The CoRoT Legacy Book

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# I.2

# Seeds take root in Europe

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The first ideas were discussed near Ussel (Corrèze, France) in 1981, during an unformal meeting devoted to solar and stellar activity, attended by a small group of scientists interested in stellar magnetism. It is there that the idea of dedicating a small satellite for monitoring stellar activity was born, taking advantage of both the UV access from space, and the possibility to perform long uninterrupted observations. Philippe Lemaire started immediately to draft the design of a simple spectrograph for monitoring simultaneously various lines probing stellar activity at various heights in stellar atmospheres. A month later, in June 1981, another meeting took place in Paris, with the goal of defining in more details the project born in Ussel.

By the late 1970s, helioseismology was a rapidly maturing field and some astronomers saw the advantage of introducing photometry to monitor simultaneously stellar oscillations and stellar activity. This coupling of seismology and activity studies within the same experiment drove most of the proposals that were made in the following years.

In 1982 the French team submitted the first proposal to CNES for a space mission EVRIS (Mangeney et al. 1982) and received funding to develop the concept. The same team submitted the project (renamed PSIVA) in response to a call for ideas from ESA, and as a possible experiment on the Space Station but these were not successful.

Then, an international colloquium organised by Françoise Praderie and André Mangeney at Paris Observatory (Meudon) in 1984 called "Space Research Prospects in Stellar Activity and Variability" gathered a world wide community of 60 participants (Praderie & Mangeney 1984) (Fig. I.2.1). It confirmed the wide and international interest for asteroseismology and stellar activity from space, and can be considered as the cornerstone of this field.

Almost simultaneously, the American community held also a workshop *Improvements in photometry*, held at San Diego in June 18–19 1984 organised by W. Borucki from NASA Ames, confirming the international interest of this new domain.

The first sketches of an instrument were designed by French space laboratories in France (Observatoire de Paris and Laboratoire d'Astrophysique de Marseille). It kicked off a long quest to find a flight opportunity for this instrument, during which many options were pursued.

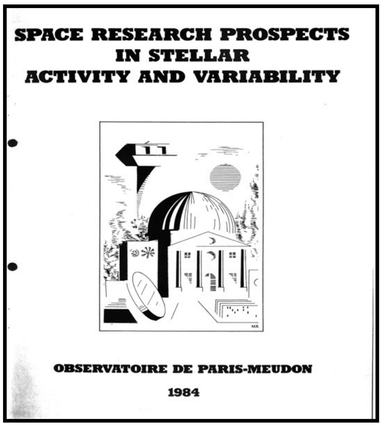



**Fig. I.2.1.** Cover page of the book of contributions of the colloquium : Space research projets in stellar activity and variability. © Observatoire de Paris

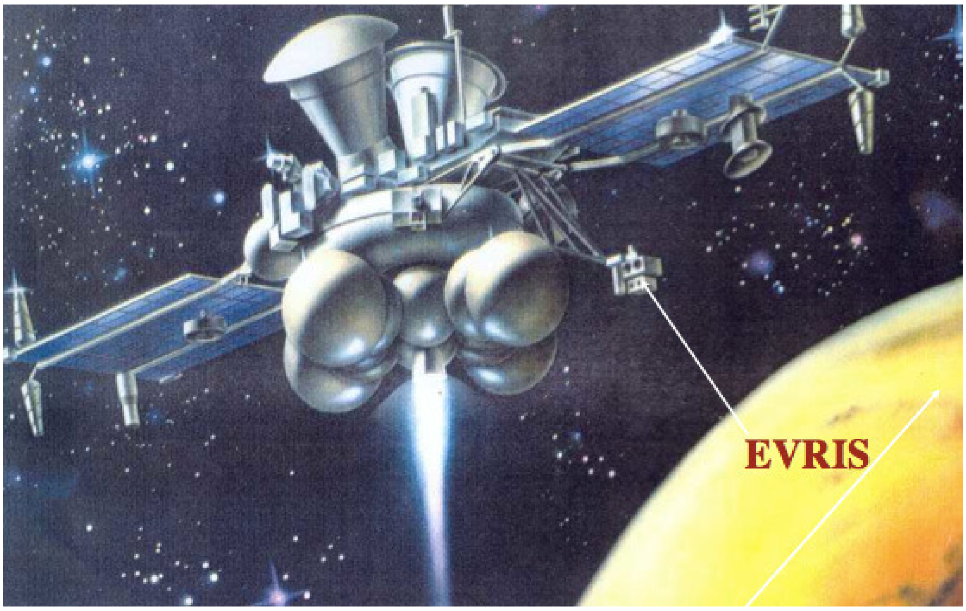
The PRISMA project has been submitted by an international team in response to a call for proposals from ESA (Praderie et al. 1985). It was a dedicated mission combining the two objectives of variability and activity. It was considered for a feasibility study, at ESA, but not selected. It was also proposed to ESA as a possible experiment on the Eureka B platform, but Eureka B was cancelled.

The EVRIS/PSIVA project was studied as a possible experiment to be installed on the interplanetary spacecraft VESTA, a USSR mission to Venus (Praderie et al. 1984) but the mission was cancelled. It was also proposed as an add-on experiment on SOHO (Praderie et al. 1987a) but rapidly rejected as being incompatible with the solar operations.

## 1. The EVRIS step

EVRIS (Etude de la Variabilité, de la Rotation et des Intérieurs Stellaires) was proposed first by Mangeney et al. (1982), then by Baglin et al. (1988/89) and Praderie et al. (1987b) and was selected to fly on board the USSR mission MARS 92 (which became MARS 96) in the framework of the French-Soviet Space Collaboration.

(a) The EVRIS instrument. © CNES




(b) Artistic view of the MARS 96 space craft and the position of EVRIS/PAIS. © pages.erau.edu/~ericksol/courses/sp425/s2003/mars.html

**Fig. I.2.2.** EVRIS experiment onboard MARS 96.

It was dedicated to stellar seismology and has been designed to observe about 10 of very bright stars (visual magnitude smaller than 6) 20 days each during the 9 months of the cruise to Mars (Michel et al. 1995).

The instrument was a small 9 cm diameter telescope, associated to a stellar sensor for pointing (Vuillemin et al. 1998; Buey et al. 1997; Weiss et al. 1998).

The detector was a photomultiplier built by Hamamatsu (at that time CCDs were not space qualified). The optics was designed to form the image of the entrance pupil on the photocathod of the detector, to gather almost all the stellar photons (Fig. I.2.2a).

It was fixed on a Russian platform PAIS, in charge of the precise pointing, and installed under the solar panels of the spacecraft (Fig. I.2.2b).

Due to political and financial difficulties in Russia, the launch was postponed and the mission became MARS 96.

After a successful launch by a PROTON rocket on October 16th 1996, from the space centre of Baïkonour, it performed three orbital Earth revolutions and due to a failure of the motors in charge of the injection on a Mars trajectory, the whole 6-tons spacecraft and its 46 experiments, including EVRIS, disintegrated in the upper Earth atmosphere above Chile and Bolivia.

## 2. Attempts in the ESA Horizon 2000 programme

Horizon 2000, the scientific programme of ESA during the years 1985/2000, was the first international space programme in which solar and stellar seismology was seriously considered. This programme consisted of 4 "corner-stones", very large missions and 4 medium size missions.

Several stellar seismology proposals were submitted in response to calls for the medium size mission (M-missions) part of the programme during these years.

The first of these was a second much superior version of PRISMA (Lemaire et al. 1989), which was covering seismology and activity (the latter in the UV). It was first assessed and then selected for a Phase A study (Appourchaux et al. 1993) but in the end, it was not chosen for flight. It lost in competition with the Integral gamma- and X-ray mission launched in 2002.

At the next call for M-mission proposals, in 1993 for a flight opportunity in 2002/2003, the STARS mission (Lemaire et al. 1992; Fridlund et al. 1995) was selected for further study. Initially it had objectives analogous to PRISMA, so that the definition phase started running at full speed.

Then in November 1995 came the stunning announcement that an actual exoplanet, orbiting the solar type star 51 Pegasi had been discovered (Mayor & Queloz 1995) and it was rapidly understood that this stellar mission can be used to simultaneously search for transiting exoplanets. This was an incredible game changer and STARS suddenly began to catch up. Even more, the 51 Pegasi b planet and the next few planets discovered before April 1996 demonstrated that STARS would find a large number of planets and also very easily. It was clear that a category of planets, the "hot Jupiters" that had been discounted by most theoreticians (except Struve 1952), was present in numbers large enough for STARS to find and study many.

It took a minimum of time and effort to implement an additional layer in the study taking the planet finding aspect into account. This led ESA to commission industry to study the exoplanetary requirements of what in principle was a large telescope (STARS the same size as Kepler later became – i.e. a one-meter class telescope) flying in space with an attached spacecraft bus. The two most stringent requirements imposed by adding a planet finding element were to achieve an as large field of view as possible, and a very high pointing stability. The optical design was a triply reflecting 1-m telescope with, a 1.5 deg$^2$ field designed by M. Badiali (Badiali & Amoretti 1997) (Fig. I.2.3). The jitter requirements have been controllable in a way analogous to the one used onboard CoRoT.

This actually saved STARS that was in competition with what eventually became the PLANCK mission for another few years. The final selection of which mission to fly was to be in April 1996, and STARS was trailing in the opinion polls behind PLANCK.

Nevertheless, STARS lost the game against PLANCK, by only one vote, in April 1996. However, the topics of asteroseismology and exoplanetology were here to stay.

At the next call for mission opportunities, issued by ESA, the EDDINGTON mission was proposed by Ian Roxburgh, Jørgen Christensen-Dalsgaard and Fabio Favata (Fig. I.2.4) (Roxburgh et al. 2000). It was selected as a "reserve mission" in 2000, approved in 2002 and put into development (the CCD detectors began to be manufactured).

EDDINGTON was designed, after MOST and CoRoT, to perform an extensive and far-reaching survey, beginning in 2008. The EDDINGTON payload was a wide-field, high-accuracy optical photometer, and it was characterised by its simplicity and robustness. Thanks to its large field of view, EDDINGTON could acquire data

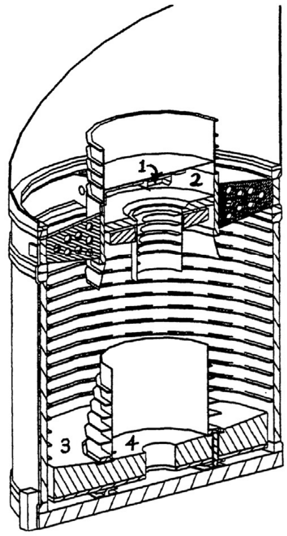



**Fig. I.2.3.** An exploded view of the payload of STARS. © ESA. The numbers refer to: 1) location of the photometric detector; 2) location of the second instrument: Lyman Alpha Monitor (LAM); 3) Outer section of the main mirror; 4) inner section of the main mirror.

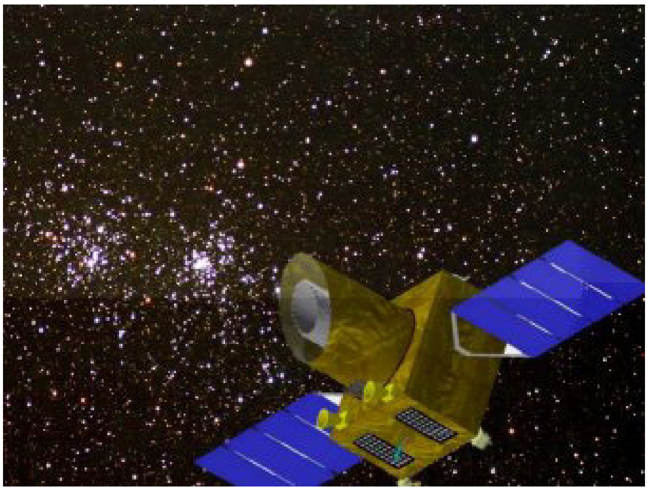


**Fig. I.2.4.** Artistic view of the Eddington project. © ESA.

simultaneously on a very large number of targets: high-time-resolution asteroseismic data would have been collected on about 50 000 stars, while planetary transits would have been searched for on about 500 000 stars.

The launch vehicle was to be a Soyuz-Fregat rocket launched from the Baïkonour Cosmodrome, and the mission was to be deployed at the L2 Lagrangian point, where it would have stayed for the planned 5-year mission length.

It was cancelled in 2004 for financial reasons (Roxburgh 2006). By that time, CoRoT, although a less ambitious mission, had stepped up to the starting line.

Finally, this long list of rejected proposals to ESA ended with the selection of their ambitious successor PLATO, provisionally scheduled for launch in 2024 (see Part V.3 of this book).

## 3. MONS in Denmark

MONS was a project proposed by Danish laboratories, to an answer to a call for the Danish Small Satellite Mission,

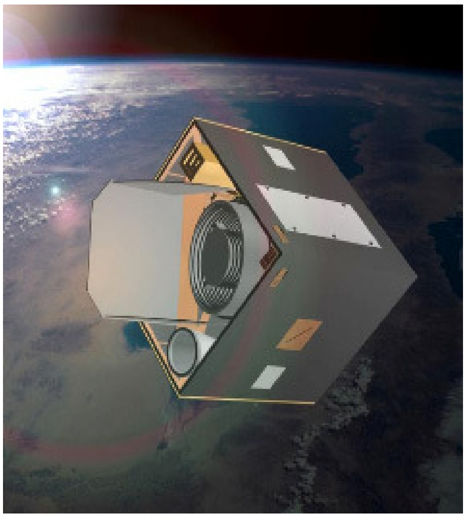


Fig. I.2.5. Artistic view of the MONS satellite. © DSRI, www.space.aau.dk.

as the main instrument on the ROEMER satellite, a small, low cost bus with only one payload and a strong cooperation between industry, universities, and research organisation (Fig. I.2.5)

Its primary objective was to observe the oscillations of 20 solar type stars, during one month (Kjeldsen et al. 2003).

The telescope was a 32-cm reflector, working in optical, and would be launched in an elliptical high apogee orbit. The detailed design phase started in June 2001, for a launch in 2004. But finally the project was not selected.

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