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The *Solar-A* mission and its scientific aims

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Descriptions of the scientific instruments on board the *Solar-A* satellite are given. Relevant parameters and merits of the *Solar-A* experiments, consisting of co-aligned soft and hard X-ray telescopes with high sensitivities and spatial resolutions, together with Bragg and wide-band spectrometers, are presented. Some of the observational targets, both flare related and non-flare-related are discussed together with brief solar physical implications of these observations. The importance is stressed for collaboration with the ground-based optical and radio observatories to maximize the scientific outcome from this small but unique satellite for the investigation of flares during the solar activity maximum 22.

1. Introduction

The *Solar-A* mission, a Japanese project with international collaboration, is constructed and will be launched under the responsibility of the Institute of Space and Astronautical Science (ISAS). Domestic collaborators include groups at the National Astronomical Observatory (NAO) and a range of Universities including the University of Tokyo (UT), Kyoto University (KU) and Rikkyo University (RU). International collaborators include groups in the U.S.A. namely Lockheed Palo Alto Laboratory (LPARL), Stanford University (SU), University of California at Berkeley (UCB) and University of Hawaii (UH) all supported by NASA and groups in the UK namely the Mullard Space Science Laboratory of University College London (MSSL), Rutherford Appleton Laboratory (RAL) and related institutes all supported by SERC.

The scientific aims of *Solar-A* are to investigate high-energy phenomena on the Sun with a coordinated set of instruments. The satellite is in the final stages of construction and the integration is now under way until August 1991, when the satellite will be moved to the launching site in Kagoshima, southern Japan. The launch is scheduled in late August to early September, 1991. The projected mission life is 2 years, but the expected life on the orbit will be 3–4 years.

The total weight of the payload is 400 kg, and the power is 560 W at maximum. Attitude control accuracy of pointing is a few arcmin but the stability will be 1 arcsec min^{-1}, and the offset range is 45 arcmin. The projected orbit is circular with a height of 600 km and an inclination of 31°. The data recorder has a capacity of 80 Mbits, with 4–32 kbps recording speed and 262 kbps playback speed.

The *Solar-A* mission (project manager, Y. Ogawara; project scientist, Y. Uchida) includes a number of scientific instruments. These are (i) HXT, a Fourier synthesis hard X-ray telescope giving hard X-ray images with high time resolution (see table 1, construction is by NAO, UT, ISAS; principal investigator, K. Kai and K. Makishima), (ii) SXT, a high sensitivity soft X-ray telescope with grazing incidence

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Table 1. *Hard X-ray telescope*

telescope type	Fourier-synthesis collimator
number of subcollimators	64 (32 sine–cosine pairs)
angular resolution	*ca.* 5 arcsec
field of view	full solar disc
image synthesis aperture	2 arcmin
total area	*ca.* 88 cm^2
detector type	NaI(TI) on square phototubes
energy range	10–100 keV
energy bands	4 channels
time resolution	0.5 s

Table 2. *Soft X-ray telescope*
(1 Å = 10^{-10} m = 10^{-1} nm)

X-ray optics	
mirror	Nariai–Werner double hyperboloid single piece, gold on Zerodur (Wolter Type I modified)
diameter	230 mm
geometric area	230 mm^2
focal length	1550 mm
wavelength	4–50 Å
resolution	2.5 arcsec (over solar diameter)
aspect telescope	
aperture	50 mm
focal length	1550 mm
transmission band	
wide band	4600–4800 Å
narrow band	4293–4323 Å
filter wheels	
6 position filter wheel	× 2 in series 6 X-ray analysis filters 1 10 % trusted X-ray mask 2 optical filters 1 optical diffuser 2 open position
detector	
VPCCD 1024 × 1024 (18.3 μm pixels)	

Table 3. *Bragg crystal spectrometer*

wavelength range	S^{XV}	5.0160–5.1143 Å
	Ca^{XIX}	3.1631–3.1912 Å
	Fe^{XXV}	1.8298–1.8941 Å
	Fe^{XXVI}	1.7636–1.8044 Å
sensitivity/*SMM*	Approximately × 10 increase	
spectral resolution	3000–6000	
time resolution	1 s	
field of view	whole Sun (non-imaging)	
date rate	2 kbps	
data queue size	384 kbits	

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Table 4. *Wide-band spectrometer*

instrument	detector	energy	PH data mode	PC data mode
SXS	Prop. C.	2–30 keV	128 ch/2 s	2 ch/0.25 s
HXS	NaI(T1)	20–400 keV	32 ch/1 s	2 ch/0.125 s
GRS	BGO(2)	0.2–10 MeV	128 ch/4 s	2 ch/0.25 s
		8–100 MeV	16 ch/4 s	2 ch/0.5 s
RBM	NaI(T1)	4–400 keV	32 ch/1 s	2 ch/0.25 s
	Si SSD	> 20 keV	—	1 ch/0.25 s
gamma-ray burst data				
HXS	—	20–400 keV	—	1 ch/31.25 ms
RBM	—	4–400 keV	—	1 ch/31.25 ms

Nariai–Werner type hyperboloid–hyperboloid mirror configuration and with very much reduced scattering compared with the *Skylab* soft X-ray telescope (see table 2, construction is by LPARL, NAO, UT, ISAS; principal investigators, L. Acton and T. Hirayama), (iii) BCS, a high-sensitivity Bragg crystal spectrometer system covering resonance lines of S^{XV}, $\mathrm{Ca}^{\mathrm{XIX}}$, $\mathrm{Fe}^{\mathrm{XXV}}$, and $\mathrm{Fe}^{\mathrm{XXVI}}$ (see table 3, construction is by MSSL, RAL, NRL, NAO; principal investigators, J. L. Culhane and E. Hiei), and (iv) WBS, a wide band composite spectrometer covering energy ranges from soft X-rays to gamma rays (see table 4, construction is by RU, ISAS, NAO; principal investigator, J. Nishimura).

HXT is a Fourier synthesis type imager with 64 Oda-collimators it uses 24 pairs of 'sine' and 'cosine' elements with appropriately assigned six position angles and six grid spacings, and four fan-beam elements at four position angles, which provide reasonable coverage of the *uv* plane. The telescope will generate one frame each 0.5 s at maximum rate. HXT is an imaging telescope operating in the 15–100 keV range free from contamination from the soft X-ray range. The spatial resolution is 5 arcsec with the full Sun field of view. With the use of the maximum entropy method, the results of simulations show sufficiently good reproduction of the intensity distributions in the model sources. In addition the high time resolution, together with the imaging, will allow us to see what is happening during the impulsive phase.

The high sensitivity and wide dynamic range of the SXT, which is due to the use of a CCD and to the use of different filters, will allow studies of both the structure of the fainter loops characteristic of the preflare states and the features of flares. This will give for the first time information about the magnetic field connectivity and its changes (reconnections) in the region where a flare starts and develops. This capability will play a vital role investigating the flare mechanism should the flare mechanism have something to do with magnetic field as described later. The spatial resolution is about 2.5 arcsec on-axis and the field of view covers the greater part of the solar disc except for very high latitude zones. Regions of interest can be selected by commands using an on-board processor which controls CCD readouts to allow high data rates for the observation of flaring regions.

The BCS, together with SXT will give information with 1 s time resolution about the creation and development of hot plasmas at various temperatures together with velocity information with $\lambda/\Delta\lambda$ of 3000–7000. Although the BCS does not have spatial resolution, its combined use with SXT will give very important clues for the flare origin because it allows us to determine the bulk-velocity of the hot plasma

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especially when the line intensity shows correlation with the time variations of the brightness of the SXT source.

The WBS gives information on the overall spectrum of the emission ranging from 2 keV to 100 MeV. Combining HXT and WBS data will give information about the creation and propagation of high-energy particles. Simultaneous use of the hard X-ray imager, HXT, with the co-aligned soft X-ray telescope, SXT, together with the white-light aspect monitor constitutes one of the greater strengths of *Solar-A*. Co-alignment of images from independent instruments is usually not easy especially in hard X-rays because the background reference structure is not visible in the hard X-ray ranges. However, to obtain co-aligned images makes the physical discussion more valid especially in the case of rapidly developing sources with spectra differing from one point to another. All of the above features constitute the advantages of *Solar-A* in aiming to clarify the mechanism of solar flares as compared with previous missions.

2. Processes leading to the production of sources of soft and hard X-rays and their relation to magnetic fields

The dissipation of large amounts of energy with a high enough rate in the corona or transition layer, where the efficiencies of losses are low, will produce very hot plasmas. Thus it is possible that different processes can produce the sources for soft X-rays. On the other hand, the hard X-rays are emitted in the collisions with ions of high-energy non-thermal electrons in the tail of distribution function. This latter process requires the occurrence of particle acceleration.

Violent disturbances in a magnetic field can produce both the hot plasmas and the high-energy particles. All the studies of solar flares made thus far indicate that the mechanism of flares is magnetic in character. (*a*) Magnetic field is almost a unique candidate, which can store the required amount of energy in the region in the form of magnetic stress energy. (*b*) Magnetic field can release the stored energy in a short dynamical timescale, e.g. in instabilities, converting the stress energy either directly into thermal energy through microscopic or quasi-microscopic dissipative processes, or, more likely, first into kinetic energy and then into thermal energy though shocks and other dynamical mechanisms of dissipation. (*c*) Magnetic shocks approaching each other, in a complicated field of disturbances, can accelerate particles very efficiently. (*d*) The magnetic field can confine the heated plasma and particles and insulate them from the cooler plasmas which may destroy (i.e. cool) them readily.

There are various classes of current-carrying magnetic field configurations which can store and release energy. The model situation proposed thus far in conjunction with the observed flare configurations may be classified into the magnetic neutral sheet configurations and the current-carrying loop configurations. No ultimate solution of the problem of flares (by identifying the real physical process occurring in them) has yet been achieved. Some difficulties, one of the most essential being the enormously long theoretical timescales of dissipation of magnetic energy compared with the observed rise time of flares, are still to be confronted (see, for example, Uchida & Shibata 1977, 1991; Shibata 1991).

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3. Targets of observations by using *Solar-A*

Targets of observations are (i) the regions heated to high temperatures for which soft X-ray data will be obtained with SXT and BCS and (ii) the locations where high energy particles emit bremsstrahlung on interacting with ions for which hard X-ray data will be obtained with HXT and WBS. The hot plasmas and high-energy particles are produced in dynamical processes in magnetic fields as mentioned above.

The most valuable findings would be those of entirely unexpected phenomena, inexplicable by an existing theoretical models. These will occur in an unexpected manner by definition and are difficult to discuss beforehand.

One of the more modest approaches may be to try to find features characteristic of the various models so far and use them to decide which is the correct model. These features, however, are more subtle than is first apparent. We suggest that our first aim should be to confirm a number of important but subtle features, found in the previous cycle by the *Hinotori* and *Solar Maximum Mission* (*SMM*) satellites but which have not necessarily attracted enough attention.

In the following we first concentrate on the flare-related items of interest for *Solar-A* observations in §3*a*, then proceed to the non-flare-related dynamical events in §3*b*. We mention those topics concerning the global features related to the solar activity in §3*c*.

(*a*) *Origin of flares and their related phenomena*

(i) *Further investigation of some clues revealed by satellites in previous activity cycles*

Many new findings have been accumulated by the previous solar X-ray satellites, e.g. *Skylab*, *SMM*, *Hinotori*, *P78–1*. However, two or three very important features that were discovered have not attracted enough attention. The first of these is *evidence for the presence of related activity immediately before the flare onset*. The onset of flares has been considered to be designated by impulsive bursts (see, for example, de Jager 1969). *SMM* and *Hinotori*, however, revealed previously unnoticed signatures of an important stage existing before the impulsive phase which was previously thought to be the indication of flare initiation. These signatures are violent uprising motions (blueshift as large 300–400 km s^{-1}), which tend to a strong turbulence (width of 150 km s^{-1}) as time progresses. These motions are seen in such high ionization potential lines as $\mathrm{Fe}^{\mathrm{XXV}}$, or $\mathrm{Ca}^{\mathrm{XIX}}$ (Tanaka *et al.* 1983; Antonucci 1983). All these occur within a minute or so of the impulsive bursts, when presumably electron bombardment has not yet started and a high temperature source of heat conduction does not exist in the corona.

The second feature is that *X-ray sources are confined at the loop top*. One of the interesting features made clear by *Skylab* and established by *SMM* and *Hinotori*, was that a large fraction of flares take the form of loops, which brighten at the top. The loop top continues to be bright for a considerable time without rapid expansion or rapid cooling. This is difficult to explain unless there is some special mechanism of confinement and insulation. It should also be noted that the loop has a density as high as 10^{10} cm^{-3} by the time it becomes visible in X-rays (Tsuneta *et al.* 1984).

The third feature is the *γ-ray line emissions appear simultaneously with hard X-ray bursts*. Unexpectedly the γ-ray line emissions appear almost simultaneously with the impulsive X-ray bursts (Nakajima *et al.* 1983). This was a surprise because high-energy ions normally take a longer time in their acceleration due to their larger mass. If we assume that the impulsive bursts indicate flare initiation, this observation may

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suggest an *instantaneous acceleration* of ions. However, the assumption should be questioned in view of the following.

The three points above suggest a possibility that a very important dynamical phase, occurring immediately before the impulsive phase, has escaped our attention so far. It is obvious that the clarification of the processes occurring in this period would be vital for the true understanding of the flare mechanism, especially for the problem of mass and energy supply in the flare loop. It is possible that some new pictures of flares are required to explain the observed features (Uchida & Shibata 1988, 1991).

Thus, an important contribution that *Solar-A* can make will be to give a clearer answer to the problem from where, when and how the mass and energy actually come to the flaring region. Information about velocity from the BCS in addition to observations of morphological development from SXT and HXT, will be very valuable, since the morphological changes can also be due to the physically unrelated successive occurrence of brightening in an extreme case. A similar situation may occur in the hard X-ray sources, but it is easier to decide that the 'motion' of the source may well be due to the shift of the region bombarded by high energy particles. The search for fainter thin-target sources possibly appearing at the loop top right before the start of the impulsive bursts will be of considerable interest in relation to the discussion above.

(ii) *Do magnetic reconnections actually occur?*

Whether or not there actually occurs magnetic reconnection right in the flare site will be one of the important problems we should, and will be able to, check by using *Solar-A*. SXT will give us the magnetic connectivity in the preflare state. This information is necessary for checking the reality of magnetic reconnection in flares.

A related question is how a flare confined in a closed loop can affect the regions external to it. Particle release to interplanetary space may be due either to an opening up of the loop or because the particles are carried in a ballooning helix. Also, the production of propagating disturbances like Moreton waves and the type II burst shocks may be examined to establish whether they are produced by some abrupt expansion of a magnetically continued region, or by some mass outflow associated with the opening up of the flux tube at a certain phase. These questions can also be answered by the *Solar-A* observations.

(iii) *Relation of simple loop flares and arcade flares*

The relation of the unitary simple loop flares and the large arcade flares which may be X-ray counterparts of two-ribbon flares in H_α, has not yet been made clear. Is an arcade flare an aggregate of loops in a cylindrical arcade? How then are the neighbouring loops ignited by the initial one, since even a big two-ribbon flare starts from a pair of bright knots called kernels? Are they connected at their top parts as postulated in the Kopp–Pneuman model, or is the condition at their footpoints roughly in the same metastable state when disturbed by the first energy release? These points may be clarified by collaborative observations of *Solar-A* and ground based H_α together with the photospheric magnetic field observations.

(iv) *When and where does particle acceleration occur?*

An important question arises as to when and where the high-energy particles, both electrons and ions, are actually accelerated. It should be noted that locations at

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which the bremsstrahlung occurs are targets of bombardment rather than the source of the particles. We should, for example, watch for the appearance of a thin-target source at the loop top before the impulsive bursts occur, since the storage of the accelerated particles may well be seen as a thin-target source unless the acceleration process is actually 'instantaneous'.

(v) *Detection of X-ray emission from shocks and magnetized plasmoids in the corona*

It is worth observing the X-ray emissions from such flare-related disturbances as the radio type II burst sources or the moving type IV burst sources. Type II burst sources are interpreted as MHD shocks (Uchida 1974). The location of the secondary acceleration of the primary high-energy electrons has been proposed to be in such shocks and the hard X-ray component in the high source in infra-limb flares has been suggested to come from the same source (Kane *et al.* 1979). If this is the case, it might be observed as a thin target source in the corona by HXT. Also the high temperature regions in MHD shocks might be seen with the high sensitivity and wide dynamic range of SXT, and thus contribute to clarifying some related problems.

The moving type IV sources, on the other hand, are synchrotron radio sources from magnetically trapped high-energy electrons. These might also be detected as thin target X-ray sources by HXT while they are moving out through corona. These sources will give us some clues about the nature of the coronal magnetic field if detected since the propagation velocity and the density in the shock will yield the field strength in the case of type II's and the thin-target X-rays and synchrotron radio intensities will give useful information about the field intensity in the moving type IV case.

(*b*) *Non-flare-related dynamical phenomena*

We may also be able to examine soft and hard X-ray sources associated with some non-flare-related ejecta. The former will give information about the Alfvén Mach number and hence the magnetic field while the latter will indicate whether particle acceleration occurs.

(i) *Surges and Brueckner jets*

Non-flare-related surges may be a giant version of magnetic ejections such as spicules. It is highly likely that surges accompany weak soft X-ray emission at the top of its supersonic flow. The weakening of the shock strength in spite of the high speed is due to the magnetic effect since the speed of the jet may be trans-Alfvénic. This will give us some information about the field intensity.

Brueckner's finding in extreme UV (EUV) of small high speed ejecta revealed the existence of such small-scale releases of magnetic energy (Brueckner & Bartoe 1983). A somewhat similar process for disposing of magnetic field may be related to the X-ray bright points while a more vigorous version might be related to flares. Microflares may also be in one of these categories, and some of them may be detectable by *Solar-A*. Furthermore, the relation of microflares to the formation of the fainter normal coronal loops, or the relation of the Brueckner phenomenon to the formation of active region loops are worth examining.

(ii) *Dark-filament disappearances*

The disappearance of a dark-filament sometimes leads to a large two-ribbon flare (Michalitsanos & Kupferman 1974). Such flares, however, lack hard X-ray emissions and as seen in soft X-rays, constitute an arcade type source (Svestka 1976). It has

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been proposed that the dark filament, which was hammocked in an arcade-like magnetic field with some shear, is destabilized and rises indefinitely cutting through magnetic field initially closed above it. A two-ribbon flare occurs at the footpoints of the reclosing arcade (Hirayama 1974; Kopp & Pneuman 1976; Svestka & Shadee 1983). This model is attractive but for some flares of this kind observed by *Skylab*, the dark-filament mass seemed to remain as an X-ray arcade. Thus it did not rise indefinitely and open up the field.

It should be remarked that the two-ribbon flare and X-ray arcade in this model are logically a byproduct of another more energetic part of the entire phenomenon, namely the rise of the filament. The latter must be more energetic if it can cut the field open. We will, however, see the whole scene with *Solar-A*, and it is hoped that the coordinated observations with the ground-based instruments will give various interesting clues to the solution of these questions.

(iii) *Coronal mass ejections*

The white-light coronagraphs aboard *Skylab*, *SMM* and *P78–1*, revealed the presence of large-scale loop-like mass ejections taking place in conjunction with the dark-filament disappearances. This seems to fit the model described in the previous section. The causality argument based on the timing (Harrison 1986) seems to be in favour of this view. If Harrison's causality argument is correct, it may be the case that Hα and soft X-rays flares can be merely the results of some repairing process of the broken-up field due to the effect of a larger event, the CME phenomena. (The timing argument, however, requires more careful consideration, because a 'balloon' can start high in the atmosphere, not necessarily from the base level.) In other words, in this picture a previously passive quiet dark-filament somehow turns into a most powerful driver, and the magnetic reconnection is merely a less energetic 'repairing process' of the broken up field and plays only a passive role. One of the alternative views, however, may be that a flare reconnection triggers the release of a 'magnetic balloon' which has a large lifting potential in the over concentrated magnetic system, the Sun. Thus the action of a knife cutting the rope of a balloon can trigger a larger energy release although it is not the action of the knife that provides the balloon with energy.

CMEs have only been observed in electron-scattered white-light, but they may be seen in other wavelengths including soft X-rays, if the sensitivity of SXT should be sufficient. The origin of CMEs in the lower corona is worth examining since the CME phenomenon is one of the important problems of solar physics even though *Solar-A* may not be able to observe faint CMEs high in the corona.

(c) *Global features related to the solar activity cycle*

In addition to observations of flares and other events, the *Solar-A* instruments will also be able to clarify a number of questions that relate to solar activity in general.

(i) *Detailed behaviour and solar cycle variation of X-ray bright points*

X-ray bright points (Golub *et al.* 1976) which probably reveal basic characteristics of the solar activity cycle are important for *Solar-A*. It is likely that examination of the behaviour of X-ray bright points down to fainter levels may give us further important information about the solar dynamo mechanism which drives the solar activity cycle.

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(ii) *Micro and nano-flares and the mass supply to the corona*

There are indications that smaller and fainter versions of particle accelerations and heating occur outside the flare-related activities (Lin *et al*. 1984). Arguments have been given that the mass and energy yield in these may be sufficient to supply the corona with energy. One of the possible explanations is that they may be due to very small magnetic reconnections similar to those considered in flare models. It can, alternatively, be a small version of Uchida & Shibata's (1988) loop flare model. We may be able to see these with *Solar-A*.

(iii) *Active region loops and loops that connect active regions*

Active region loops which delineate the magnetic field above the active regions will be the targets of SXT. The detailed process of the formation, evolution and disappearance of these loops will be of importance in relation to the understanding of the magnetic behaviour of the Sun, which is the prototype of the similar activities on other stars. These observations are also necessary in understanding the flare physics itself, as mentioned above. Another aspect relates to the formation of bright loops interconnecting separate active regions. Such formation requires reconnection if the flux rope floats up from the sub-photospheric layers, but this is seen to occur in *Skylab* observations without any drastic phenomenon as soon as a new active region emerges. The problem of how the field of a newly emerged active region can connect with a part of another one approximately 10^5 km away and in some cases across the equator (Svestaka & Howard 1981) requires calcification.

(iv) *Behaviour of quiet coronal loops and coronal holes*

Fainter normal coronal loops may or may not be visible to *Solar-A*, but if visible even faintly, we can address to the problem of the formation of the corona. Such loops should be somewhat similar to active region loops but with less clear photospheric roots.

In contrast coronal holes are dark regions, sometimes with a size of a fraction of the solar hemisphere, lacking closed coronal loops (Krieger *et al*. 1973). They are identified with the locations from where the fast stream of the solar wind emanates. Curiously enough, they keep their shape for many rotational periods while all other features rotate differentially.

If the faint coronal loops can be seen, the behaviour of the coronal holes can be studied as the region where coronal loops are not seen, and therefore, the detailed behaviour of coronal holes may be studied if the faint coronal loops can be seen even vaguely by SXT. The coronal holes, rotating rigidly in the situation in which other features on the photosphere are rotating differentially, pose an enigma. It is possible that they reflect the effect of 'active longitudes' which rotate rigidly (Gaizauskas *et al*. 1983) and absorb nearby flux of opposite polarity, leaving open field regions on the opposite side of the globe.

(*d*) *Other topics to be pursued by using the white-light aspect telescope*

There is also an opportunity to obtain information in the white-light band by making use of the white-light aspect telescope on board.

An interesting project, which will be automatically performed throughout the mission, will be the search for white-light flares around the start time of large flares by using the white-light aspect telescope. White-light flares appear near the border

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of opposite polarities inside δ type complex sunspots which are formed by the coalition of two active spot groups. A time-lapse frame subtraction method used with the CCD images will make the detection probability much higher than was previously possible, even for smaller flares.

Another topic which can be studied using the white-light aspect telescope is the five minute oscillation, although this work will require periods in which no active region is likely to produce flares. Stability of the pointing over a longer time-span is required and the whole-sun field of view should be used to obtain information about global modes of oscillation. The contribution of *Solar-A* can be appreciable to the problem, but the X-ray observations of flares and other active phenomena which can not be done from the ground or from the *SOHO* satellite, will naturally have priority given that the primary purpose of the *Solar-A* missions involves the study of high-energy phenomena.

4. Summary

In this paper, we have described the capabilities of the instruments on-board *Solar-A* and have presented possible observations that could be undertaken by these instruments. Developments in the field together with novel ideas have resulted in the availability of a small but powerful satellite for the solar flare mission.

The wide dynamic range and high sensitivity of the SXT, due to a low scattering mirror system and the use of CCD detectors, will enable us to register both the main phase of the flare and the faint preflare loop structures which clarify the magnetic connectivity and its changes in the site of flare development. Assuming that the magnetic field plays an essential role in the flare phenomenon, these observations will provide important information on the nature of solar flares.

The availability of both the SXT and the HXT, which are well co-aligned, will permit studies of the acceleration of high-energy particles in relation to plasma dynamical events in the varying magnetic field. The use of the BCS and WBS will greatly add to the value of this work by providing information about the plasma velocities and the energy spectrum of the accelerated high energy particles.

Finally, we have stressed that collaborative ground-based optical and radio observations are extremely valuable for providing, in cooperation with the instruments on-board *Solar-A*, a complete physical picture of the flare phenomenon. Collaborations can be arranged either on a personal or team basis in accordance with the policy for data sharing which has been formulated by the *Solar-A* team. Those interested are encouraged to contact the authors for further information.

We acknowledge the efforts and dedication of the members of the *Solar-A* team, both domestic and international, which have made the preparation of the satellite and its payload possible. We would like to express our gratitude to Professor M. Oda, Professor J. Nishimura and Professor Y. Tanaka and to the staff members of ISAS for their support on the entire *Solar-A* project. We look forward to a successful mission which will provide the data that are required to advance our understanding of the many long-standing questions in solar physics in general and solar flares in particular. We deeply regret the death of Professor K. Kai on 11 March 1991.

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