Global Oscillation Network group. Further data can be obtained with instruments observing the solar disk with various spatial resolutions. This is the case of the filter built by Cacciani et al. (1981). For high degree oscillations, we must mention the Mount Wilson system (Rhodes et al. 1983) using a CID camera. A second version of the Fourier tachometer developed by SPO and HAO is now operating; with the 100 x 100 Reticon array, the velocity noise is less than 5 ms^{-1} for each pixel (a few cm s^{-1} for the full-disk average velocity). The spatial distribution of velocity fields can be provided by the two-dimensional solar spectrometer of Birmingham, with a view to oscillations as well as large-scale motions. The resonance-cell instrument developed in Bordeaux (Robillot et al. 1984) is also suited for differential rotation measurements. Solar diameter fluctuations complement velocities for helioseismology studies. The Pic-du-Midi heliometer is designed for high accuracy measurements. The solar diameter monitor (Brown et al. 1982) is mainly devoted to long-term effects (1 arc sec/century), as is the Astrolabe of CERGA Observatory, France (Laclare 1983). Observations of global brightness variations of the photosphere are achieved at the Crimean Observatory where a 16 x 16 detector matrix is used for center-limb measurements. For stellar comparisons, the solar cycle can be investigated by spectrometers observing the Sun as a whole. In this context, the Selective Solar Irradiance Spectrometer (Oranje 1982) realizes spectrograms of Ca II lines from the entire solar disk, as well as from smaller areas.

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II. Solar Maximum Year

(D.M. Rust)

A. ACTIVITIES

Work begun during the Solar Maximum Year (SMY) (1980-1981) was the focus of

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several sympsoia and workshops starting in March 1981 with the International SMY Workshop in Simferopol, Crimea (Obridko 1981). Results of the Annecy SMY Workshop (Annecy, France, October 1981) were presented in May 1982 with later work presented at the first SMY symposium (Švestka et al. 1982) in Ottawa, Canada. A special symposium for the Study of Travelling Interplanetary Phenomena was held in Maynooth, Ireland, in August 1982 (Shea et al. 1984). Another SMY workshop was held in November 1983 in Kunming, China (Chen 1984), and the second SMY symposium was held in June 1984 in Graz, Austria (Simon 1985). The scientific progress of the SMY is detailed in the above-mentioned publications and in the 1982 U.S.-Japan Seminar "Recent Advances in the Understanding of Solar Flares" (Kane et al. 1983). Highlights of the work of the SMY's Flare Build-Up Study, Study of Energy Release in Flares, and Study of Travelling Interplanetary Phenomena are presented below.

B. RESEARCH

1. Flare Build-Up

a. The Magnetic Field Situation. An important development has been the increasing utilization of measurements of the transverse component of the photospheric magnetic fields beneath flares. Although the interpretation of the polarization measurements from which the magnetic fields are inferred is still beset with uncertainties (Stenflo 1984), maps of the transverse field outside sunspots may give useful clues to the magnetic field configuration in flares. When measured transverse fields differ significantly from potential fields, one says that the degree of shear is large. Hagyard et al. (1984) found that several flares occurred at persistent sites of high photospheric field shear. Krall et al. (1982) used the proper motions of sunspots in the same series of observations to infer how much energy is in sheared magnetic fields. Their results on the best-studied (Strong et al. 1985) active region of the SMY (AR 2372, April 6-14, 1980) agree with earlier studies in implying that the transverse motions of sunspots cause storage of $\sim 10^{32}$ ergs day^{-1} in the magnetic fields. The flares in AR 2372 were homologous (Martres 1985) in that the morphology of each flare differed only slightly from the preceding and following flares. Most of the flares in the region originated at a growing bipolar feature that moved laterally, thus distorting the photospheric neutral line in the sunspot region. This familiar scenario was studied analytically by Low (1982), who showed that it leads to the creation of magnetic free energy, severe shearing of low-lying loops, and the emergence and disappearance of flux. Low showed how to find the magnetic free energy from vector magnetograph observations and potential field calculations. The theoretical work by Low and others and the renewed interest in vector magnetographs have not produced any breakthroughs yet. But the models are better, e.g., three-dimensional, non-constant-α force free fields versus the old two-dimensional constant-α approximation, and terms are being more clearly defined. The next IAU report may include news of a convincing, quantitative demonstration of magnetic free energy accumulation and release.

b. Preflare Emission. The sites of magnetic free energy accumulation might be detectable by increased emission or turbulence, and many new reports of preflare brightening and filament activation were received (Simon 1985, Simon et al. 1984). Lang & Willson (1985) used the VLA at 20 cm to study preburst heating. Their results are consistent with other studies in showing preflare temperatures T_e 2 x 10^7 K and preflare densities n_e 10^{10} cm^{-3}. Models of chromospheric heating by electron beams are hard to reconcile with such a high preflare density.

2. Flare Energy Release

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a. Impulsive Phase. The improved time resolution of instruments placed in regular use for the first time during the SMY has yielded important new data on the fundamental processes of the impulsive phase. Kaufmann et al. (1984) achieved a time resolution of ~1 ms at 22 and 44 GHz and reported on a spike burst that had quasiperiodic structure at a frequency of 16-20 s^{-1}. The frequency is too high to have been detected with the SMM Hard X-Ray Burst Spectrometer, which also recorded the burst. However, the SMM record did show fine structure at the 0.3 s level, suggestive of unresolved higher frequencies. The authors believe that the ultra-fast time structures resulted from discrete emission events from individual flare kernels. If this interpretation is correct, the kernels emit at extremely high radio brightness temperatures. A maser mechanism was suggested by Melrose & Dulk (1984) to explain high radio burst brightness temperatures and the apparent cross-field spread of flare excitation. Their theory is further discussed below. Other microwave observations of ultra-fast structures were made by Takakura et al. (1983), who found that the millimeter structures correlated very well with hard x-ray structures recorded at the Hinotori satellite, and by Zhao (1982), Fu et al. (1984), and Li et al. (1984). Ultra-fast fine structures may be absent for several hundred milliseconds and then reappear in clusters of spike bursts. It is not clear, then, whether the bursts reflect a fundamental phenomenon, such as emission from elementary flare kernels, or a secondary phenomenon, such as Type III bursts. The high brightness temperatures (10^{10}-10^{15} K) inferred for the microwave bursts mean that the radio emission must result from a non-thermal population of electrons. Melrose & Dulk (1982) suggested that even the mild anisotropies that result from precipitation from flare loops of electrons with small pitch angles can lead to maser radiation. Maser radiation at the first harmonic of the local gyrofrequency would not escape the immediate vicinity of the flaring loop. Melrose and Dulk suggest that it is by absorption of this intense microwave radiation that loops adjacent to a primary energy release site are heated. The bright microwave bursts would, in their view, be second harmonic gyroradiation. This and other interpretations of the ultra-fast microwave emission were reviewed by Holman (1982). The most important result about the impulsive phase, described in the previous IAU review period, was the detection of hard x-ray emission at the feet of flare loops and of microwave emission at the apex of the loops (Rust 1982). Now, with many more observations in hand, the picture we had of an electron beam accelerated at the top and precipitated at the feet has become cloudy. Kundu's (1984) latest review of VLA and hard x-ray flare images includes nearly every permutation of microwave and x-ray sources that five-color figures allow. It shows that the idealizations used earlier to interpret the first results cannot be relied upon. Current interpretation of the SMM results is reviewed by Machado in this report.

b. Thermal Conduction and Electron Beams. The physical processes that transport energy from the flaring corona to the chromosphere were the subjects of many SMY studies. Henoux et al. (1983) found linear polarization in chromospheric lines (Hα and SI 1437 Å) during the flare gradual phase and found that it was almost certainly not caused by direct excitation by 10-100 keV beamed electrons. The polarization is best understood as a result of anisotropic excitation by thermal electrons carrying heat from the corona through the transition zone and into the chromosphere. The conductive heat flux can be deduced from the observed degree of linear polarization. Henoux et al. concluded that the conductive flux was of the same order of magnitude as the chromospheric radiation that finally carries the added heat away. Rust et al. (1985) found fast-moving fronts in sequences of soft x-ray images from the Utrecht-Birmingham x-ray imager on SMM, and interpreted them as thermal conduction fronts. The observed velocities were 900-1700 km s^{-1}, and in one case for which simultaneous Hα data were available, they concluded the chromospheric radiation losses could not be accounted for by the energy in an electron beam. The Hα emission was sustained by thermal conduction after the first 30 s of the

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flare. Kämpfer & Magun (1983) also investigated simultaneous Hα and coronal emissions. A solid-state, two-dimensional array detector recorded Hα brightness variations with 1.4 s time resolution while a radiospectrograph recorded 8.4-19.6 GHz microwaves with 100 ms resolution. The result was that, although one Hα kernel brightened simultaneously with the radio source, other kernels experienced delays of up to 30 s. Evidently, beams were effective in transporting energy, probably by thick-target collisions, in one kernel, while most energy was carried to the chromosphere by slower-moving conductive processes. Another approach to differentiating between electron beam and thermal processes in flares was taken by Brown et al. (1983). They compared x-ray flux ratios predicted for five flares seen by two widely-separated spacecraft, ISEE-3 and Pioneer-Venus Orbiter, in order to determine the height structure of the sources of hard x rays. In each of the five cases, one spacecraft saw radiation from the entire flare, while the other saw radiation from only the upper portion. Brown et al. found that the energy dependence of the occultation ratio was not consistent with that predicted by the thick-target model. In three events, non-collisional losses must have been important; and, in two events, bremsstrahlung emission other than that from a beam must have been important. The effect of electron beams and of thermal conduction on the chromosphere was considered in a number of papers from the San Diego group (Ricchiazzi & Canfield 1983, Canfield et al. 1982, Canfield et al. 1984a). Using numerical models of static flare chromospheres and theoretical Hα line profiles to interpret observations obtained at Sacramento Peak, they were able to distinguish between the effects of intense electron beam heating and thermal conduction. In two small events Canfield et al. (1984b) found that the thick-target input power implied by the Hα observations was indistinguishable from that inferred from the corresponding hard x-ray bursts. Other studies of hard x-ray bursts and chromospheric phenomena, including chromospheric evaporation, were published by Antonucci & Dennis (1983), Antonucci (1982), Somov et al. (1982), and many others. At the present time, the relative importance of thermal and non-thermal phenomena in the impulsive phase of flares is still not clear. It may be that beams play an energetically minor role in chromospheric heating (Rust 1985), albeit an interesting and eye-catching role. A better understanding of the preflare corona seems to be required, because the models are strongly dependent on assumptions about preflare density and the magnetic field configuration.

c. White-light Flares. An area of outstanding progress was in observations of white-light flares. Before the SMY, only one or two flares had been observed spectroscopically, but an intensive program at the Sacramento Peak Observatory and at the Big Bear Observatory yielded many broadband filter observations as well as some superb high-resolution spectra (Neidig & Wiborg 1984). The Paschen jump near 8500Å was seen for the first time and it indicates that the Paschen continuum may be a substantial contributor to the visible flare continuum. A complete understanding of white-light flare emission is not available yet, since the blue excess (Neidig 1983) is not understood. Also, some white-light flare features are closely associated with hard x-ray spikes, while others are found in the main phase ribbons (Boyer et al. 1985). White-light flares had been thought to be caused by protons, but the SMM gamma-ray observations of the July 1, 1980, flare (Ryan et al. 1983) showed conclusively that the gamma-ray emission due to protons was not correlated with the optical continuum emission (Zirin & Neidig 1981). Models to explain white-light flare emissions were published by Livshits et al. (1981) and Dame & Cram (1983).

d. Main Phase and Coronal Transients. Understanding of the main phase of flares has reached a very high level, with the model of Kopp & Pneuman (1976) undergoing continual refinements and observational tests. It now appears that coronal magnetic field lines do open outward with the eruption of an Hα filament and a coronal transient (Low et al. 1982), and it is the reconnection and contraction of the associated magnetic field back into a system of loops that drives the main

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phase of flares. The process has most recently been modeled by Forbes & Priest (1982), Kopp & Poletto (1984), and Pneuman (1982). For a discussion of the coronal transient and its passage into interplanetary space, the reader is referred to Howard (1985) and Shea et al. (1984).

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III. Solar Maximum Mission Results
(M.E. Machado)

The ongoing research carried out by the solar community has been reported in the proceedings of several recent symposia, seminars and workshops, as well as in scientific journals (Kane et al. 1983, Švestka et al. 1982a, Shea et al. 1984, Kundu & Woodgate 1984, Simon 1984). We summarize here some of the novel results with reference to flare research as far as SMM data analysis is concerned. Understanding of impulsive phase phenomena was one of the primary goals of the SMM. The early reports from the analysis of the first ever obtained high-resolution images in the <30 keV energy range stressed the fact that some flares showed hard x-ray (HXR) bright sources at the feet of coronal loops (Hoyng et al. 1981a,b, Machado et al. 1982, Duijveman et al. 1982), the so-called HXR "footpoints," favoring the thick-target beam mechanism for the production of HXRs, and indicating acceleration efficiencies $>20\%$ during the early impulsive phase. This phenomenon was shown to be accompanied by soft x-ray (SXR) line broadening, indicative of strong turbulence, and the immediate appearance of blue shifted spectral lines, which shows that plasma heated to $>10^7$ K rises from the footpoints of loops with velocities to 300 km s^{-1} (Antonucci et al. 1982, Antonucci et al. 1984a). This result provides a strong indication of the chromospheric evaporation phenomenon, which has been confirmed in analyses of combined SXR and Hα observations (Acton et al. 1982, Gunkler et al. 1984).

High temporal resolution HXR observations ($E < 300$ keV) have revealed the existence of millisecond time variations (FWHM $\approx$ 45 ms)during the impulsive bursts. These place new constraints on the physical nature of the HXR source. Particularly, in a non-thermal scenario the observed time scales are upper limits to the temporal scale of the acceleration process itself, while within the context of thermal HXR models, it follows that they lose their energetic advantage over the non-thermal hypotheses (Kiplinger et al. 1983). Along the same lines, the combined analysis of HXR and UV impulsive bursts, particularly those observed in the OV line at 1371 Å, formed at $T \simeq 2.5 \times 10^5$ K, has shown a simultaneity in the burst structures to within <1 s, limited by the UV temporal resolution (Woodgate et al. 1983). There is also very good correlation between the appearance of HXR and UV spikes, and the density of the UV burst region as determined from the Si IV/O IV line ratio (Cheng et al. 1981) yields a range $5 \times 10^{12} < n < 10^{13}$ cm^{-3}, confirming that UV burst emission originates below the height of the preflare transition region. An important aspect stemming from this