SANTA MARIA:
AN ORBITING MULTISPECTRAL OBSERVATORY

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1. Experiment concept

SANTA MARIA is a program of international scope, being a collaboration between scientific groups in Italy, Spain and the United States. The experiment consists of a cooperative space project with the objective of designing, developing, launching, data processing and scientific exploitation of an astronomical satellite under the name of SANTA MARIA.

The three research organizations will contribute to the project with tasks shared in the most practical way to guarantee the success of SANTA MARIA. The distribution of responsibilities is as follows:

- The spacecraft will be provided by Spain (financing, construction and integration).
- USA will provide the launcher under the Small Explorer Program.
- Italy will provide the launching and mission operations from the San Marco base in Kenya.
- The payload will be shared between the three countries.

SANTA MARIA is a small, low cost satellite which will perform imaging spectroscopy in the range from 200 to 7000 Å of astrophysical and solar system sources. It will also perform continuous measurements of the earth plasmasphere and the solar flux.

To achieve this task, SANTA MARIA will be equipped with several spectrographs operating simultaneously to provide coverage of the whole wavelength range. The detectors will be ICCD's. The scientific payload will include a particle analyser for plasmasphere studies and a solar spectrometer.

SANTA MARIA will be capable of obtaining simultaneous multiwavelength observations over long time scales of a large variety of astrophysical and planetary

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objects. The understanding of many such objects is, in fact, often limited by a fragmentary picture of their behaviour in the different wavelength regions and by lack of extended temporal coverage. Much of modern astrophysics is now concerned with situations where significant variations are observed to occur over a wide range of time scales in many spectral regions.

2. Scientific instrumentation

The scientific instrumentation for SANTA MARIA is divided into three sections :

1) The primary experiment package consisting of a set of imaging spectrographs covering the spectral region from 200 Å to the visible. They are designed for simultaneous pointed observations of solar system and astrophysical objects. Table I gives the instrumental parameters.

2) The main spectrographs are complemented for earth atmospheric studies by an earth plasmasphere experiment.

3) The solar system observations are further complemented by a solar experiment.

Table I: Instrument Parameters

Channel	Wavelength range (Å)	Resolution (Å)	Aperture (cm^2)	Sensitivity (*)	Configuration
EUV2	200–600	10	4 × 12	6	Grazing;ICCD; windowless intensifier
EUV1	550–850	5	4 × 12	7	Grazing;ICCD; windowless intensifier
FUV	800–1300	1-2	25 × 36	8–4	Telesc+Rowland grat.; ICCD; windowless int.
UV	1150–3200	5	10.5 × 15	0.4	Telesc+Rowland grat. ICCD; sealed int.
Vis	3000–7000	7.5	10.5 × 15	0.1	Telesc+Rowland grat.; ICCD; S20 cathode

(*) Point source continuum, S/N=10, in units 10^{-13} erg s^{-1} cm^{-2} $Å^{-1}$

The largest fraction of the experimental payload is dedicated to the primary instrument. The earth plasmasphere and solar experiments are small instruments integrated into the spacecraft structure and will use only a small portion of the spacecraft resources. In the primary instrument, the spectrum between 200 and 7000 Å will be recorded simultaneously in 5 spectral channels with intensified charge

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coupled devices (ICCD's). In all these channels spatial resolution is maintained in the cross dispersion direction thereby providing a monochromatic imaging capability for targets with strong emission lines. An angular resolution of 4.5 arc seconds is foreseen. The largest aperture is that of the 800–1300 Å FUV spectrometer. It consists of a telescope and a Rowland grating spectrograph with two ICCD's which will provide resolution of 1 A/pixel. The apertures of the remaining channels are scaled to yield sensitivities to be compatible with the FUV channel.

The longer wavelength channels, UV (1150–3200), and visual (3000–7000 Å), will have the same optical configuration as the FUV channel, but only one ICCD will be needed to obtain the required resolution. The preliminary configuration of the two EUV channels EUV1 (400–860) and EUV2 (200–600) consists of small grazing incidence telescopes and spectrographs. Other configurations have been proposed by Naletto and Tondello (1988) and will be considered in a further study.

The 5 spectral channels can also function as broad band photometers simply by summing contiguous spectral elements on the detector, sensitivities in this mode are correspondingly higher.

SANTA MARIA will contain several small instruments to provide continuous spatial photometry of the Earth's plasmasphere and atmosphere which will be complemented by absolute measurements of the solar ionizing flux. Miniature optical imagers will measure the distribution of He^+(304 Å), He(584 Å), O^+(834 Å), H(1216 Å) and O(1304 Å) from a swathe 30 degrees wide through the orbit. An Imaging spectrometer for Energetic Neutral Particles (ISENA) will detect and image the ENA particle flux from the same look directions as the optical imagers. The ENA particles originate from charge exchange reactions of neutral hydrogen with the ions of the plasmasphere. The ISENA will preserve information on the arrival direction of the particles and will be able to distinguish H, He, and O particles while measuring their energy.

The solar experiment consists of pinhole spectrographs (200–3200 Å) giving spectral half width of about 4 Å. An absolute measure of the solar ionizing flux will be made periodically using a gas ionization cell.

The very ambitious scientific goals of SANTA MARIA are possible due to the detector technology. The use of intensified charge coupled devices provides us with an imaging detector system that simplifies the mechanical design of the instrumentation and constrains the optical system to be small.

The instrumentation and technique for SANTA MARIA are now state-of-the-art, i.e. no instrument development is proposed. All elements of the various instruments and detectors will be or have been flight proven in presently and previous funded programs.

3. Scientific program

Much of modern solar system physics and astrophysics are now concerned with situations where significant variations are observed to occur in the UV and optical bands over a wide range of time scales. Obtaining a reasonably complete and coherent picture of how activity in different wavelength regions is interrelated is fundamental to our basic understanding of many type of objects. Such variable

phenomena occur at all time scales ranging from very short, of the order of minutes, to very long, of the order of years.

Studying active phenomena frequently involves attempts to coordinate simultaneous observations involving various astronomy satellites and ground based-observers. In spite of the large logistical problems which lead to discouragingly low success rates, the enormous scientific value of coordinated observations has produced an increasing amount of this type of observation. Several successful observing programs involving coordinated spacecraft and groundbased observations can attest to the value of simultaneous and long term coverage (Barstow et al. 1986 and Pringle et al. 1987).

SANTA MARIA instrumental sensitivities are determined by the primary goal of achieving time-resolved, multispectral observations of at least several key objects in a variety of important astrophysical classes. An important feature of SANTA MARIA will be the ability of observers to trade off increased signal-to-noise ratio on fainter targets against time or spectral resolution. As a dedicated multispectral observatory it is anticipated that SANTA MARIA will focus on those problems which, by their nature, will require a commitment of large segments of observing time.

SANTA MARIA provides an ideal complement to many of the actual and future facilities which will operate during the next decade, such as IUE, HST, ISO, etc., and the ground based telescopes of new generation.

SANTA MARIA will include the following research fields:

- Solar, Planetary and Terrestrial observations.
- Hot and cool Stars.
- Cataclysmic Variables.
- Active Galactic Nuclei.

References

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