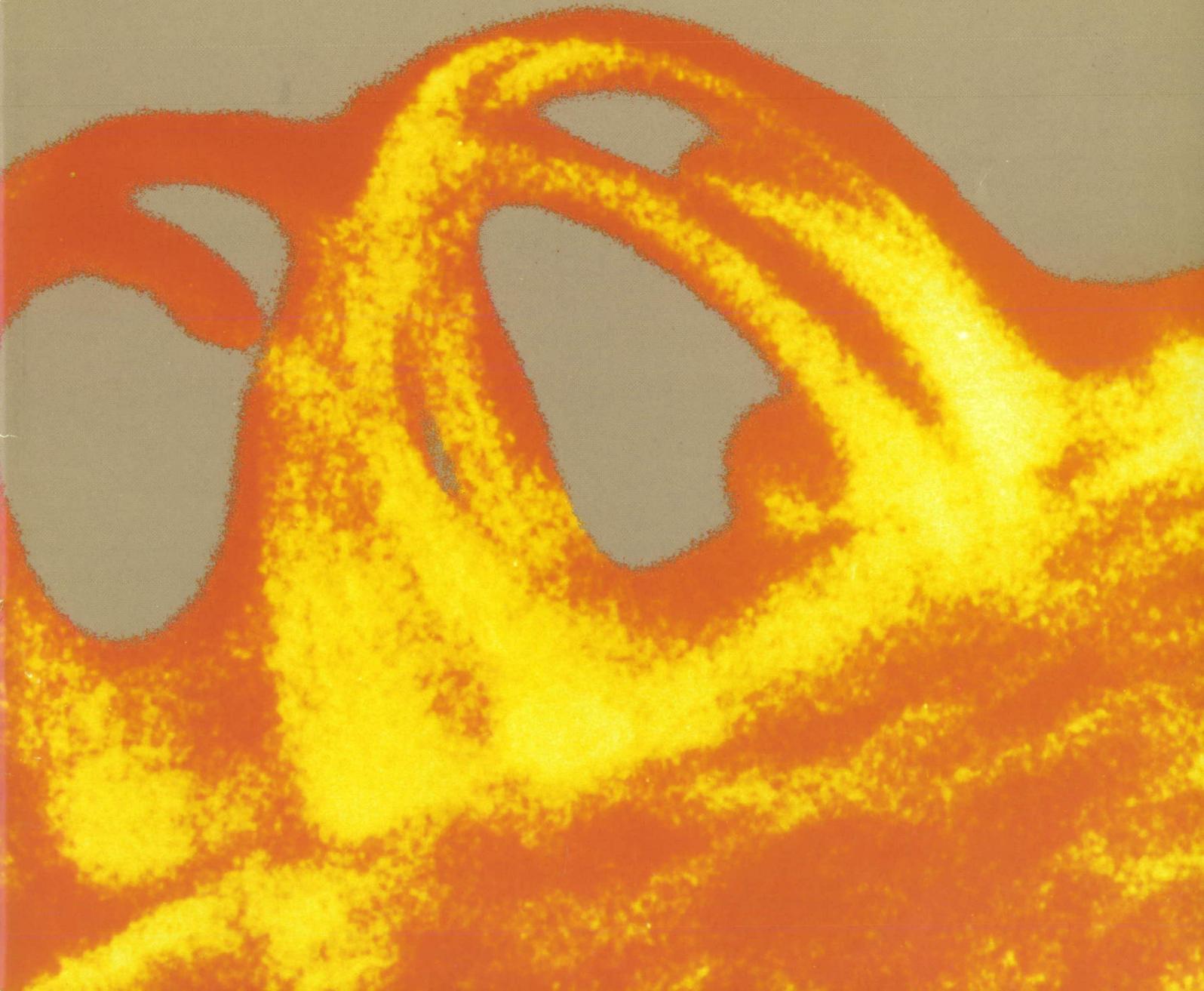


**THE SOLAR ACTIVITY MEASUREMENTS EXPERIMENTS (SAMEX)**  
*for Improved Scientific Understanding of Solar Activity*

N90-150.36

NASA TM - 100372



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*"A great solar flare is a truly beautiful event that captivates the onlooker and fills him with a sense of awe. He may witness, over the space of an hour, the release of an enormous quantity of energy – the largest in the solar system – and its transformation into an incredibly complex variety of forms. Afterwards, he may wonder: how did it all begin?"*

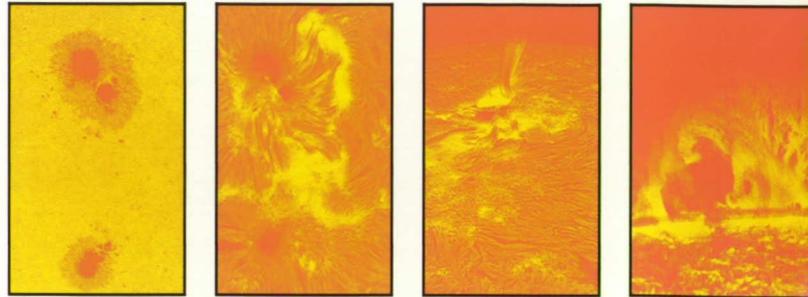
*E. R. Priest  
University of St. Andrews, Scotland*

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## The Challenge: Understanding Solar Activity

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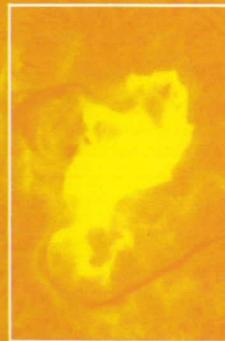
d.

a. Bipolar sunspot group in white light,  
21 May 1972  
Big Bear Solar Observatory

b. Bipolar sunspot group in  $H\alpha$ , 21 May 1972  
Big Bear Solar Observatory

c. Bright flare and dark surge from a sunspot,  
 $H\alpha$ , 22 May 1970  
Big Bear Solar Observatory

d. Solar prominence (70,000 km high),  $H\alpha$ ,  
31 March 1971  
Big Bear Solar Observatory



e.



A broad endeavor of solar research is to understand the various aspects of solar activity, ranging from the sporadic, explosive energy releases in flares to the ubiquitous heating of the corona. This quest is important for guiding and testing our understanding of magnetoplasma phenomena in more remote astrophysical objects as well as for understanding the Sun's modulation of Earth's space environment and atmosphere.

The Sun is the only star near enough to be observed in detail. By studying it, we gain insight into stellar features and processes elsewhere in the universe. While our physical



*f.*

*e. The great "sea horse" solar proton flare, H $\alpha$ , 7 August 1972  
Big Bear Solar Observatory*

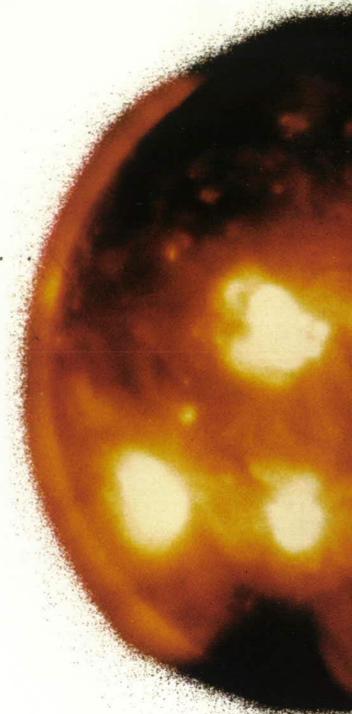
*f. Solar proton flare at peak intensity, H $\alpha$  detail, 7 August 1972  
Big Bear Solar Observatory*

understanding of more distant celestial objects is limited by weaker signals and lack of spatial resolution, we can see and measure solar phenomena with considerable clarity. Many of the features we now take for granted as characteristic of stars – flares, coronae, spots – were discovered by first observing them on the Sun. Solar observations are the foundation of many of today's astrophysical theories, and the Sun is a model for understanding other stars. Our explanations of active galaxies and exotic phenomena, such as quasars and black holes, owe much to our observations of solar activity.

Studying the Sun also gives us insight into events occurring nearby, in Earth's space environment and atmosphere. Observations of sunspots, flares, and the extended solar corona and detection of the solar wind in interplanetary space are the foundation of solar-terrestrial physics. It is evident that solar activity profoundly affects Earth and that improved solar observations are needed to understand and predict these relationships.

The root cause of solar activity lies in the interaction between the ionized solar gases and the magnetic field generated by convective and rotational motions in the solar interior. Manifestations of this interaction include:

- The solar cycle
- Emerging magnetic flux
- Active regions and sunspots
- Spicules
- Coronal heating
- Active filaments, surges, and sprays
- Flares, coronal transients, and mass ejections.



The Sun is an important laboratory for studying matter and energy under extreme conditions that cannot be duplicated on Earth. The basic laws of physics can be tested and refined through observations of intense solar magnetic fields, explosive processes, and the behavior of matter and energy across the Sun's tremendous temperature scale.

We have used a variety of observational techniques – from the ground and from spacecraft – to develop our understanding of solar activity. The contributions to knowledge from solar astronomy in space are impressive.

The first astrophysical X-ray observations were made by rocket-borne instruments observing the Sun. These early results pointed the way to the Skylab solar observatory (1973-1974). Skylab provided the opportunity for prolonged, extensive views of the high-temperature solar chromosphere and corona, a plasma threaded by magnetic fields. Coronal holes were discovered and related to the magnetic field patterns.

The Orbiting Solar Observatory (OSO) satellites extended knowledge of the temperature structure of the solar atmosphere. Later observations by the Solar Maximum Mission (SMM, 1980's) expanded our understanding of solar flares, explosive phenomena fueled by the transformation of magnetic energy. In 1985, Spacelab 2 solar observations revealed new timescale features of the interplay between magnetic fields and convection in the photosphere.

Space age research has transformed solar science, yet we are still developing a basic understanding of many fundamental solar phenomena such as flares, coronal holes, and magnetic field evolution. To test current theories and answer unsolved questions, scientists need long-term, high-resolution observations of solar activity.

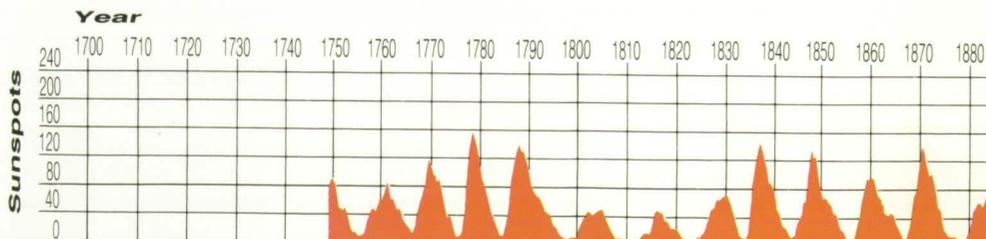
### PERPLEXING QUESTIONS

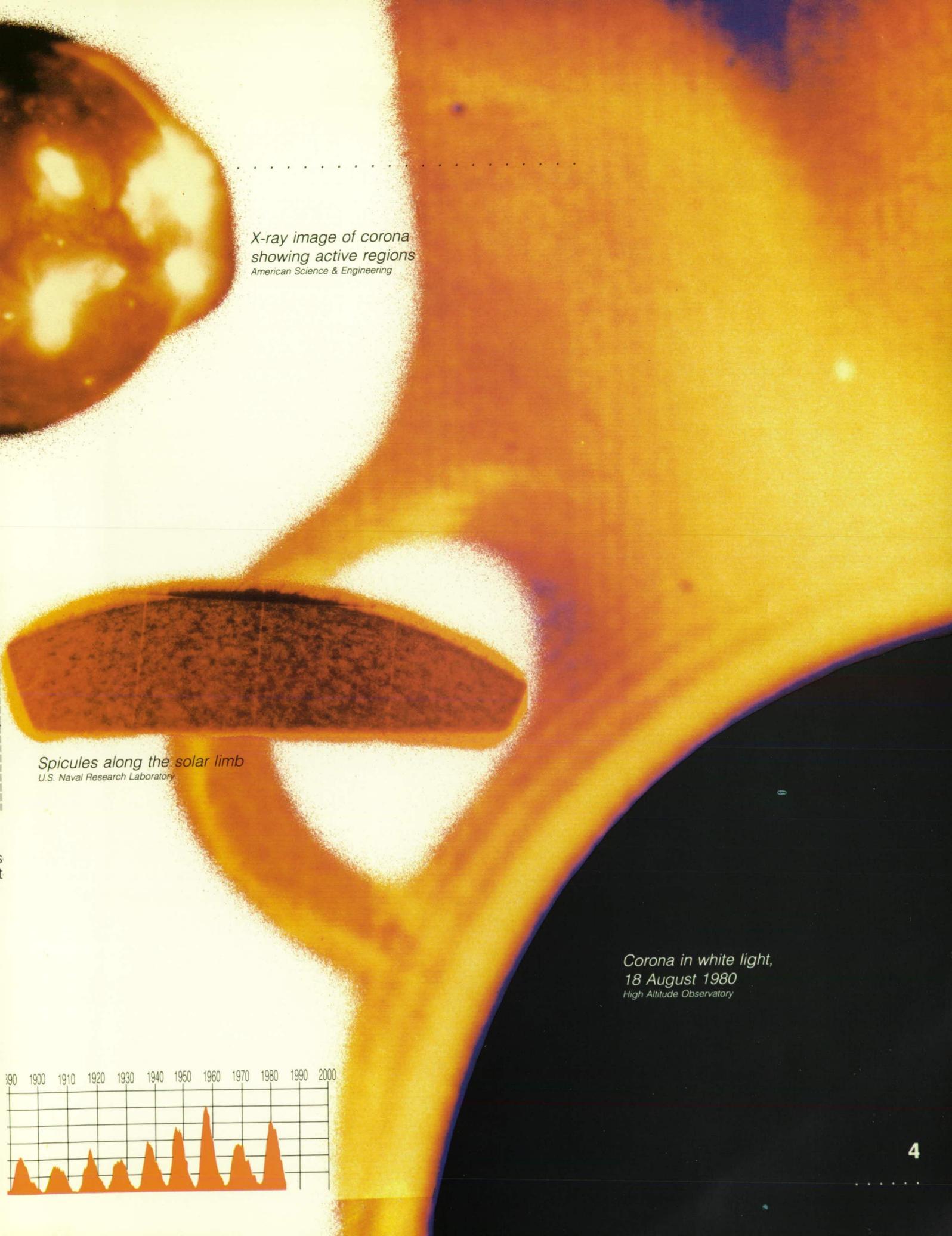
The data base for solar science today is two decades' worth of extensive ground-based observations and spectacular, but occasional, observations from space. While some of the details of solar astrophysics are now familiar, many basic questions are still unanswered:

- What causes the sunspot cycle?
- How do subsurface fields become buoyant, emerge, diverge, and submerge?
- How (why) do sunspots form, persist, and then disintegrate?
- What are spicules?
- How is the corona heated?
- What causes filaments to activate and erupt?
- What is the basic mechanism that leads to the explosive release of magnetic energy in the form of energetic particles and radiation?
- Why does the energy release occur at places where there is no vertical magnetic field?
- What are the dynamics and evolution of the coronal structure above active regions?

The common thread in all these questions is the **solar magnetic field**.

*Sunspot cycle*  
NASA/Marshall Space Flight Center

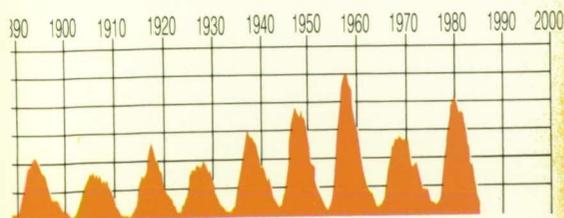




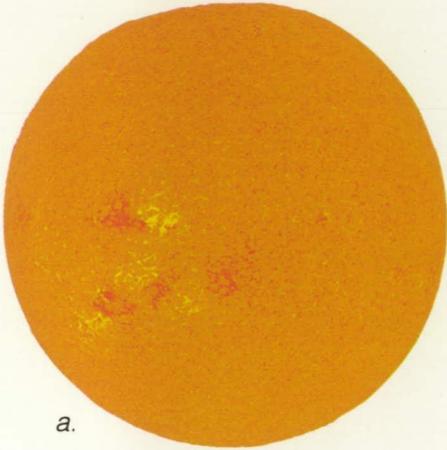
*X-ray image of corona  
showing active regions*  
American Science & Engineering

*Spicules along the solar limb*  
U.S. Naval Research Laboratory

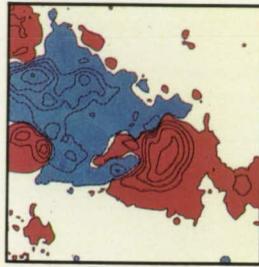
*Corona in white light,  
18 August 1980*  
High Altitude Observatory



## The Key: Solar Magnetism

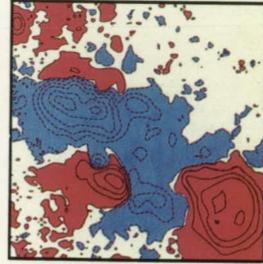


a.

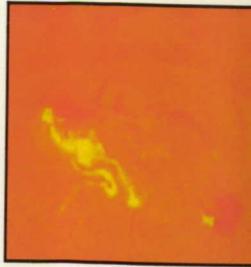


05:1603 UT

c.



06:1436 UT



06:1423 UT

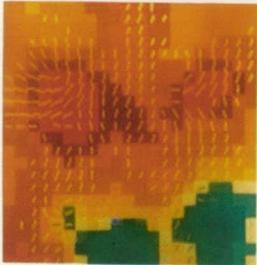
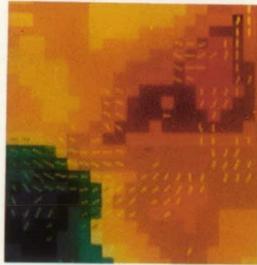
d.

a. Full disk magnetogram,  
31 July 1985

National Solar Observatory, Kitt Peak

b. Magnetogram showing  
details of magnetic field,  
31 July 1985

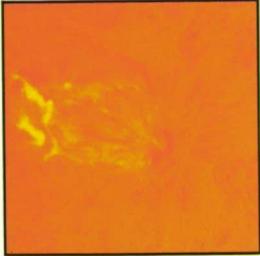
NASA/Marshall Space Flight Center



b.



Active Region 4680 July 31, 1985



06:1557 UT

*c. Magnetogram,  
5-6 April 1980  
NASA/Marshall Space Flight Center*

*d. H $\alpha$  comparison,  
5-6 April 1980  
Solar Optical Observing Network*

The answers to our questions are rooted in the Sun's magnetic field, the single most important force in the solar atmosphere. Since George Ellery Hale first demonstrated the existence of magnetic fields on the Sun, we have come to realize the pervasive influence of magnetism in the physics of solar activity. We can trace its influence from the solar interior up into the solar atmosphere and beyond, even to the surface of our planet Earth.

In the visible layers of the solar atmosphere, we see this field shaping and controlling the solar plasma, originating with the convective motions of the subsurface plasma to produce the solar activity cycle, appearing in the supergranular cells as subarcsecond concentrations of kilogauss fields, forming sunspots, and providing the energy source for the explosive phenomenon of solar flares.

The X-ray, extreme ultraviolet (XUV), and coronagraph images from Skylab forcefully demonstrated that the entire outer solar atmosphere is largely a consequence of the magnetic fields extending above the photosphere. The structure, heating, and dynamics of the chromosphere and corona, from global scales down to the smallest scales yet resolved, are seen to be strongly controlled and basically caused by the magnetic field.

Thus, the key to understanding solar activity lies in detailed examination of the solar magnetic field and its interaction with the solar plasma. Observations must provide thorough knowledge of the vector field, its evolution and cyclic variations, and the process by which magnetic energy is stored, converted, and released as solar activity.

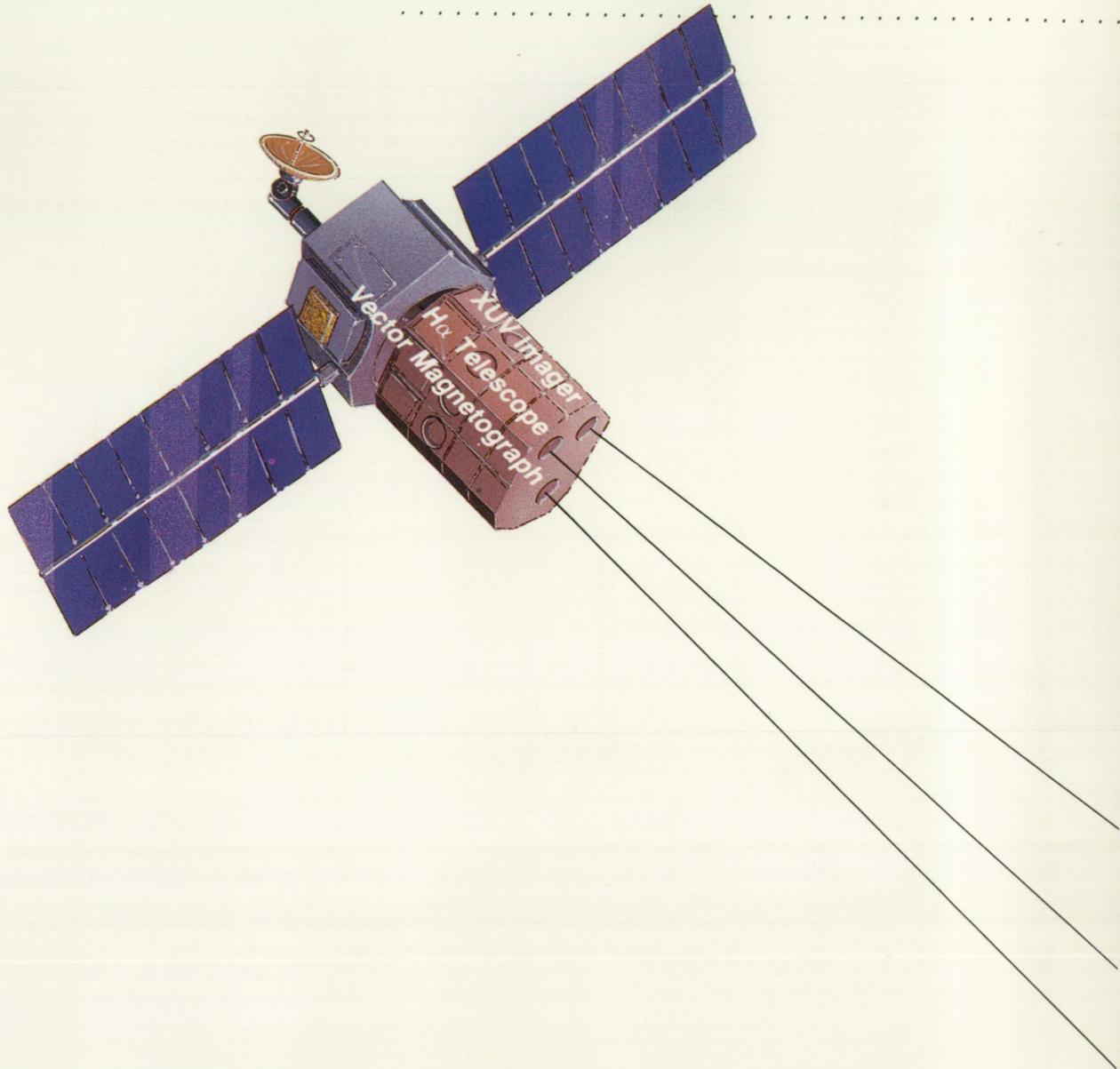
Ground-based observations have provided some clues, but the definitive observations must be made from space. X-rays and most ultraviolet radiation do not penetrate the atmosphere, and it is impossible to achieve from ground-based observations the extreme sensitivity and high spatial resolution required over long periods of time. Yet, to date, no space observations have been dedicated to this important purpose.

*Coronal loop structure  
U.S. Naval Research Laboratory*



**The Solution: SAMEX –**  
*Solar Activity Measurements Experiments*

.....



Morphology:	Magnetic Field Configuration Sunspot Magnetic Structure
Topology:	Current-Carrying Fields Magnetic Shear Across Neutral Lines
Evolution:	Changing Magnetic Fields Emerging-Submerging Magnetic Flux
Kinematics:	Photospheric Bulk Shearing Motions
Dynamics:	Pre-Flare Heating Flux Tube Interactions Magnetic Energy

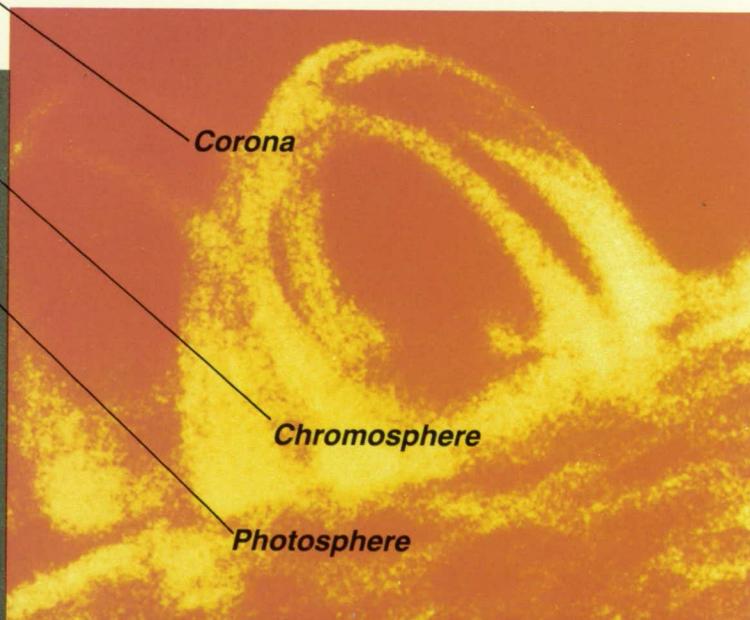
## MEETING THE SCIENTIFIC OBJECTIVES WITH SAMEX

SOLAR PHENOMENA	REQUIRED OBSERVATION	SAMEX INSTRUMENTATION
<b>New Emerging-Flux</b> ▪ Photospheric Shearing Motions ▪ Flux tube interaction ▪ Field cancellations	$\vec{B}, \vec{V}$	Vector Magnetograph
<b>Electric Currents</b> ▪ Energy storage rates ▪ Coronal field configuration	$\vec{B}, \vec{V}$	
<b>Magnetic Field Geometry</b> ▪ Photosphere ▪ Chromosphere ▪ Transition region ▪ Corona	$\vec{B}$	H $\alpha$ Telescope
	H $\alpha$	
<b>Flare Onset</b> (early recognition)	XUV Lines	XUV Imager
	XUV, Soft X-ray	H $\alpha$ Telescope
	H $\alpha$ , continuum	

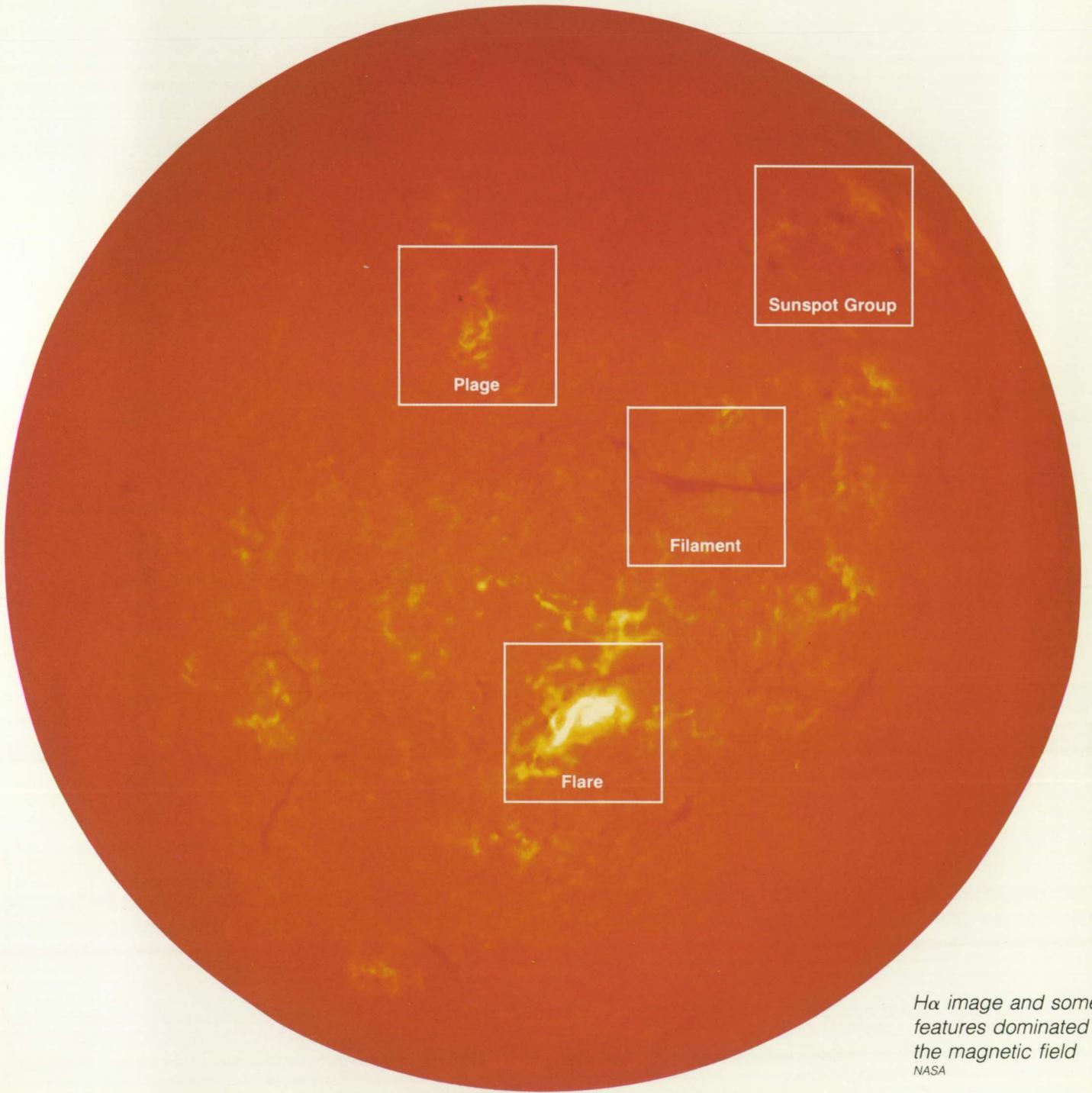
To address the fundamental problems of solar activity, we must explore the nature of the Sun's magnetic field. The Solar Activity Measurements Experiments (SAMEX) will be the first spacecraft mission dedicated to the study of solar magnetic fields and their role in solar activity. It will provide observations of the magnetic field through the solar atmosphere in three dimensions, using a highly sensitive vector magnetograph to study the photosphere, a hydrogen-alpha telescope for observations of the chromosphere, and an XUV imager to view the corona and transition region.

The key scientific objectives of SAMEX are:

- To place on a quantitative basis our understanding of the buildup and storage of energy in the magnetic field and its relationship to structures at all levels in the solar atmosphere.
- To identify the necessary conditions for release of energy in various solar transient phenomena.
- To determine whether this knowledge is sufficient to predict where, when, how much, and in what form the energy will be released.



U.S. Naval Research Laboratory (photo)  
NASA/Marshall Space Flight Center (spacecraft)



*H $\alpha$  image and some features dominated by the magnetic field*  
NASA

The key features of SAMEX are:

- Quantitative measurements of the three-dimensional vector magnetic field with three coaligned, cospatial instruments:
  - Photospheric vector magnetograph
  - Chromospheric H $\alpha$  imager
  - Coronal XUV imager
- Unprecedented accuracy in these quantitative measurements:
  - Measurement of the photospheric line-of-sight component to 1 G or better
  - Measurement of the photospheric transverse component to 30 G or better
- High spatial and temporal resolution:
  - 0.5 arcsecond spatial resolution over a 4 x 8 arcminute field of view
  - 5 minute or better temporal resolution

- Simultaneous observations with three cospatial imaging instruments
- Long periods of continuous observations over an extended mission lifetime.

SAMEX will provide data on magnetodynamic and magneto-hydrodynamic processes fundamental to all areas of astrophysics: magnetic flux emergence, dynamic field reconfigurations, reconnection and magnetic instabilities, magneto-acceleration of plasma and particles, wave propagation, field-aligned current configurations and effects, and the structure and general dynamics of magnetoplasmas.

SAMEX is envisaged as a joint, open project of the National Aeronautics and Space Administration (NASA) and the United States Air Force (USAF).

**Features Linked to the Solar Magnetic Field**

<b>Layer</b>	<b>Quiet Sun</b>	<b>Evolving Sun</b>	<b>Dynamic Sun</b>
<i>Photosphere</i>	Granules Network Umbral Dots Supergranules	Pores Sunspots Plage Emerging Flux Evolving Flux Active Regions	Flares (white light) Stressed Fields Convective Motions
<i>Chromosphere &amp; Transition Region</i>	Fibrils Spicules Prominences Sunspot Structure	Plage Filaments Arch Filament Systems UV Bright Points	Flares Active Filaments Microflares
<i>Corona</i>	Coronal Loops Streamers	Coronal Holes X-Ray Bright Points	Flares Eruptive Prominences Post-Flare Loops Coronal Mass Ejections

**SAMEX Research: Scientific Objectives  
and Observational Requirements**

.....

**Corona (1,500,000 K)**  
*X-Rays*

**Prominence**  
*H $\alpha$*

**Chromosphere/Corona  
Transition Region**  
**(30,000 – 500,000 K)**  
*Ultraviolet*

**Chromosphere (10,000 K)**  
*H $\alpha$  and Ultraviolet*

**Photosphere (6,000 K)**  
*Visible Light*

The SAMEX mission will allow scientists to take advantage of the latest technology and solar data to investigate the processes that give rise to intense solar activity. With coordinated, high-resolution observations from Earth orbit, the SAMEX instruments will focus on the evolution of the solar magnetic field, observing it at all levels simultaneously: the field itself in the photosphere, field-aligned structures in the chromosphere, and X-ray/XUV emissions in the million-degree plasmas that fill the closed field structures in the transition region and corona.

**e (5,000 – 10,000 K)**  
*and Ultraviolet*

**Flare (10,000,000 K)**  
*Extreme Ultraviolet,  
Gamma Rays, X-Rays*

The study of flare evolution is the focus of the SAMEX mission.

Questions to be asked include:

- What is the magnetic field configuration prior to solar flares? How is this pre-flare configuration formed?
- How is the magnetic field destabilized?

Related questions about other phenomena will be addressed and will benefit from the long-term measurements of solar magnetic field activity:

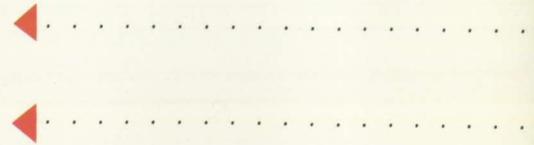
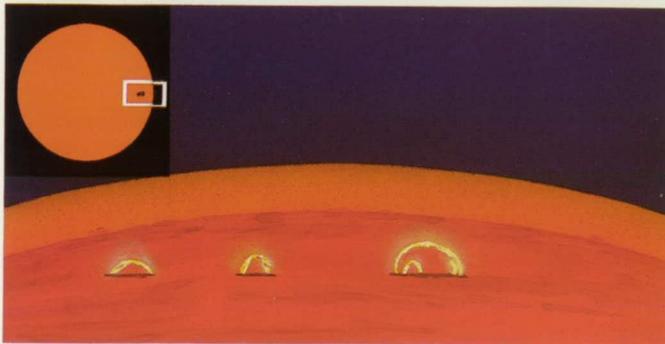
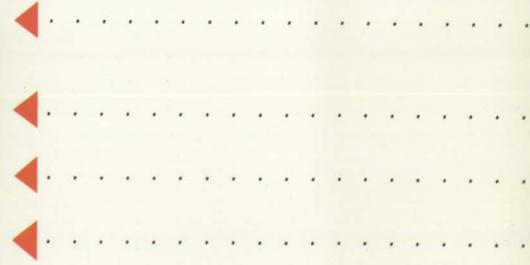
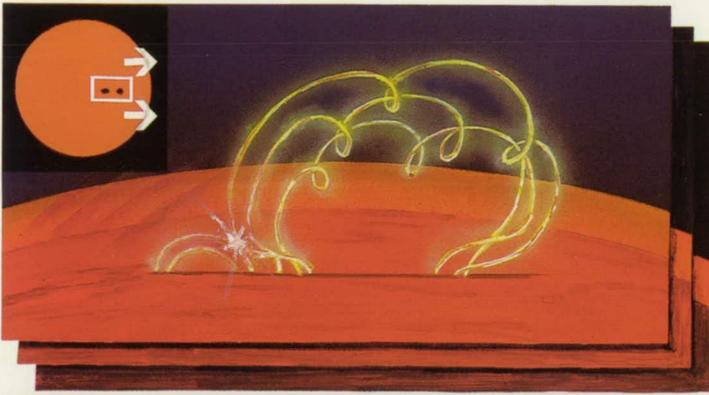
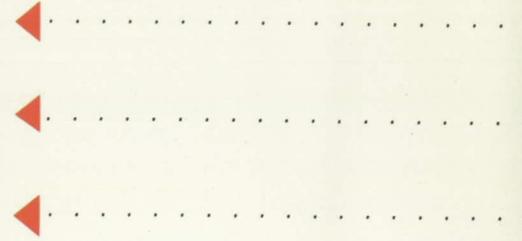
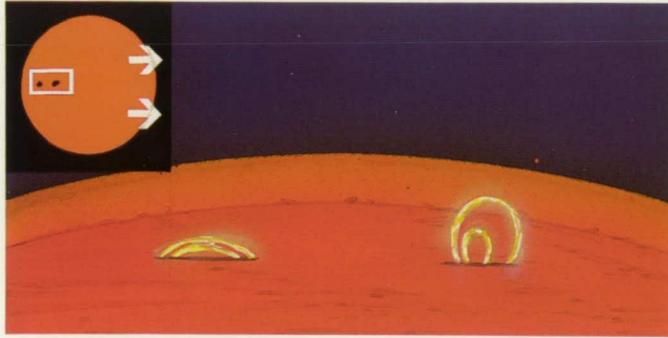
- How do sunspots form? How do they disappear?
- How do magnetic field structures vary with the solar cycle?

The data from SAMEX observations will allow scientists to reformulate older theories about these processes and generate new ones as knowledge of solar activity expands.

*The three-dimensional Sun*  
NASA



TIME



# ***SAMEX Coverage of the Evolution and Dynamics of the Solar Atmosphere***

*LARGE-SCALE TEMPORAL CHANGES*

*CHANGES IN THE CHROMOSPHERE*

*SMALL-SCALE AND WEAK FIELD EVOLUTION*

*GROWTH AND CHANGES OF THE CORONA – THE INHOMOGENEITY OF THE CORONA*

*CHROMOSPHERE AND TRANSITION REGION EVOLUTION*

*GROWTH OF LARGE-SCALE ACTIVE REGION*

*DETAILED TEMPORAL CHANGES*

*X-RAY EMISSION OF THE CORONA*

*DYNAMICS OF THE CHROMOSPHERE*

*MAGNETIC RECONFIGURATION, TEMPORAL AND SPATIAL RESOLUTION ON A LARGE AND SMALL SCALE AT HIGH MAGNETIC SENSITIVITY*

*GLOBAL DYNAMICS, CORONAL HOLES, VELOCITY FIELDS*

*SUBMERGENCE OF MAGNETIC FIELD*

The primary scientific objectives of the SAMEX mission are to observe the formation and configuration of energy-packed, nonpotential magnetic fields in active regions, to quantify the nonpotential characteristics of these fields (shear, stress, free energy, electric currents, magnetic forces, instabilities) as they develop and evolve, and to determine what factors lead to the destabilization of the fields with the subsequent eruption of flares.

Specific observations are needed to meet these objectives. We must observe, measure, and monitor the solar magnetic field from the base, from the photosphere to the corona. We must derive quantitative measurements with unprecedented accuracy to obtain the free energy and other characteristics of this field. Furthermore, we must measure the field over the extent of an entire active region, with the best possible spatial and temporal resolution.

Solar scientists, astrophysicists, and plasma physicists all will benefit from these detailed observations by SAMEX. The Sun is a laboratory in which we can study at close range the high-energy processes that occur in other stars. Specifically, SAMEX will give us a look at the interactions of magnetic fields and plasmas that create flares and other explosive events. To understand these phenomena, we must first understand the evolution through which their energy is built up, stored, and released.

To fulfill these science objectives and observational requirements, the SAMEX instruments were carefully chosen to form a configuration of three coaligned instruments capable of cotemporal observations of the solar field from photosphere to corona. The instruments make observations at different wavelengths; they reflect the best technology available for the observations planned.

Quantitative measurements of the three components of the vector field can be made reliably and with high spatial resolution only in the lower atmosphere, but the field morphology can be traced in the higher atmosphere from spectroheliograms that highlight the filamentary structure of the chromosphere and corona. Thus, the optimum complement of instruments for SAMEX includes a vector magnetograph that will accurately measure the vector magnetic field in the photosphere, a hydrogen-alpha telescope to image the chromospheric field and coronal prominences, and an XUV imaging telescope to outline the loop structure of the coronal field.

All three instruments are required to provide the coaligned, cotemporal data needed to detail the 3-D structure of the field, to register the locations of flare onset, and to define the 3-D changes wrought by flares. **These observations must be made from space**, because XUV radiation does not penetrate the atmosphere and because it is impossible to achieve from the ground the long-term, high spatial resolution observations that are necessary to understand how the field evolves toward flare conditions. Too many times, Earth-based observations are terminated at critical times because of

weather, day-night cycles, and poor seeing. Even a low-Earth orbit will provide long periods of uninterrupted viewing. Furthermore, the magnetic sensitivity required of the vector magnetograph can be achieved only from space. The trio of instruments cannot be separated; they must be flown together and coaligned.

### VECTOR MAGNETOGRAPH

The solar vector magnetograph will measure all three components of the surface magnetic field and the line-of-sight velocities of the photospheric gases.

The vector magnetograph is the essential core SAMEX instrument, for it provides the necessary *quantitative* measurements of the vector magnetic field. It has been especially designed to achieve the most important objective of the mission – to measure the magnetic field as accurately as possible. Present systems are limited to measuring the transverse (to the line-of-sight) component with accuracies on the order of 150 G. This accuracy level is inadequate to observe the characteristics of nonpotential magnetic fields that are essential for studying solar activity. The SAMEX magnetograph will yield magnetic field measurements with a sensitivity of approximately 30 G, a dramatic improvement over present systems; this is a factor of 25 in polarimetric accuracy.

Among the results anticipated through use of the SAMEX vector magnetograph are the following:

- More accurate measurements of the azimuth of the transverse component and, thus, more accurate measurements of the degree of magnetic shear as evidenced by this azimuth.

- A significant reduction in the errors in calculating electric currents, magnetic free energy, Lorentz forces, and magnetic gradients.
- More accurate model calculations.
- First-time observations of the transverse field in emerging and submerging flux and in flux cancellation.
- Detection of changes in the magnetic field as a result of flares.

Achieving this level of instrument sensitivity has required several unique design concepts:

- A rotating polarizer and quarter-wave plate for the primary elements of the polarimeter.
- Specially designed coatings for mirrors and lenses to minimize instrumental polarization.
- A spectral range from 5243 to 5254 Å that minimizes the requirements on the optics but allows flux tube diagnostics.

- A large-array (2048 x 2048) solid-state detector with multiport readout.

Limitations of present technology and the realities of making space-based observations from a free-flying satellite impose certain restrictions on the interrelated parameters of field of view, spatial resolution, magnetic sensitivity, and temporal resolution. The final parameters selected for the SAMEX magnetograph were derived from an extensive trade-off study, and they represent an optimum compromise for carrying out the primary scientific objectives.

The 0.5 arcsec spatial resolution will allow scientists to see a solar region as small as 360 kilometers (222 miles) wide and thus will resolve most features in active regions. The spatially unresolved fields can be analyzed using flux tube diagnostics because of the special spectral lines

included in the selected spectral range.

The time resolution ( $\leq 5$  minutes) is consistent with the spatial resolution and sufficient to observe most of the dynamic phenomena related to solar activity, especially the process of field evolution building up to flare onset, and is consistent with the spatial resolution.

The field of view will completely cover all but a few extremely large active regions. This coverage is essential for model calculations to provide the proper boundary conditions for the models, for observing associated activities, and for submergence studies.

**IMAGING TELESCOPES**

The XUV imaging telescope will observe the high-temperature plasma structures in the transition region and corona, showing the location and magnitude of solar activity. This instrument will utilize recent advances in optical design to attain excellent spatial resolution and large fields of view. The hydrogen-alpha telescope will observe the structure and dynamics of the plasma in the chromosphere with high temporal and spatial resolution.

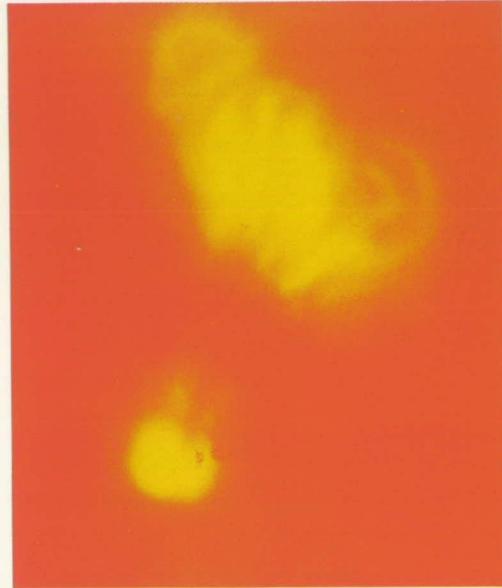
The requirements on these two systems are set by the specifications of the vector magnetograph and the scientific objective to map the magnetic field from the photosphere to the corona cospatially and simultaneously. Thus, they have the same field of view, spatial resolution, and temporal registration – a necessity demonstrated by the limited space observations of the past two decades.

<b>Instrument Characteristics</b>	<b>Vector Magnetograph</b>	<b>H<math>\alpha</math> Telescope</b>	<b>XUV Telescope</b>
Atmospheric region	Photosphere	Chromosphere	Corona
Telescope type	Cassegrain	Cassegrain	Wolter I*
Telescope aperture	30 cm	30 cm	35 cm
Spatial resolution (arc sec)	0.5	0.5	0.5
Field of view (arc min)	4.3 x 8.5	4.3 x 8.5	4.3 x 8.5
Spectral resolution	1 m $\text{\AA}$	20 m $\text{\AA}$	1–20 $\text{\AA}$
Spectral bandpass	120 m $\text{\AA}$	250 m $\text{\AA}$	Variable
Spectral range	5243–5254 $\text{\AA}$	6563 $\pm$ 4 $\text{\AA}$	3–400 $\text{\AA}$
Temporal resolution	$\leq 5$ minutes	1 second	1 second

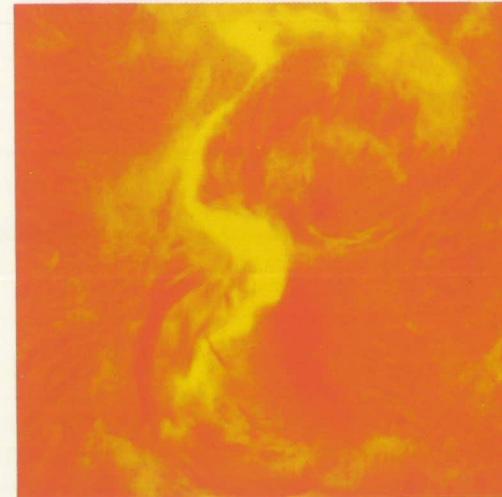
\* or Normal Incidence Newtonian

<b>Instrument Specifications: SAMEX Vector Magnetograph</b>	
Spatial Resolution	0.5 arcsec
Field of View	4.3 x 8.5 arcmin
Polarization Sensitivity	10 <sup>-4</sup>
Magnetic Sensitivity	
Line-of-Sight Field	1 G in 40 seconds
Transverse Field	~ 30 G in 4 minutes
Spectral Parameters	
Position Accuracy	1 m $\text{\AA}$
Full Width at Half Maximum	120 m $\text{\AA}$
Range	5243 – 5254 $\text{\AA}$
Doppler Velocity Resolution	60 msec <sup>-1</sup>
Temporal Resolution	
Vector Magnetogram	5 minutes
Dopplergram	10 seconds

- Detector System**  
(common to all 3 instruments)
- 2048 x 2048 CCD array with 27  $\mu\text{m}$  pixels, or quadrant structure of four 1024 x 1024 arrays
  - half array for imaging, half for storage/readout
  - 1 msec image-to-storage shift time (eliminates need for shutter)
  - serial readout ports (reduces readout time below exposure time)
  - pixel binning capabilities



a.



b.

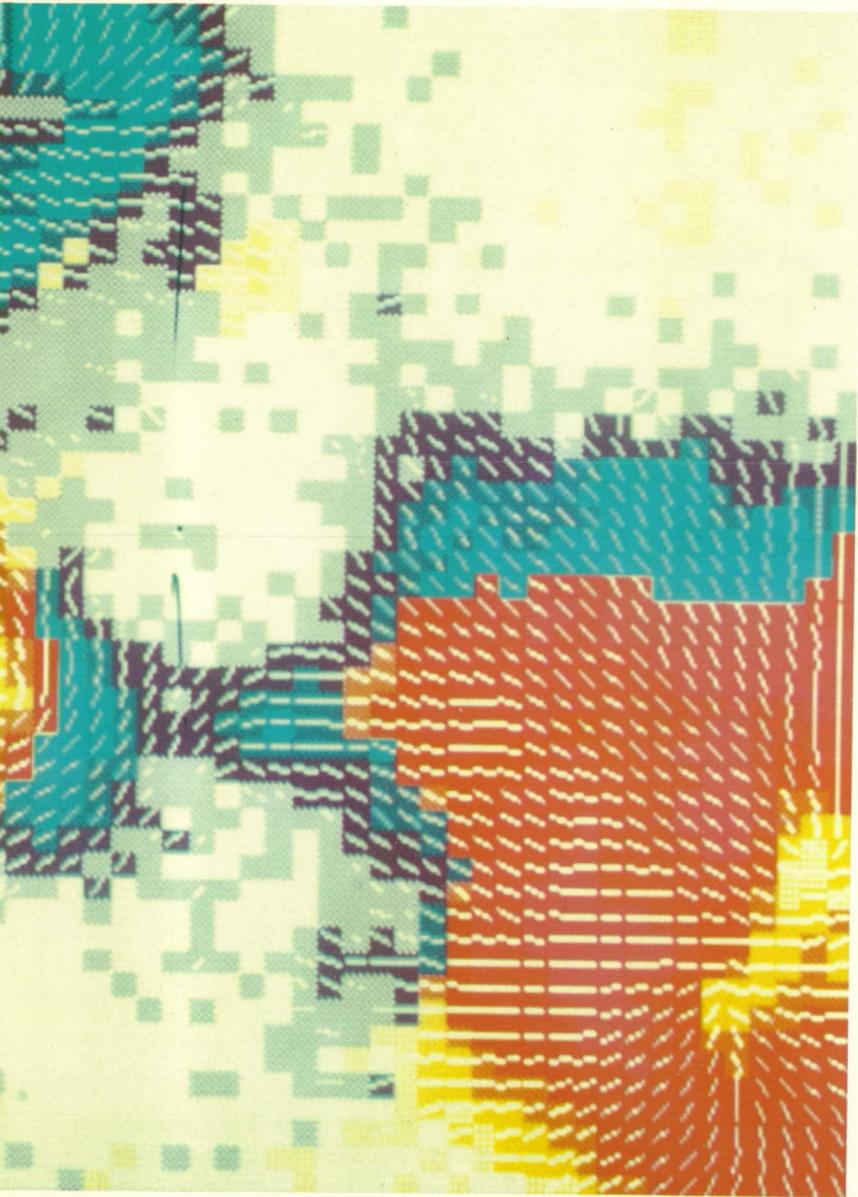


c.

a. *H $\alpha$  image*  
*Solar Optical Observing Network*

b. *X-ray image*  
*American Science & Engineering*

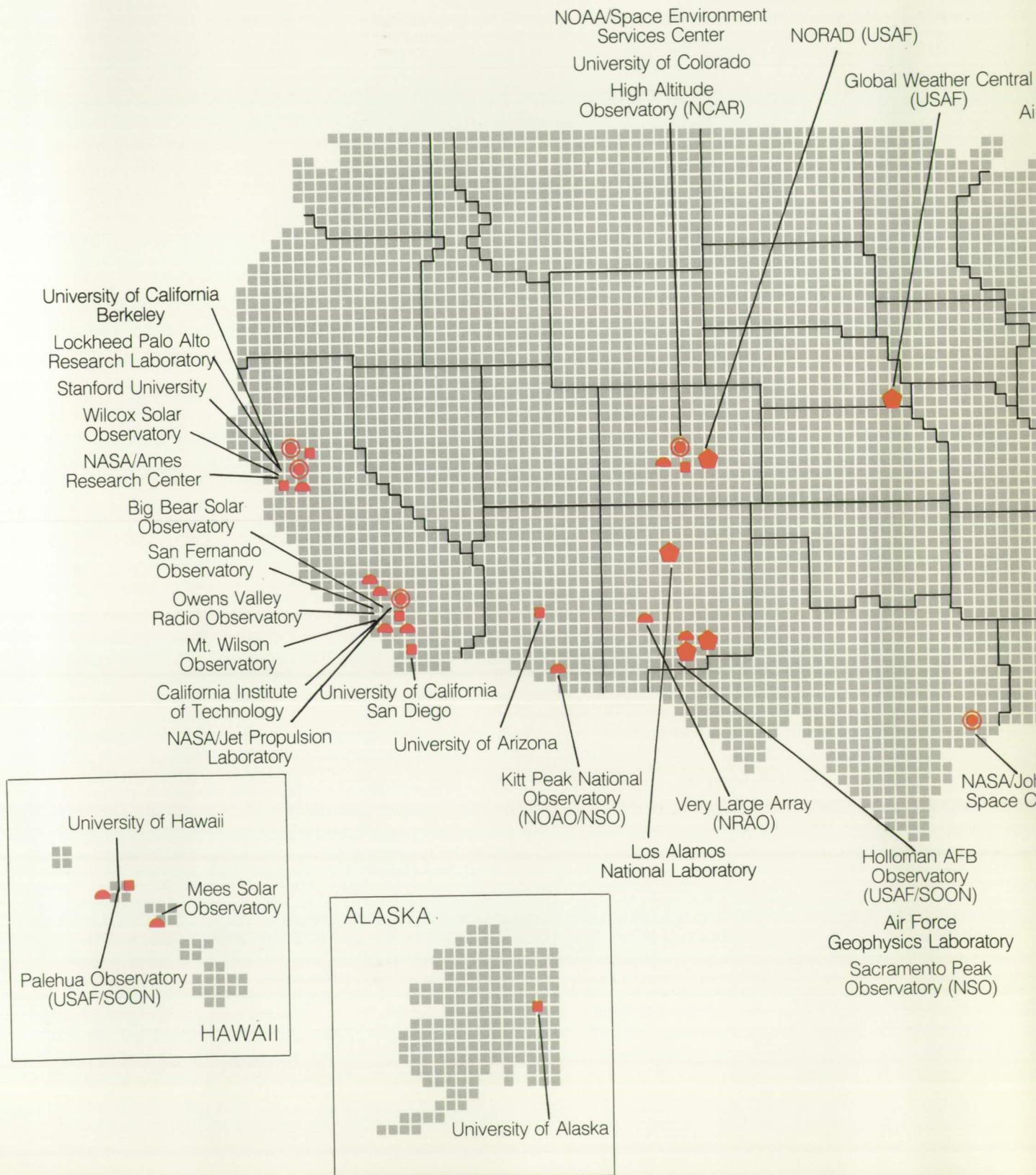
c. *Magnetogram image*  
*NASA/Marshall Space Flight Center*

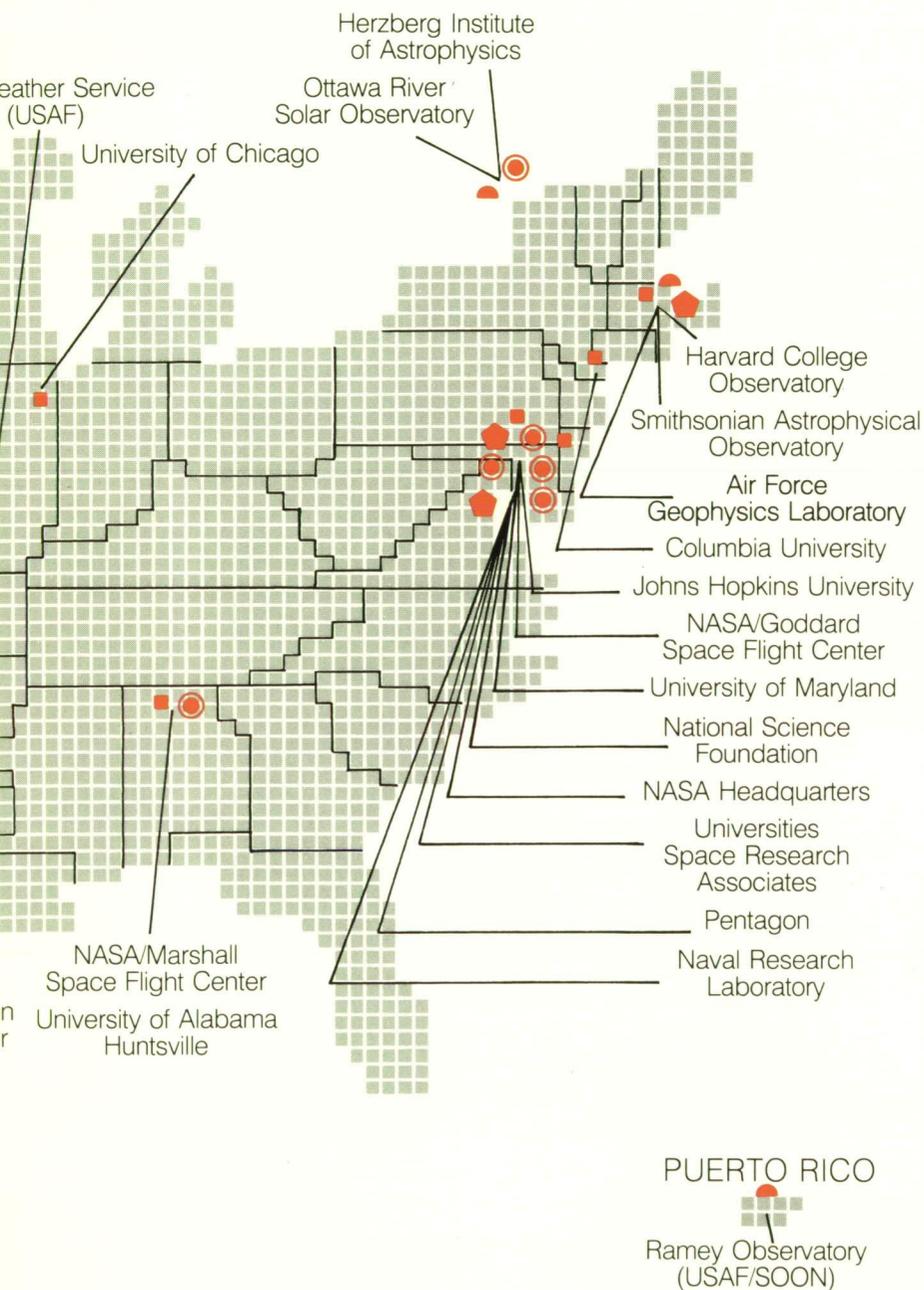


The significant advantage of the SAMEX mission lies in the coordination of these three instruments for simultaneous observations. SAMEX will be able to see solar active regions in detail, providing images and spectral data on the birthplaces of solar flares. Furthermore, SAMEX will monitor the precursors of flare eruptions (such as intensified magnetic shear, filament activation, or early signs of enhanced X-ray emission) as well as the presence of coronal holes. SAMEX will also detect coronal loops, enabling analysts to determine the magnetic field configuration of the outer solar atmosphere and its effect on the solar wind that will have an impact on the geomagnetic environment.

The SAMEX instruments will form the first complement of experiments ever flown on a mission specifically designed to study the buildup and release of energy in solar flares. For that reason alone, the instruments are being designed with the best technology. Meeting the specifications for sensitivity, field of view, spectral coverage, spatial resolution and temporal resolution, they will achieve the scientific objectives of the SAMEX mission. We expect many exciting discoveries about our star, the Sun.

# Shared Benefits: A Broad Community of Users





SAMEX is logically the next spacecraft for research in solar activity. It is the product of careful deliberation and planning within the solar physics community to determine the best means of answering the most important questions about the Sun's activity.

The scientific community has laid a firm foundation in solar research with almost three decades' worth of rocket-borne and orbital instruments. Results from sounding rockets, the manned Skylab Apollo Telescope Mount, the small Orbiting Solar Observatories, the Solar Maximum Mission spacecraft, and Spacelab 2 have shown us a Sun that is dynamic, changeable, explosive, and mysterious. Designed with the advantages of today's technology and the knowledge gleaned from past research, SAMEX is the best research tool yet devised to answer the many perplexing questions that still cloud our understanding of the Sun.

SAMEX fits into the broad international strategy for concentrated solar physics research into the next century. This observatory complements other proposed spacecraft and augments all ground-based observatories. Through a data analysis facility and network, scientists at universities and research centers around the world will have access to SAMEX data for a comprehensive understanding of the Sun. SAMEX is a crucial link in the chain of solar research. SAMEX data also will be important to astrophysicists studying magnetized plasmas elsewhere in the universe.

**LEGEND:**

- Universities
- Observatories
- ⊙ Space
- ⬠ DOD

While the research results of SAMEX will be impressive, the rewards of a SAMEX mission will extend beyond the scientific community. The effects of solar radiation on military and civilian systems in space are severe: communications blackouts, navigation errors, and garbled signals are just a few of the hazards to routine and emergency operations of aircraft, spacecraft, and ground systems. Managers and operators of such systems would benefit tremendously from knowing when solar events will occur. The information from SAMEX observations of flare and pre-flare phenomena will lead to the development of improved prediction techniques, enabling us to protect expensive and sophisticated systems from the effects of solar radiation.

Among the beneficiaries of SAMEX will be the many subscribers to the Space Environment Services Center, operated jointly by the National Oceanic and Atmospheric Administration (NOAA) and the Air Force. The Center distributes alerts, forecasts, indices, and reports based on real-time data from worldwide sources. These services help individuals and organizations reduce losses caused by sporadic solar activity.

Sharing the benefits will be the military; satellite and aviation industries whose operations are affected by vagaries in the space environment; electric power, telephone, and pipeline utilities; geophysical exploration enterprises affected by geomagnetic variations; and scientists with sensitive research instruments in space, in the atmosphere, or on the ground. Personnel in manned spacecraft and high altitude aircraft will benefit from improved information about the status of their environment.

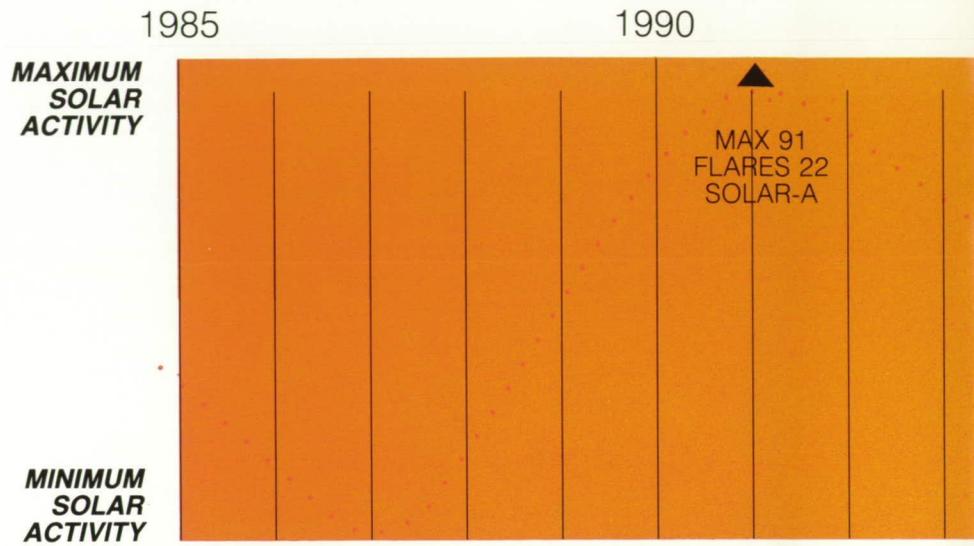




*International network of  
solar observatories and  
research centers*  
NASA/Marshall Space Flight Center

# A Current Need: Planning for the 21st Century

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Research missions  
during the solar cycles,  
1985-2010  
NASA/Marshall Space Flight Center





National Aeronautics and  
Space Administration

**Marshall Space Flight Center**

