetic reconnection takes place far above the cusp (Tsuneta et al. 1992; Tsuneta 1996; Forbes and Acton 1996).

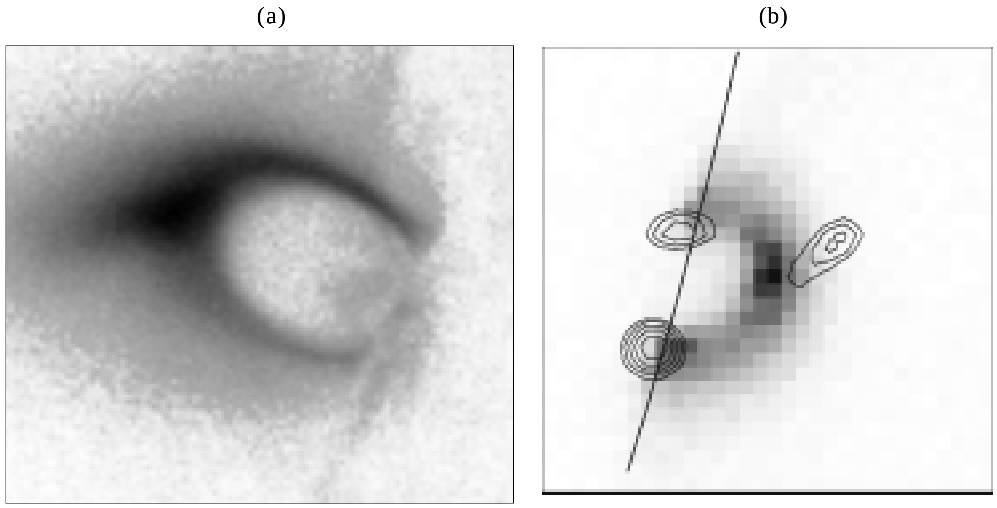

Fig. 1.. (a) Cusped soft X-ray structure of the 21 February 1992 flare at the solar limb (Tsuneta et al. 1992). (b) A hard X-ray source above a flaring loop and double sources at the photospheric footpoints of the loop. Soft X-ray image of the 13 January 1992 flare at the solar limb with hard X-ray (33-53 keV) image contours superposed (Masuda et al. 1994).

3. A hard X-ray source was discovered above a flaring loop of an impulsive flare (Figure 1b). This finding suggests that some impulsive flares have configurations similar to that of long duration flares with a cusp-shaped soft X-ray structure. A reconnection site in the corona above the soft X-ray flaring loop drives a rapid outflow, which impinges on denser material in the underlying magnetic loop and creates the hard X-ray source (Masuda et al. 1994, 1995).

4. Many flares show traces of ejection of hot material seen in soft X-rays (Shibata et al. 1995; Ohyama and Shibata 1997).

5. Simultaneous X-ray and radio observations showed that at least two loops are involved in the majority of impulsive flares (Hanaoka 1996; Nishio et al. 1997). Typical sizes of the two loops are different from each other; one is compact, typically less than 20 arcsec. This finding suggests that a newly emerging flux is involved in the energy release of flares.

6. The separation between hard X-ray double footpoint sources increases during the impulsive phase for half of solar flares, whereas some of flares show decreasing footpoint separation (Sakao, Kosugi, and Masuda 1998). The magnetic field configuration inferred from the former class of flares suggests a picture in which magnetic reconnection takes place above a flaring loop. The latter class of flares suggests a picture in which magnetic reconnection takes place between a newly emerging flux and a pre-existing flux.

New views of the corona in which the corona is extremely dynamic are illustrated with the following dynamical phenomena which were first found with *Yohkoh*:

1. Transient brightenings of compact loops occurring in active regions. Their energy is at the small end of flare sizes ($10^{25} \sim 10^{29}$ ergs), qualifying them as microflares, and close to qualifying them as nanoflares (Shimizu et al. 1992; 1994). Transient events are also found in X-ray bright points and quiet region networks (Strong et al. 1992; Krucker et al. 1997).

2. X-ray coronal jets (Shibata et al. 1992, 1994; Shimojo et al. 1996). Jets are accompanied by microflares or flares, and can be well explained by magnetic reconnection between a newly emerging magnetic flux and a pre-existing flux (Yokoyama and Shibata 1996). Some of type III bursts are associated with coronal jets (Kundu et al. 1995).

3. Slowly expanding active-region loops with velocity of a few to a few tens of km/s (Uchida et al. 1992). Their morphology distinguishes them from coronal mass ejections (CMEs), suggesting a different physical origin.

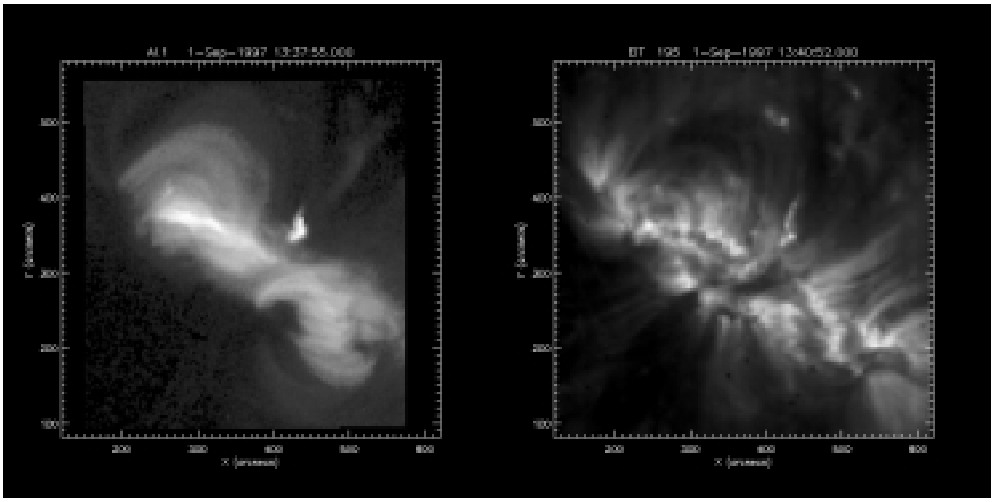

Fig. 2.. An active region simultaneously observed with *Yohkoh* SXT (left) and SoHO EIT (right) on 1 September 1997. *Yohkoh* mainly observes coronal plasmas above 3 MK, whereas SoHO EIT observes less than 2 MK plasmas. This region was extensively studied in the 3rd *Yohkoh*-SoHO coordinated data analysis workshop.

4. Coronal restructuring frequently occurs from large scale to small scale. Large-scale coronal restructuring events appear to be X-ray counterparts of steamer disruptions (Tsuneta et al. 1992; Hiei, Hundhausen, and Sime 1993; McAllister et al. 1996).

With the capability of estimating physical parameters of coronal loops, *Yohkoh* has given some hints in understanding the heating of the corona. Some findings regarding coronal heating are listed as follows:

1. The frequency distribution of microflares (transient brightenings) is well represented by a power-law function with an index of 1.5 - 1.6 (Shimizu 1995). This indicates that microflares are just flares at the smaller end of normal flares, suggesting that microflares do not contribute significantly to coronal heating of active regions.

2. Multi-temperature structures in the corona are revealed with joint observations with SoHO (Figure 2), sounding rocket experiments, and ground-based coronagraphs (Ichimoto et al. 1995; Yoshida et al. 1995; Nagata et al. 1999).

3. The SXT temperature maps show that the temperature structure is far different from the spatial distribution of soft X-ray intensity (Yoshida and Tsuneta 1996). The active region corona consists of two components; one is cooler, quasi-steady structures with 3 - 5 MK, and the other is hotter (> 5 MK), transient structures such as cusp-shaped features and multiple loop structures due to microflares (Sterling, Hudson, and Watanabe 1997).

4. The temperature of coronal holes may be similar to that of quiet regions (Hara et al. 1994). In these regions, the temperature of the corona appears to slightly increase with height (Sturrock, Wheatland, and Acton 1996; Foley, Culhane, and Acton 1997).

5. A deep survey of nanoflare events was made with temporal sequences of high sensitivity SXT images (Shimizu and Tsuneta 1997). Short time scale variability fainter than transient brightenings (microflares) is found almost everywhere in active regions and X-ray bright points, whereas no significant variability is found in quiet regions.

6. The distributions of physical parameters along coronal loops have been studied to learn about the heating mechanisms (Kano and Tsuneta 1995; Klimchuk and Porter 1995). The temperature is higher at the apex than at the footpoints of coronal loops. The "RTV" scaling law among the maximum temperature, gas pressure, and length of loops was confirmed with *Yohkoh*.

7. Soft X-ray imaging observations have been continuously made for more than 7 years since 1991. Long-term changes of the heating in different coronal regions have been monitored from the solar maximum over the solar minimum.

Table 1.. Overview of Solar-B mission.

Orbit	600-km Sun-synchronous polar orbit
Weight	$\sim$ 700 kg (dry) + $\sim$ 170 kg (thruster gas)
Launch date	summer 2004
Lifetime	$\geq$ 3 years
Attitude control	3-axis stabilized body control
	with a tip-tilt mirror for optical telescope as image stabilizer
Data rate	$\sim$ 500 kbps maximum
Amount of data	$\sim$ 4 Gbits per orbit (recorder capacity)
Telemetry rate	$\sim$ 5 Mbps for reproduction of stored data

3. Solar-B Mission

The Solar-B mission is the Japan's next solar physics mission. ISAS (Institute of Space and Astronautical Science) plans to launch Solar-B as its 22nd science satellite in the summer of 2004. The Solar-B program was officially approved by ISAS in 1997, and the program is now in the conceptual design study phase. The Solar-B scientific instruments will be prepared in international collaboration with the United States (NASA) and the United Kingdom (PPARC).

The scientific objectives of Solar-B are mainly to study the following three basic and important topics:

1. The origin of hot plasma in the solar corona.
2. The coupling between the dynamic processes occurring in the corona and the fine magnetic structure at the photosphere.
3. The basic mechanisms involved in magnetic reconnection as a converter of magnetic energy into thermal/kinetic energy.

To obtain valuable information on magnetic fields and plasmas over a range of different heights and temperatures, i.e., from photosphere (6,000 K) to hot corona ($>$ 2 MK), Solar-B will have a coordinated set of three scientific instruments:

1. A 50 cm optical telescope equipped with a two-channel filtergraph and a spectro-polarimeter.
2. An X-ray telescope.
3. An extremely-ultraviolet (EUV) imaging spectrometer.

The optical telescope is for making accurate measurements of vector magnetic and velocity fields at the photosphere and chromosphere, and the X-ray/EUV instruments are for diagnosing the corona and transition region.

Table 1 gives an overview of the Solar-B satellite. We should note that details of the specifications listed in the table are not finalized at this stage and the ongoing design study may change some of the specifications. Solar-B will be launched by an M-V rocket into a 600-km circular polar sun-synchronous orbit. This orbit is identical to the orbit of TRACE, and it provides us with continuous viewing of the Sun for about 8 months in a year. *Yohkoh* has satellite night continuing for about 40 minutes every $\sim$ 96 minutes' orbit, interrupting observations of X-ray phenomena of interest. Big flares often take place during night and *Yohkoh* has missed observations of such flares. At ground-based observatories, one can observe the Sun continuously for about 12 hours at maximum, but excellent seeing conditions do not continue for more than tens of minutes. Thus, with continuous observations from space, great advances will be expected on studies of evolutional changes of magnetic and velocity fields.

Solar-B will be designed to be operational in orbit for more than 3 years. The launch date will enable the mission to make observations during the declining phase of the current solar activity cycle which is expected to reach its maximum around 2000. The mission period will not provide us with the frequent occurrence of large flares, but smaller flares and microflares will be well observed with Solar-B. Note that SoHO has observed a lot of dynamical phenomena in the corona even during the solar minimum phase. Moreover, the Solar-B telescopes with narrow

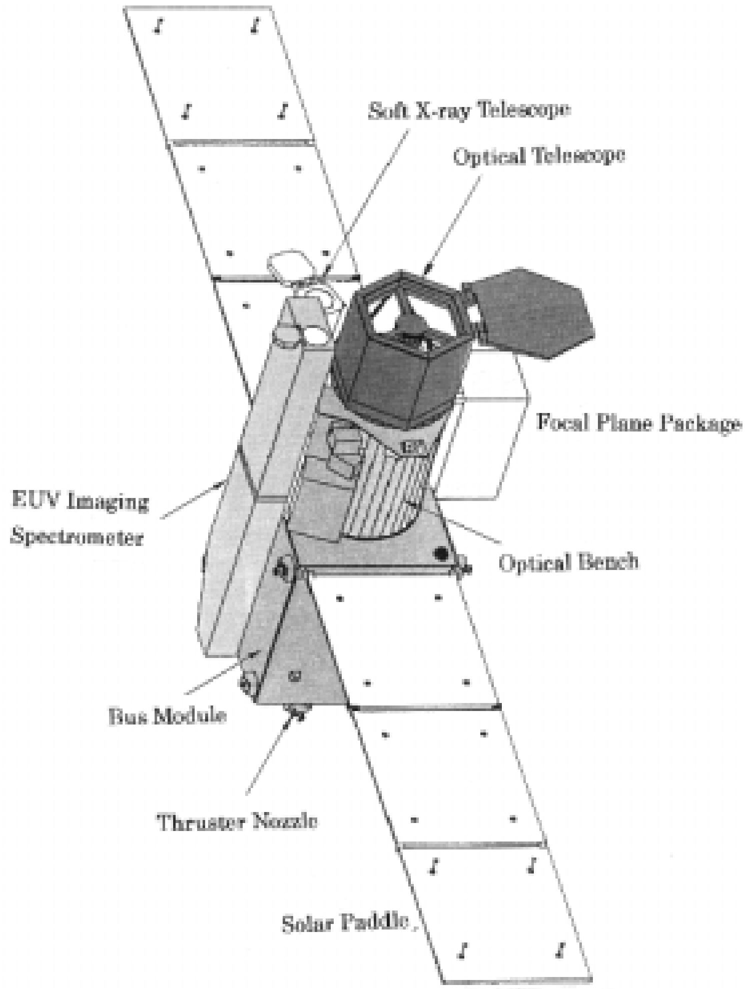

Fig. 3.. Solar-B spacecraft based on a draft design.

fields-of-view can be focused on an active region of interest on the disk as long as possible, because the number of active regions is limited on the solar disk during the mission. In addition to observations of active regions, much time can be allocated to observations of quiet regions.

Figure 3 shows the layout (draft version) of the Solar-B spacecraft. The upper central part of the spacecraft is occupied by the optical telescope. The X-ray telescope and EUV imaging spectrometer are mounted on an optical bench (pedestal) enclosing the lower half of the optical telescope. The optical bench provides the base which is thermally stable, minimizing the effect of thermal distortion on co-alignment of the three telescopes. Focal-plane instruments for the optical telescope are installed in the focal plane package equipped on the optical bench. The optical bench with these scientific telescope instruments is mounted on the bus module including spacecraft components and a thruster gas tank.

Table 2.. Baseline Specifications of the Optical Telescope.

Telescope Optics	Aplanatic Gregorian with heat dump mirror and collimator $\sim$ 50 cm ϕ primary mirror, primary-secondary length 1.2 m
Two-channel filtergraph	
Narrow-band filter	
Objective	Mapping of magnetic and velocity fields
Wavelength	4500 − −6600Å , tunable
Spectral resolution	0.1Å at 6000Å
Interference filter	
Objective	High spatial resolution imaging
Wavelength	4305, 3933Å
Spectral resolution	10 − 20 Å
Detector	2048×2048 CCD
Plate scale	$\sim$ 0.1 arcsec/pixel
FOV	$\sim 200'' \times 200''$
Spectrograph	
Objective	High precision magnetic field observations
Wavelength	6302/6303 Å
Spectral resolution	0.025Å at 6000Å
Detector	2048×2048 CCD
Plate scale	0.1 arcsec $\times$ 25mÅ /pixel
FOV	$\sim 150'' \times 0.2''$ with a scanning mirror
Changing FOV	Spacecraft attitude control
Image stabilizer	Tip-tilt mirror with correlation tracker

4. Solar-B Scientific Instruments

4.1. Solar Optical Telescope

The main tasks of the optical telescope are to obtain continuous series of diffraction-limited images and also to make highly accurate measurements of vector magnetic fields. The baseline telescope is an Aplanatic Gregorian (1.2 m in length) with a $\sim$ 50-cm-diameter primary mirror. The telescope provides $\sim$ 0.2 arcsec spatial resolution in the 390 (430) – 600 nm wavelength range, enabling to approach the size of magnetic flux tubes at the photospheric level. A collimator lens is placed after the Gregorian focus to yield a pupil image around a polarization modulator just behind the primary mirror and also to relax a positional tolerance between the telescope and the following focal-plane package. The focal plane package consists of a two-channel filtergraph and a spectrograph. The filtergraph is used for high time resolution observations, in which the tunable narrow-band filter provides 2-D maps of magnetic and velocity fields and the interference filter provides high-quality images. The spectrograph provides three components of the photospheric magnetic field with high accuracy (S/N $\sim 10^{-4}$) by measuring Stokes *I, Q, U, V* profiles of magnetic sensitive lines, although on relatively slow time scales. A tip-tilt mirror with a correlation tracker is used to stabilize images on the CCD detectors. The baseline specifications for the optical telescope are listed in Table 2. More detailed descriptions of the telescope can be found in Suematsu (1999).

4.2. X-Ray Telescope

The X-ray telescope is designed to image coronal plasma in the range of 1 − 10 MK at $\sim$ 1 arcsec resolution and hence to give the spatial distribution of temperature and emission measure of coronal plasma. Joint observations among SoHO EIT, *Yohkoh*, and sounding rocket experiments have shown different coronal structures from each other due to the difference in the temperature response of the telescopes; Coronal loops are more clearly seen in

Table 3.. Baseline Specifications of X-Ray Telescope.

Optics	Grazing-incidence, Wolter-type I
Wavelength	TBD Å
Detector	Back-illuminated CCD (2048 × 2048)
FOV	The entire Sun
Spatial resolution	$\sim$ 1 arcsec
Temperature range	1 – 10 MK
Standard exposure	0.01 (flare) - 200 (hole) sec
Time resolution	$\sim$ 100 sec (full frame)
	$\sim$ 10 sec (partial frame)
Aspect sensor	visible-light images

Table 4.. Baseline Specifications of EUV Imaging Spectrometer.

Optics	Normal incidence
	Collective area $\sim$ 225 cm^2
Wavelength	250 – 290Å
Detector	Back-illuminated CCD
Pixel size	2 arcsec, 0.02Å
FOV (slit direction)	$\sim$ 300 arcsec
Time resolution	$\sim$ 10 sec

Yohkoh images, while footpoints of the *Yohkoh* loops are more clearly seen in EIT images (Figure 2, also see, e.g., Yoshida et al. 1995). The significant difference reflects multi-temperature nature of solar coronal plasmas. Scientific advances can be achieved with the observations of not only magnetic field topology but also multi-temperature structures. The wide coverage of temperature range above about 1 MK is required for the X-ray telescope, with a capability of temperature diagnostics. A grazing-incidence type optics, which is similar to *Yohkoh* SXT, is used with a back-illuminated CCD detector. High temporal resolution is necessary to catch the dynamical nature of fine scale ($\sim$ 1 arcsec) coronal structures. The baseline specifications for the X-ray telescope is listed in Table 3.

4.3. EUV Imaging Spectrometer

The EUV imaging spectrometer is a spectrograph with a slit/slot and a scanning mirror. The main task of the spectrometer is to measure spectral profiles of several lines formed over a range of temperatures in the corona and the transition region. The observed spectral profiles will give a detailed information on physical condition of plasmas such as velocity, density and temperature. The observing wavelength in the baseline design is 250 – 290 Å , where several coronal and transition-region spectral lines are observed. This wavelength region is one of the regions to make both coronal and flare plasma diagnostics possible. The sensitivity much higher than SoHO CDS and the 0.02Å /pixel spectral resolution enable to measure Doppler shifts of spectral lines with statistical accuracy of 1–2 km/s and line-width broadening with accuracy of 3–5 km/s. Thanks to the high sensitivity, the observing cadence is much higher than SoHO CDS, enabling it to catch mass motions involved in dynamical phenomena, such as magnetic reconnection. The spectrometer can be also used to connect coronal and chromospheric/photospheric magnetic fields in joint observations with the optical and X-ray telescopes. The baseline specifications for the EUV imaging spectrometer are listed in Table 4.

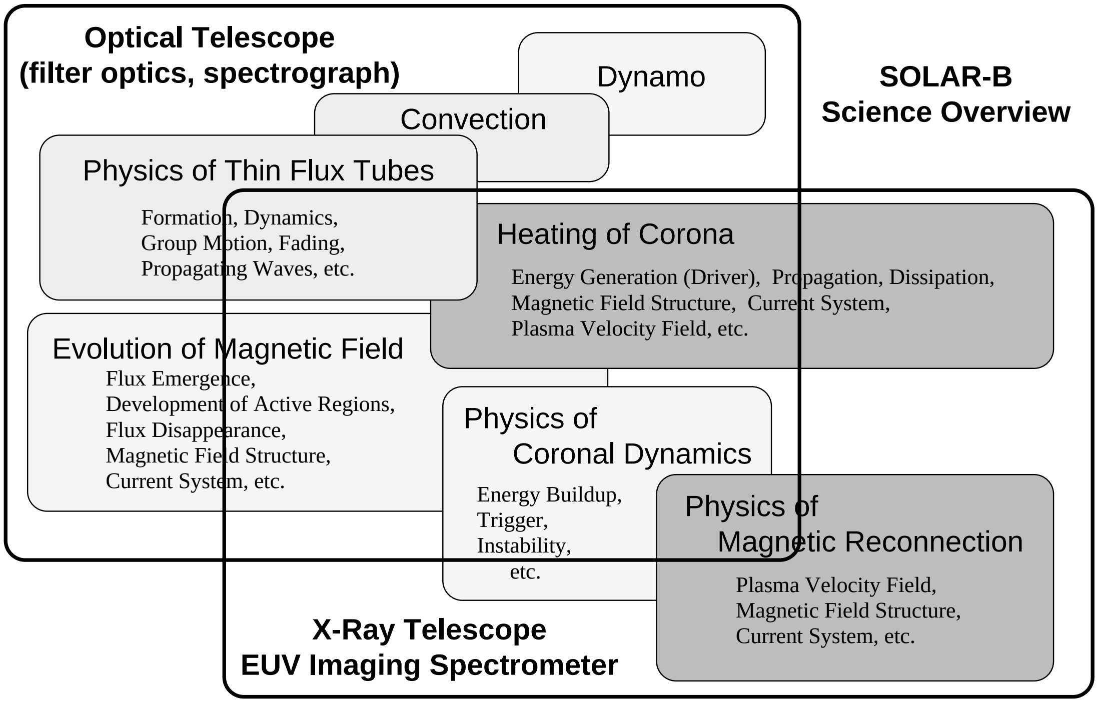

Fig. 4.. Overview of science objectives of Solar-B.

5. Solar-B Scientific Objectives

The main goal for the Solar-B mission is to comprehensively understand the corona and photosphere as a system. This goal covers many scientific areas in solar physics. Figure 4 summarizes the scientific objectives of Solar-B. Instruments necessary for understanding each topic are also indicated in the figure. In the following subsections, we discuss four selected major topics.

5.1. Nature of Magnetic Field in the Photosphere

It is widely believed that the magnetic field of the Sun is formed and maintained by a dynamo process operating near the base of the convection zone. Magnetic fields balloon up to the photosphere due to magnetic buoyancy and appear above the photosphere as newly emerging flux. The magnetic field strength just after emergence is observed to be less than ~ 500 gauss (Brants 1985; Martinez Pillet, Lites, and Skumanich 1997), whereas most of the magnetic field at the photosphere is strong (greater than 1000 gauss) (e.g., Stenflo 1994). Strong magnetic fields, which are called thin magnetic flux tubes, are localized with a diameter of ~ 100 km and thus have a discrete spatial distribution on the photosphere. The flux tubes expand to weak (a few $\times 10$ – a few $\times 100$ gauss) magnetic fields in the corona where they manifest themselves as coronal loops.

The physical processes involved in the emergence of magnetic fields, the formation (also diffusion) of strong thin flux tubes, and the dynamics of flux tubes have not been observed in detail because of lack of continuous high-spatial resolution observations. The Solar-B optical telescope has 0.2 arcsec resolution which is comparable to the size of thin flux tubes at the photosphere, enabling us to access to physical processes involved in flux tubes. Measurements of Stokes profiles with high precision also provide physical condition inside thin flux tubes, although the spatial resolution of the telescope may not be enough to completely resolve the structure inside tubes.

Since the formation and diffusion of thin flux tubes is closely associated with convective motions at and below the photosphere, understanding of convective motions is also a major objective of Solar-B. Three scales of convective motions have been observed; granulation in $\sim 1{,}000$ km, meso-granulation in $\sim 10{,}000$ km, and super-granulation in $\sim 30{,}000$ km. The convective motions are complicated and anomalously shaped granules are frequently observed. Considering the complicated behavior of convective motions, we can imagine that magnetic flux tubes also have

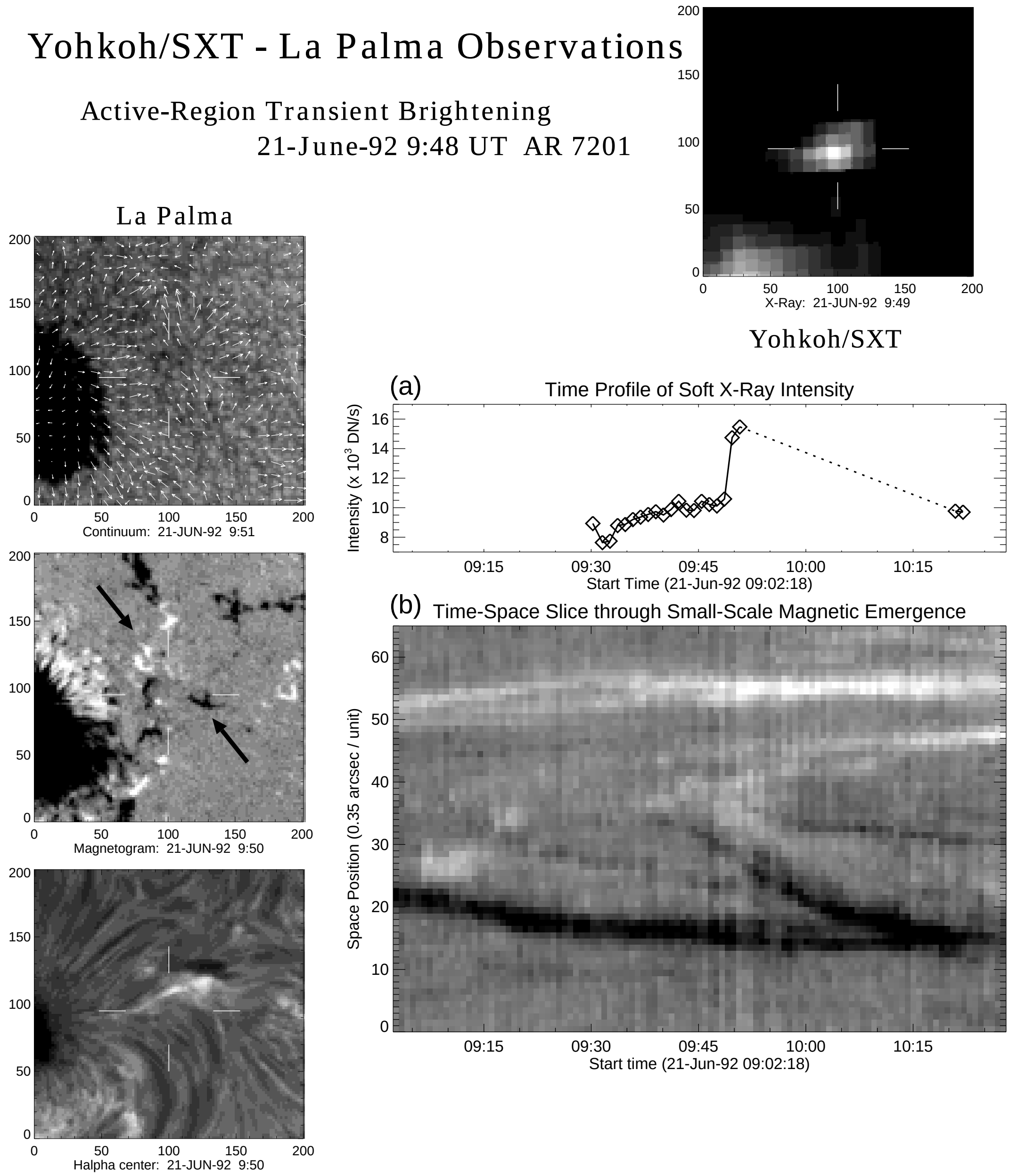

Fig. 5.. An example of the connection of coronal activity with the photospheric magnetic field. Visible light observations were made at La Palma (Swedish Solar Observatory) simultaneously with *Yohkoh* X-ray observations. Time-space slice map (right bottom) shows the evolutional change of the longitudinal magnetic field at the spatial section indicated by arrows in the magnetogram image. See the text for the details.

complicated dynamics (Berger et al 1998). Such motions of flux tubes may play an important role in heating the upper atmosphere and triggering dynamical phenomena in the corona.

5.2. Coupling of Coronal Dynamics with Photospheric Magnetic Fields

Yohkoh observations show that the hot corona is full of dynamical phenomena, such as flares, microflares, jets, and coronal restructuring (§2). Observing photospheric magnetic field changes is the key to understanding flares and dynamical phenomena. It is well known that phenomena such as δ-sunspot configurations and newly emerging flux are associated with these events. Due to limitations imposed by atmospheric seeing, however, we have not clearly identified the photospheric magnetic activities responsible for coronal disruptions. The Solar-B optical telescope will provide continuous sequences of images of the magnetic field at the photosphere with high spatial, temporal, and spectral resolution. Joint observations involving the optical and X-ray telescopes will be used to identify the key changes in the vector magnetic field that are responsible for flares and coronal activities.

Figure 5 illustrates the importance of high spatial and temporal resolution observations with high precision in understanding physical processes of coronal dynamics. The small-scale emergence of a magnetic flux pair took place $\sim$ 10 minutes prior to the onset of a transient brightening (microflare). The bulk of the positive-polarity magnetic flux moved outward with the speed of 2.8 km/s, while the bulk of the negative-polarity flux moved in the opposite direction. The flux magnitude of the emerging flux elements is in order of $10^{17} \sim 10^{18}$ Mx; this emerging activity is small. This study (Shimizu 1995) found that such a small-scale emerging flux was seen prior to the onset of brightenings for 8 events of 16 microflares examined. The majority of the 8 events accompanied the emergence of a small-scale flux element 5 $\sim$ 30 minutes prior to the onset of the brightening. On the other hand, the study showed no evolutional changes in photospheric magnetic field for the rest of the microflares examined (8 events). Most of these microflares were observed in relatively strong magnetic field regions, such as plage regions and satellite sunspots. The reason why no evolutional changes were observed for the microflares occurring in strong magnetic field regions may be the lack of spatial resolution and accuracy in the measurement of polarization; in observations from the ground, seeing introduces false, rapidly fluctuating noise in the measurement of polarization, making it difficult to identify the small-scale emerging flux in strong magnetic field regions.

5.3. Coronal Heating

The mechanisms that heat the solar corona to high temperatures ($> 10^6$ K) remain controversial. Solar-B can be expected to give observational hints to answer why the corona is so hot. It is widely accepted that the energy to heat the corona to high temperatures originates in the convection below the photosphere. This energy propagates into the upper atmosphere through magnetic field lines and then dissipates in the corona. Alfven waves and electric currents have been considered as possible mechanisms to transport the energy into the corona. Alfven waves generated by twisting and bending of the magnetic field propagates along magnetic flux tubes into the corona. Current sheets (tangential discontinuities) arise as a consequence of intermixing of the footpoints of the magnetic field due to convective motions in the photosphere. The nature of the magnetic field at the photosphere will be investigated by the Solar-B optical telescope, with coordinated observations with the X-ray/EUV instruments measuring the dissipation of the energy involved in the coronal magnetic field. The EUV imaging spectrometer will be also used to investigate how the energy propagates into the corona through the transition region.

5.4. Physics of Magnetic Reconnection

Yohkoh has shown that magnetic reconnection plays a major role of energy release in solar flares (§2). Understanding the details of magnetic reconnection process is also an important objective for Solar-B. Since Solar-B will fly during the declining phase of the current solar activity cycle, large flares will not occur frequently during the mission. Yet smaller flares and microflares frequently occur throughout the solar cycle. Magnetic reconnection may play a major role of energy release even in smaller flares and microflares. *Yohkoh* showed that the frequency distribution continues from major flares to microflares, which suggests that microflares share the same physics with major flares (Shimizu 1999).

The velocities expected to be associated with the processes of magnetic reconnection range from a few tens to more than 1000 km/s; the velocity of plasma inflow into a reconnection site is expected to be a few tens km/s, and the high-speed jets ejected outwards from the reconnection site move at the Alfven speed in the corona. Slow and fast mode shocks may be produced by the reconnection jet. By measuring mass motions over a range of temperatures characteristic of the pre-flare and flaring states, the X-ray telescope and the EUV imaging spectrometer will be able to identify the role of magnetic reconnection in flares.

6. Summary: Radio Observations and Solar-B

We believe that the Solar-B mission will allow us for the first time to observe the dynamical nature of elemental magnetic flux tubes responsible for the dynamics and heating observed in the corona and hence to study magnetic coupling between the photosphere and the corona. Radio observations will provide complementary information for understanding of the magnetic coupling. For example, since the Solar-B instruments do not provide physical information on accelerated non-thermal electrons in solar flares, radio observations are helpful for deducing the dynamical behaviors of non-thermal electrons. Thus, the coordinated observations simultaneously made between Solar-B and radio instruments on the ground are important to much increase scientific outputs. Solar-B will be designed to have a capability of co-aligning the Solar-B data with ground-based radio data within less than a few arcsec.

The Solar-B mission is planned by Solar-B Working Group under the Institute of Space and Astronautical Science. The author would like to express his thanks to Prof. T. Kosugi, Working Group chair, and the SOC of this conference for providing me with the opportunity to give a talk about Solar-B.

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