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THE SIMURIS INTERFEROMETRIC MISSION: SOLAR PHYSICS OBJECTIVES AND MODEL PAYLOAD

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ABSTRACT

We describe the SIMURIS Mission with emphasis on the scientific goals and related capabilities of the major instruments of the model payload.

INTRODUCTION

SIMURIS (*Solar, Solar System, and Stellar Interferometric Mission for Ultrahigh Resolution Imaging and Spectroscopy*) has been proposed to ESA as a Mission in the context of the Space Station in November 1989 in answer to the Call for the Next Medium Size Mission (M2). It has completed, since, an Assessment Study /1/, and is now proceeding for an ESA Phase A.

SIMURIS is a mission to study the Sun at very high spatial resolution, using both imaging and spectrometry simultaneously in the ultraviolet and the visible. It addresses the basic and unresolved problems of coronal heating and magnetic confinement. Its major goal is to achieve sufficiently high spatial resolution to resolve the fine structuring governed by basic magnetohydrodynamical and plasma physics processes in solar physics. It offers an unprecedented opportunity to observe physical processes at their characteristic scales in the atmosphere and on the surface of the Sun. In meeting this goal, to be achieved with new interferometric techniques, SIMURIS also furnishes research capabilities of interest to solar system science and galactic astrophysics, and may be seen as a precursor to future developments, both in the context of understanding astrophysical processes and in the context of developing space interferometry at short wavelengths.

SIMURIS employs advanced interferometric techniques. The payload includes two major instruments which are the *Solar Ultraviolet Network* (SUN), an interferometric array of four 20-cm telescopes on a 2-m baseline, and the *Imaging Fourier Transform Spectrometer* (IFTS) which uses light from a 40-cm Gregory telescope. The diffraction limited use of SUN, provides an unprecedented resolution of 10 km on the Sun in the far UV and, at the same time, IFTS provides velocity and magnetic maps of the solar region under study with a 0.1 arcsec resolution and a high spectral resolution. EUV multi-layer telescopes complete the payload for diagnostics of the very high temperature plasma. The characteristics of the SIMURIS Model Payload, which includes four different type of instruments, are summarized in Table 1. A recent paper describe the SIMURIS model payload /2/ and several papers from the SIMURIS Workshop Proceedings /3/ present the design of the different instruments in detail. Additionally, technical reports from ESA /4,5/ and TPD /6,7/ give a deeper understanding of mechanical and thermal studies, optical tolerances, *etc.*

	Instruments	Wavelength range (Å)	Resolutions: spatial (arcsec) and spectral (Å)	Field-of-view (": arcsec) (': arcmin)	Optical characteristics
High Spatial Resolution Imager	**SUN (Solar Ultraviolet Network)**	1170 — 2000 1300 — 2800 2800 — 4800 4800 — 5000 5000 — 8000 8000 — 11000	0.012" / 0.1 Å 0.06" /~ 200 Å 0.028" / 0.1 Å 0.05" /~ 200 Å 0.05" / 20 mÅ 0.08" / ~ 10 Å	6" x 6" 30" x 30" 7" x 7" 25" x 25" 13" x 13" 20" x 20"	Four Ø20 cm Cassegrain telescopes, Double Monochromator with 6 channels, and Fabry Perot in the 500 — 800 nm channel
High Spectral Resolution Imager	**IFTS (Imaging Fourier Transform Spectrometer)**	1200 — 2000 2500 — 9000	0.1" / 30 mÅ 0.1" / 10 mÅ	25" x 25" 25" x 25"	Folded Gregory telescope Ø40 cm, Double Monochromator, and two channels FTS
High Temperature Imager	**EUVT (Extreme Ultraviolet Telescope)**	Fe XX/XXIII 133 Fe IX/X 173 Fe XII/XXI 192 Fe XIV 211	0.6" / ~ 10 Å	5' x 5'	Ø10cm Ritchey-Chrétien telescope, selectable multilayers
Large Field and Survey Imagers	**UVC (Ultraviolet Camera)**	Lyman α 1216 C IV 1550 Continuum 1600	0.6" /~ 100 Å 0.6" / ~ 8 Å "	2.5' x 2.5'	Ø10 cm Gregory telescope with filter wheel (including a FP filter)
	HLT (Helium II Telescope)	He II 304	3" / ~ 15 Å	Full Sun	Ø10cm Ritchey-Chrétien telescope (multilayered)

TABLE 1 — Summary of the characteristics of the SIMURIS Model Payload

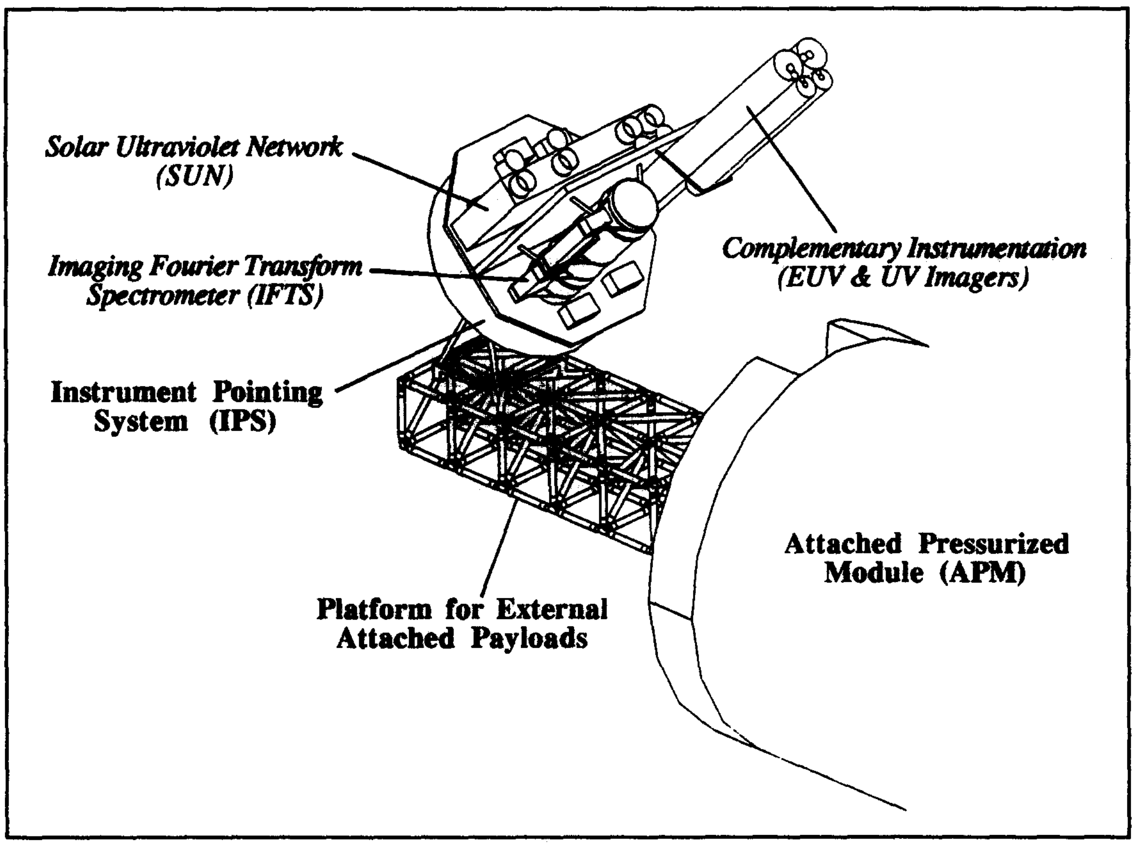

Fig. 1 — Possible implementation of the SIMURIS Model Payload at the far-end of the Attached Pressurized Module of the Space Station Freedom

MISSION CONTEXT

The SIMURIS mission is intended for the Space Station where it will use the *Instrument Pointing System* (IPS) — a large pointing platform of Ø2 m —, which could be accommodated on the end of the Attached Pressurized Module (cf. Fig. 1) or, alternately, on the new truss structure.

The IPS has been flown on Spacelab2 with measured performances of pointing stability and accuracy of ~ 1 arcsec. The improved electronics and control system studied by DORNIER (under ESA contract) should provide Space Station performances of ~ 0.5 arcsec. A major feature of the IPS is its ability to rotate around its line-of-sight, allowing the SUN instrument to synthesize an image in 1 minute. Other advantages of the Space Station are the available power (6 kW), and an important telemetry potential, equivalent to a double rack of microgravity (34 Mbits/s). More detailed aspects of the Space Station environment and accommodation of the SIMURIS Model Payload are described in the Assessment Study Report /1/, in Haskell and Olthof /3/ and in Lemmer et al. /3/.

SIMURIS SCIENCE OBJECTIVES

The general aims, scientific objectives and mission approach of SIMURIS have recently been summarized in Damé and Rutten /3/, and a more complete overview of SIMURIS is given in the Assessment Study Report /1/. The emphasis of the SIMURIS Mission is on achieving high spatial resolution in solar imaging and solar spectrometry, simultaneously for the photosphere, the chromosphere and the transition region, with additional larger-field reference imaging at various wavelengths.

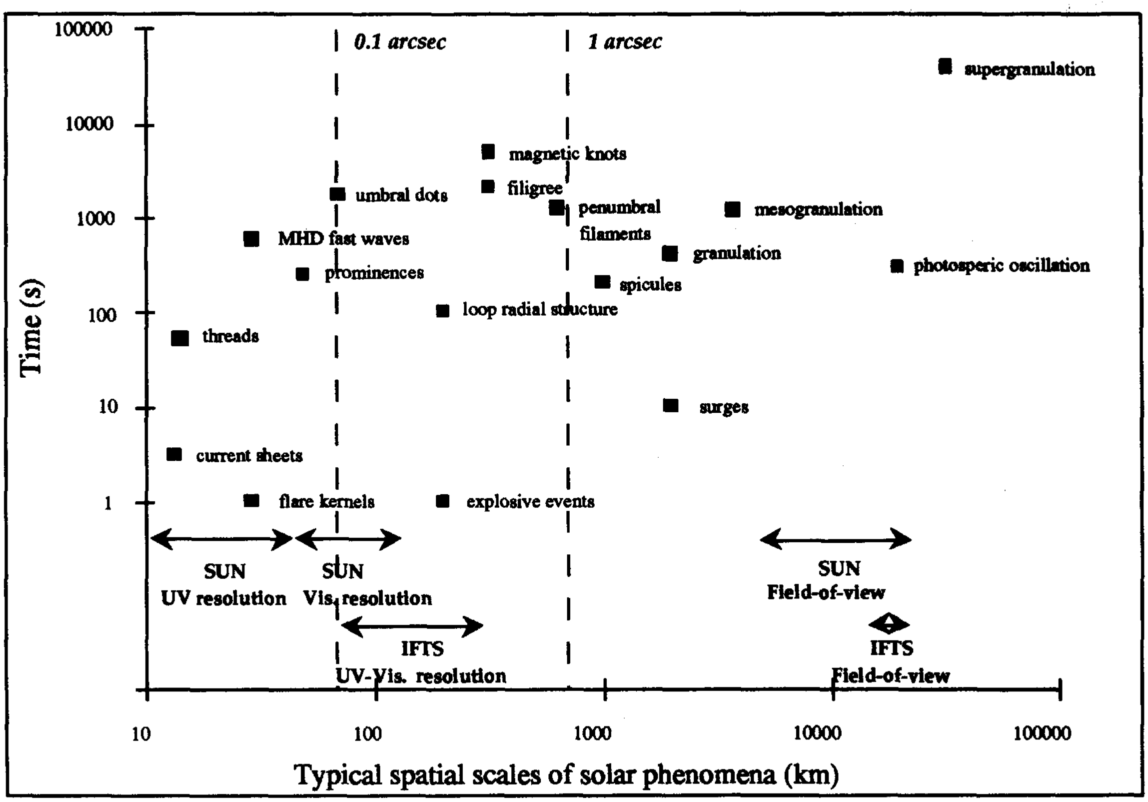

Fig. 2 — Typical lifetime and spatial scales of the major solar structures and phenomena

SIMURIS aims to study physical processes rather than phenomena. In many areas of modern astrophysics, the nature of the physics underlying observed patterns comes under scrutiny, rather than just the patterns. The questioning evolves from asking how things are to asking why they are so. Solar astrophysics is in a prime position to achieve this transition because the Sun is sufficiently close that basic physical scales such as density scale height and photon mean free path are in reach of observation. In angular measure, these are a million times smaller for other stars; thus, solar physics requires only a millionth of the baseline needed to resolve comparable physical processes outside the solar system.

The Sun represents an astrophysics laboratory of huge interest. The solar photosphere is the only place where stellar convection can be observed in detail; the outer atmosphere, pervaded and finely structured by highly intricate magnetic fields, provides a tremendous array of plasma processes, offering much to learn to plasma physicists and astrophysicists alike. Solar physics topics of obvious interest are:

- *MHD configurations*: fluxtubes, canopies, loops;
- *structure and evolution of magnetic patterns*: umbrae, penumbrae, plage, network, grains, fibrils, spicules, prominences;
- *instabilities and eruptive phenomena*: jets, bullets, explosive events, flares, microflares;
- *radiation hydrodynamics*: granulation, oscillation grains, shocks, extreme limb,

plus probably quite a number of structuring agents and dynamical processes that aren't known yet, at scales below the ~ 500 — 1000 km resolution presently obtainable at best.

The variety of solar research topics is very large (see Fig. 2). Nevertheless, they may be grouped together in a single theme, which is defined as the complex entity constituted by a magnetically-active star's outer envelope. In the lower atmosphere, the transition from convective to radiative energy transport causes detailed structuring of the surface layers accessible in the visible part of the spectrum. And the structuring and energy balance of the outer solar atmosphere — a very dynamic and active plasma where the magnetic fields play a dominant role — is best observed in the ultraviolet down to the soft X-ray domain.

SIMURIS brings also promising capabilities to non-solar studies. Photon gathering capacity is modest, but one should note that the Sun is as dim per resolved pixel as any other cool star, since the signal is measured for image elements rather than global irradiance. The Study Report (# 1.4 & 1.5) indicates solar-system and galactic studies of interest.

PROSPECTS AND CONCLUSIONS

The development and realization of the SIMURIS instruments will be a major endeavor, worth the quantum step in performances compared to classical instrumentation if a true physical understanding of the solar atmosphere is sought for. Many of the proposed designs and techniques are new requiring further detailed studies and laboratory testing. Some of them will be possible during the ESA Phase A that is now engaged, but further support for developments is also expected from National Agencies through the Columbus Preparatory Programs (Precursor Flights).

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REFERENCES

/1/ Coradini, M., Damé, L., Foing, B., Haskell, G., Kassing, D., Olthof, H., Mersch, G., Rutten, R.J., Thorne, A.P. and Vial, J.-C., 'SIMURIS Scientific and Technical Study – Phase I', ESA Report SCI(91)7, August 1991

/2/ Damé, L., Rutten, R.J., Thorne, A.P. and Vial, J.C., 'Model Payload and System Design of the SIMURIS Interferometric Mission', in Proc. of the 43rd Congress of the International Astronautical Federation, August 28-September 5, Wahington DC, 1992 (to be published in **Acta Astronautica**)

/3/ Damé, L. and Guyenne, T.D., *Solar Physics and Astrophysics at Interferometric Resolution, An International Workshop to Present SIMURIS*, ESA SP-344, 1992

/4/ Pang, J., 'SIMURIS—SUN Instrument Assessment Study, Mechanical Outline', ESA-ESTECReport YMD/JP/SUN/9102, February 1991

/5/ Bureo, R., 'SIMURIS—SUN Instrument, Structural Assessment', ESA-ESTEC Report YME/RB/1125, September 1991

/6/ Snijders, B. and Braam, B.C., 'SIMURIS-SUN Assessment Study: System Review, Optical Lay-out Evaluation, Sensitivity Analysis', TPD/TNO Report TPD-HOI-RPT-91-148, September 1991

/7/ Braam, B.C., Snijders, B., Bokhove, H and Lansbergen, R., 'Imaging Fourier Transform Spectrometer (IFTS) Preliminary Design Study', TPD/TNO Report TPD-HOI-RPT-92-133, 1992