Nikolsky, G.M., Kim, I.S., Koutchmy, S., Stepanov, A.I., Stellmacher, G.: 1985,Astron. Z., 62, 1147.
Osherovich, V.A.: 1985, Astrophys. J., 297, 314.
Pneuman, G.W.: 1984, Solar Phys., 94, 299.
Poland, A.I., Mariska, J.T.: 1986, Solar Phys., 104, 303.
Querfeld, C.W., Smartt, R.N., Bommier, V., Landi, E., House, L.L.: 1985, Solar Phys., 96, 277.
Raadu, M.A., Kuperus, M.: 1973, Solar Phys., 28, 77.
Raadu, M., Malherbe, J.M., Schmieder, B., Mein, P.: 1987, Solar Phys., in press.
Rust, D.M.: 1984, Solar Phys., 93, 73.
Schmahl, E., Orrall, F.: 1986, in CPP proceedings, A. Poland Ed., 127.
Schmieder, B., Malherbe, J.M., Mein, P., Tandberg-Hanssen, E.: 1984a, Astron. Astrophys., 136, 81.
Schmieder, B., Ribes, E., Mein, P., Malherbe, J.M.: 1984b, Mem. S.A. It., 55, 319.
Schmieder, B., Raadu, M.A., Malherbe, J.M.: 1985, Astron. Astrophys., 142, 249.
Simon, G., Mein, N., Mein, P., Gesztelyi, L.: 1984, Solar Phys., 93, 325.
Smartt, R.N., Zhang, Z.: 1985, Solar phys., 90, 315.
Solovev, A.A.: 1985, Soln. Dannye, 9, 65.
Soru-Escaut, I., Martres, M.J., Mouradian, Z.: 1985, Astron. Astrophys., 145, 19.
Sparks, L., Van Hoven, G.: 1985, Solar Phys., 97, 283.
Stellmacher, G., Koutchmy, S., Lebecq, C.: 1986, Astron. Astrophys., 162, 307.
Stewart, R.T.: 1984, Solar Phys., 94, 379.
Tachi, T., Steinolfson R.S., Van Hoven G.: 1985, Solar Phys., 95, 119.
Tang, F.: 1986, Solar Phys., 105, 2.
Tsubaki, T., Ohnishi, Y., Suematsu, Y.: 1987, Publ. Astron. Soc. Japan, 39, 179.
Tsubaki, T., Takeuchi, A.: 1986, Solar Phys., 104, 2.
Van Hoven, G., Mok, Y.: 1984, Astrophys. J., 282, 267.
Van Hoven, G., Sparks ,L., Tachi, T.: 1986, Astrophys. J., 300, 249.
Van Hoven, G., Tachi, T., Steinolfson, R.S.: 1984, Astrophys. J., 280, 391.
Wang, J.L.: 1985, Scientia Sinica, 28, 1308.
Wu, S.T., Hu, Y.Q., Nakagawa, Y., Tandberg-Hanssen, E.: 1986, Astrophys. J., in press.
Zarkhova, V.V.: 1984, Astron. Astrophys., 51, 45.
Zhang, Q.Z., Fang, C.: 1987, Astron. Astrophys., 175, 277.
Zirker, J.B.: 1985, Solar Phys., 102, 33.

V. Solar Maximun Analysis

(Z. Svestka)

The basic results of the SMA were presented and summarized in two SMA Symposia Proceedings, edited by Simon (1984 (I) we will refer to this publication using abbreviation SIM) and by De Jager and Svestka (1986, DJS (II)). Other papers discussing SMA results can be found in Proceedings of SMM Workshops (Kundu and Woodgate, 1986 - KAW (III) ; Poland, 1986 - POL (IV) ; Dennis et al., 1987 (DOK (V)) and three other meetings held at Kunming (De Jager and Chen Biao, 1985, JCB (VI)) Irkutsk (Stepanov and Obridko, 1986 (SAO (VII)) and Sacramento Peak (Neidig, 1986, NEI (VIII)). A summary of Soviet contributions to the SMA (until 1985) was prepared by Stepanov (in SAO, p. 5). Kindly note that this Section does not mention most of the SMA results that belong to the topics of the subsequent sections of this report : thus the SMA results of space observations should be found in Section VI, radio observations in Section VII, etc. The present report will be mostly limited to those results of the SMA which use or interpret optical ground-based data.

A. FLARE BUILD -UP

A useful discussion of preflare activity can be found in Priest et al. (in KAW, Chapter 1). Kuin and Martens (Martens, 1986 and ref. there) extended the scenario for preflare energy build-up in a filament circuit to a 3D-model. Energy storage in sheared magnetic field structures has been discussed by Zwingmann et al. (1985) and Hofman et al. (1987). Peres-Enriquez (1985) revived and reexamined the old Elliot's idea of a build-up in the form of energetic particles stored in magnetic loops. Lin Xinping and Chang Guohua (in JCB, p. 436) suggest a transformation of kinetic energy from convection as the source of energy storage. Wu et al. (in SAO, p. 393 and DJS p. 53) have developed a numerical MHD model to study energy buil-up in the form of electric current.

Several Chinese authors in JCB (pp. 219 - 317) modeled force-free fields with constant α in flaring active regions. Seehafer (1985) considers a spatially constant, but time-variable α and believes to find the topology responsible for a series of homologous flares. Also several papers in SIM discuss various aspects of the flare build-up and problems related to homologous flares. Machado (1985) has found that changes in flare homology correlate with the development of magnetic shear.

The earlier idea (Hagyard et al. in SIM, P. 71) that a flare is triggered when the shear exceeds a critical limit has not been confirmed: The shear is a necessary but not sufficient preflare condition (Hagyard and Rabin in DJS p. 7). Strong shear can be present without concurring flaring (Athay et al., 1986a). The most energetic flares do not always occur at the places of the highest shear, though the flare onset is commonly observed there (Machado et al. in DJS, p. 33). Lin Yuanzhang and Gaizauskas (1987) find that Hα kernels in a flare agree with peak values of the longitudinal electric current. The best observed mechanism for the formation of shear is sunspot motion (Gezstelyi and Kalman in DJS, p. 21 ; Neidig et al., DJS, p. 25 ; Kovocz and Dezso, DJS, p. 29 ; Gezstelvi, in NEI, p. 163). Sometimes shear can develop from head-on collision of spots (Gaizauskas and Harvey in DJS, p. 17), and also large-scale plasma flows can produce shear (Athay et al., 1986b). Other sources of shear can be flux emergence, submergence, and even flux cancellation (Martin in POL, p.73).

Martin et al. (in SIM, p. 61) have identified and analysed the evolution of flare sites where new magnetic flux emerged. Flux emergence prior to the occurrence of three major flares was reported by Guo Quanshi et al. (in JCB, p. 642). Kundu (in DJS, p. 63) and Lang and Wilson (in DJS, p. 97) present high-resolution microwave observations of tentatively emerging new flux. Rising and twisting of magnetic loops around the site of the subsequent flare was reported by Kundu et al. (1985). Forbes (in SIM, p. 53) and Forbes and Priest (1984) have made numerical simulations of reconnection in an emerging magnetic field Priest (in DJS, p. 73) also gives a review of the role of magnetic reconnection in flares : it can give rise to small flares, trigger larger events, and release magnetic energy in major flares, Hong et al. (1987) consider the development of microinstabilities during emergence of new flux and propose four different types of reconnection that lead to different kinds of activity. Magnetic reconnection in a high-temperature turbulent sheat was considered by Somov and Titov (1985), and Tachi et al. (1985) expanded their earlier treatment of reconnection by including effects of compressibility and viscosity (see also section IV A).

Van Hoven and Hurford (in SIM, p. 95 and DJS, p. 83) have summarized the most recent progress in the study of flare precursors and provided new theoretical results on filament formation and eruption. They find ample evidence that energetic processes are already at work minutes before the onset of the flare impulsive phase. Many other papers also discussed the preflare filament activation and eruption (see section IV D) and some describe or model the untwisting and relaxation of the rising filament (Gaizauskas in JCB, p. 710 ; Kurokawa et al., 1987 ; see section IV D). As the flare onset is concerned, the reader is referred to Section VI.

B. ENERGY RELEASE

Henoux (in SIM, p. 227) and later on several other authors have reviewed the recent advances in the energy release in flares : Somov (in DJS, p. 177) emphasized the increasing evidence for reconnection in flares ; Kundu (in DJS, p. 207) stressed the evidence for simultaneous production of MeV electrons and protons; Machado and Moore (in CDS, P. 217) have discussed the association of the energy release with the magnetic environment ; Sturrock et al. (1984) examined observational evidence concerning energy release in flares and proposed different processes that may be operative in flares on different time scales, Simnett (1986) considers a model in which the bulk of energy released during the impulsive phase resides in non-thermal protons. The impulsive phase energy transport was discussed extensively by Canfield et al. (in KAW, chapter 3). The SMA also produced many papers on particle acceleration, but we leave all the discussion of this topic to Sections VI and VII.

https://doi.org/10.1017/S0251107X00006957 Published online by Cambridge University Press

Great attention has been paid to the problem of chromospheric evaporation manifested by asymmetrical profiles in flare spectra. Blue asymmetry in coronal lines found by Antonucci et al. (1985) and red asymmetry commonly seen in chromospheric lines (e.g., Ichimito and Kurokawa, 1984) was for the first time observed simultaneously in the same flare (Zarro et al., in DJS,p.155). While Canfield and Gunkler (1985) have found that evaporation is predominantly caused through conduction, Fisher et al. (1985) demonstrate that explosive evaporation is produced by electron beams which are turned on instantaneously. When the conductive flux out of the explosively evaporated plasma becomes comparable to the deposited electron heating flux, evaporation ceases to be explosive and is driven there after by conduction (Fisher, 1987). Theoretical red-shifted Hα profiles during explosive evaporation were computed by Canfield and Gayley (in DOK, p. 249). The impulsive phase gas dynamic has been thoroughly reviewed by Canfield (in NEI, p. 10 and DJS, p.167). A numerical simulation for dynamics of non-thermal electrons injected into coronal loop has been made by Takakura (1986) who concludes that the column density in the loop decides whether the resulting energy release is impulsive or gradual.

Close association of Hα kernels with individual peaks of energy release in hard X-rays was demonstrated by Loughhead et al. (1985), Kurokawa (in NEI, p. 51), and Wulser an Kampfer (in DOK, p. 301). The Hα-line asymmetry in flaring kernels was studied by Gaizauskas (in NEI, p. 37), First images of flare kernels in λ4686 line of He II were obtained by Zirin and Hirayama (1985). A kernel model in which chromosphere largely evaporates and Hα emission is radiated by a thin layer at the kernel basis has been proposed by de Jager (1985). Very small geometrical thickness of the emitting flare layer has been confirmed by Hirayama and Nakita (in NEI, p. 298). Gan and Fang (1987) analyzed chromospheric spectra of a major flare and time variations in the flaring chromosphere. Sylwester et al (1986) discussed the intensity ratio of the components of the Mg XII 8.42Å doublet in flare spectra obtained in Intercosmos 7.

Great progress has been made in observation and interpretation of the γ-ray flares, but this whole topic, though being one of the most fruitful fields of the SMA, clearly belongs to Section VI. For a recent review, the reader is referred to Hudson (1985) and Vlahos et al. (in KAW, Chapter 2). Another impulsive phase phenomenon intensely studied during SMA was the white-light (WL) emission from flares. Several papers on this topic were published in NEI (pp. 128 - 282) : deep atmospheric heating during flares, and WL flares in particular, was discussed by Emslie (p. 182), and Rust (p. 282) ; Gesztelyi et al. (p. 163) proposed a WL flare interpretation by means of current dissipation deep in the atmosphere. Lites et al. (p. 101) established chromospheric origin of a WL flare from measurements of He I and He II lines in its spectra. Neidig (pp. 142 and 152) demonstrated the possibility of a purely chromospheric origin for the WL emission and Avrett et al. (p. 216) computed chromospheric flare models with particular emphasis on the WL emission. Impulsive and gradual components in WL emission correlating with similar components in hard X-rays and microwaves have been demonstrated by Kane et al. (1985). In several papers, Aboudarham and Henoux (1986) have considered the energy deposit by electron bombardment during WL flares, the subsequent radiative heating of the photosphere and the energetic equilibrium of a flaring chromosphere. Hiei (in DJS, p. 227) presents continuous spectra of several WL flares and suggests that there exist three different types of the WL emission. A list of 45 WL flares and their characateristics was published by Chen and Wang (in JCB, p. 735).

C. GRADUAL PHASE AND FLARES IN GENERAL

Several papers on Hα observations of major two-ribbon flares and spectra of post-flare loops were published in JCB. Motions in post-flare loops were studied by Gu et al. (in JCB, p. 669), Din et al. (p. 673), Li and Zhang (p. 685) and by Xu (in SAO p. 147). Tang (1985) demonstrated various flare topologies from Hα observations including multiple- ribbon flares. A study of growing loops at various temperatures (Hα to X-rays) has revealed that the (post-) flare loops must be shrinking and their density must be increasing during their cooling (Svestka et al., 1987). Indeed, Hanaoka et al. (1986) found electron densities of 8 x 10^9 and 10^{11} cm^{-3} in the hot and cold loops, respectively. According to Sakurai (1985), potential-field modeling gives a reasonable fitting in the case of two-ribbon flares ; but other kinds of flares, and

https://doi.org/10.1017/S0251107X00006957 Published online by Cambridge University Press

impulsive phase of flares, do not fit. Forbes and Malherbe (in NEI, p. 443) generalized the Kopp and Pneuman model for coronal condensations in the two-ribbon flares. Kopp and Poletto (in SAO, p. 103 and POL, p. 235) present a numerical technique which enables one to reconstruct the reconnected magnetic field after two-ribbon flares and computed the coronal electric field in the Kopp and Pneuman model (in NEI, p. 453). Aly (1985) has studied the evolution of a force-free field toward an open field, driven by shearing motions, and applies it to the theory of two-ribbon flares and giant post-flare arches.

The energetics of flares was discussed by Somov (in SAO, p. 181) and by Wu et al. (in KAW, Chapter 5). Various factors causing varieties in flares were discussed by Svestka (in NEI, p. 332), flare observations in helium lines were summarized by Zirin (in NEI, p. 78), and an atlas of Hα images flares of different types was published by Ambastha and Bhatnagar (1985). Several extensive papers have presented complex analyses of major flares, based on data obtained at various wavelenghts Tanaka and Zirin, 1985 ; De Jager and Svestka, 1985 ; McCabe et al., 1986 ; Wang Jialong et al., 1986). At the other end of the flare-size spectrum, Schadee and Gaizauskas (in SIM, p. 117) identified two extremely weak X-ray bursts with Hα miniflares, while the long-lived weak X-ray enhancements have been tentatively ascribed to the collective result of a manifold of "nanoflares" (Schadee, in DJS, p. 41).

A real progress has been made in our understanding of mass ejections from the Sun, but once again, the reader is referred of the Section VI for reports on this topic. The scientific highlights of STIP intervals during the SMY/SMA period have been summarized by Dryer and Shea (in DJS, p. 343). Advances made in CME research during the SMA period were reviewed by Hildner (in DJS, p. 297). The second volume of JCB contains many papers concerning CMEs. The unique method of CME observations with zodiacal light photometers of Helios spacraft has been described by Jackson (1985).

References

I : Solar Maximun Analysis, Adv. Space Research 4, N°. 7 (SIM), Simon, P.A. (ed), 1984.

II : The Physics of Solar Flares, Adv. Space Research 6, No. 6 (DJS), de Jager and Svestka, Z. (eds.), 1986.

III : Energetic Phenomena on the Sun, NASA CP 2439 (KAW), Kundu, M., and Woodgate, B. (eds,), 1986.

IV : Coronal and Prominence Plasmas, NASA CP 2442 (POL), Poland, A.I. (ed.), 1986.

V : Rapid Fluctuations in Solar Flares, NASA CP 2449 (DOK), Dennis, B.R., Orwig, L.E., and Kiplinger, A.L (eds.), 1987.

VI : Proc. Kunming Workshop on Solar Physics and Interplanetary Travelling Phenomena, Beijing, (JCB), De Jager, C. and Chen Biao (eds), 1985.

VII :Solar Maximun Analysis, Proceedings SMA Worksop Irkutsk, VNU Science Press (SAO), Stepanov, V.E. and Obridko, V.N. (eds.), 1986.

VIII : Proc. NSO/SMM Symposium, AURA (NEI), Neidig, D.L. (ed.), 1986.

Aboudarham, J. and Henoux, J.C: 1986, Astron, Astrophys, 156, 73 and 168, 301, 1987, Astron, Astrophys. 174, 270.

Aly, J.J: 1985, Astron, Astrophys. 143, 19.

Ambastha, A and Bhatnagar, A.: 1985, Photographic Atlas of the Solar Chromosphere, 1976 – 1984, Udaipur Solar Observatory.

Antonucci, E., Dennis, B.R., Gabriel, A.H., and Simnett, G.M.: 1985, Solar Phys, 96, 129.

Athay, R.G., Jones, H.P., and Zirin, H.: 1986a, Astrophys. J. 303, 877.

Athay, R.G., Klimchuk, J.A., Jones, A.P., and Zirin, H.: 1986b, Astrophys. J. 303, 884.

Canfield, R.C, and Gunkler, T.A.: 1985, Astrophys. J. 228, 353.

de Jager, C.: 1985, Solar Phys. 98, 267.

de Jager and Svestka, Z.: 1985, Solar Phys. 100, 435.

Fisher, G.H.: 1987, Astrophys. J. 317, 502.

Fisher, G.H., Canfield, R.C., and McClymont, A.N.: 1985, Astrophys. J. 289, 425 and 434.

Forbes, T.G. and Priest, E.R.: 1984, Solar Phys. 94, 315.

Gan, W.Q. and Fang, C.: 1987, Solar Phys. 107, 311.
Hanaoka, Y., Kurokawa, H., ans Saito, S.: 1986, Solar Phys. 108, 151.
Hofmann, A., Rendtel, J., Aurass, H., and Kalman, B.: 1987, Solar Phys. 108, 151.
Hong, W.L., Pallavicini, R., and Cheng, C.C.: 1987, Solar Phys. 107, 271.
Hudson, H.S.: 1985, Solar Phys. 93, 105.
Ichimoto, K. and Kurokawa, H.: 1984, Solar Phys. 93, 105.
Jackson, B.V: 1985, Solar Phys. 100, 563.
Kane, S.R., Love, J.J., Neidig, D.P., and Cliver. E.V.: 1985, Astrophys. J. 290, L45.
Kundu, M.R. and 5 co-authors: 1985, Astrophys. J. Suppl. 57, 621.
Kurokawa, H., Hanaoka, Y., Shibata, K., and Uchida, Y.: 1987, Solar Phys. 108, 251.
Lin, Y. and Gaizauskas, V.: 1987, Solar Phys. 109, 81.
Loughhead, R., Blows, G., and Wang, J.: 1985, Publ. Astron. Soc. Japan 37, 619.
Machado, M.E.: 1985, Solar Phys. 99, 159.
Martens, P.C.H.: 1986, Solar Phys. 107, 95.
McCabe, M.K. and 4 co-authors: 1986, Solar Phys. 103, 399.
Perez-Enriquez, R.: 1985, Solar Phys. 97, 131.
Sakurai, T.: 1985, Solar Phys. 95, 311.
Seehafer, N.: 1985, Solar Phys. 96, 307.
Simnett, G.M.: 1986, Solar Phys. 106, 165.
Somov, B.V. and Titov, V.S.: 1985, Solar Phys. 95, 141, and 102, 79.
Sturrock, P.A., Kaufmann, P., Moore, R.L., and Smith, D.F.: 1984, Solar Phys. 94, 341.
Svestka, Z. and 5 co-authors : 1987, Solar Phys. 108, 237.
Sylwester, B. and 8 co-authors: 1986, Solar Phys. 103, 67.
Tachi, T., Steinolfson, R.S., and Van Hoven, G.: 1985, Solar Phys. 95, 119.
Takakura, T.: 1986, Solar Phys. 104, 363.
Tanaka, K. and Zirin, H.: 1985, Astrophys. J. 299, 1036.
Tang, F.: 1985, Solar Phys. 102, 131.
Wang, J. and 4 co-authors: 1986, Acta Astrophys. Sinica 6, 26.
Zirin, H. Hirayama, T.: 1985, Astrophys. J. 299, 536.
Zwingmann, W., Schindler, K., and Birn, J.: 1985, Solar Phys. 99, 133.

VI. Highlights of the Solar Activity Studies Made with Instruments Aboard Spacecraft

(S. R.Kane)

A. INTRODUCTION

Although the solar activity began to decrease rapidly after 1983, the analysis and interpretation of the observations made with instruments aboard the SMM, Hinotori, P78-1, ISEE-3 (ICE), PVO, Venera, and PROGNOZ spacecraft continued to produce important scientific results. The observational results inspired new theoretical studies or extensions of the earlier studies. Several symposia and workshops were organized for presentation and discussion of coordinated studies or studies in progress.

Symposia on the results from the Solar Maximum Data Analysis (SMA) were held in Gratz, Austria (Simon 1984 (I)) and Toulouse, France (de Jager and Svestka 1986 (II)). The SMM workshops helped to bring together many solar physicists from many countries to study specific aspects of solar activity. The participants included both ground-based observers and those associated with instruments aboard spacecraft. The proceedings of the following three SMM workshops have now been published : Energetic Phenomena on the Sun (Kundu and Woodgate 1986 (III)), Coronal and Prominence Plasmas (Poland 1986 (IV)) and Rapid Fluctuations in Solar Flares (Dennis et al. 1986 (V)). The proceedings of the National Solar Observatory/SMM symposium on the Lower Atmosphere of Solar Flares have also been published (Neidig 1986 (VI)). Results related to the Sun and the Heliosphere in Three Dimensions are available in the proceedings of the 19th ESLAB Symposium (Marsden 1985 (VII)). Studies related to solar flares and particle acceleration have been reviewed by de Jager (1986).

The largest number of spacecraft observational studies were related to solar flares. This is to be expected since the instruments aboard spacecraft such as SMM and