

Françoise Praderie

Opening new ways in stellar physics



*the
1960's*

Model atmospheres - radiative transfer

1960: Françoise's first paper in « Annales d'Astrophysique »

ÉCARTS A L'ÉQUILIBRE ET ABONDANCES
DANS LES PHOTOSPHÈRES SOLAIRE ET STELLAIRES

III. — ÉCARTS A L'ETL DANS LA BANDE CH 4 300 (CAS SOLAIRE).

par Françoise EUGÈNE-PRADERIE ⁽¹⁾ et J.-C. PECKER

(École Normale Supérieure de jeunes filles de Sèvres et Observatoire de Meudon)

Manuscrit reçu le 7 janvier 1960.

Françoise is among the first to recognize the importance of NLTE and to derive methods to compute spectral lines in NLTE

NLTE radiative transfer will always remain one of her major centres of interest

*the
1960's*

A-type stars

1960-1967: Françoise's thesis, under advisorship of J.C. Pecker, then R. Cayrel

Am stars: model atmospheres, abundance determinations, physical interpretation

ANALYSE D'ÉTOILES A RAIES MÉTALLIQUES

II. COMPOSITION CHIMIQUE DE ζ LYR A SPECTRE INFRAROUGE PROCHE DE CINQ ÉTOILES A_m

Annales d'Astrophysique:

Manuscrit reçu le 10 novembre 1967.

par Françoise PRADERIE,
Observatoire de Paris-Meudon.

- atmospheric structure
(hydrogen Balmer and Paschen lines)
- NLTE abundance determination
NLTE radiative transfer and
model atmospheres still in their infancy
(Mihalas book 1st edition = 1970)
- atomic parameters
not well known:
oscillator strengths, collision x-sections, broadening
collaboration with atomic physicists

Françoise will then
play major role in
the development of
these areas

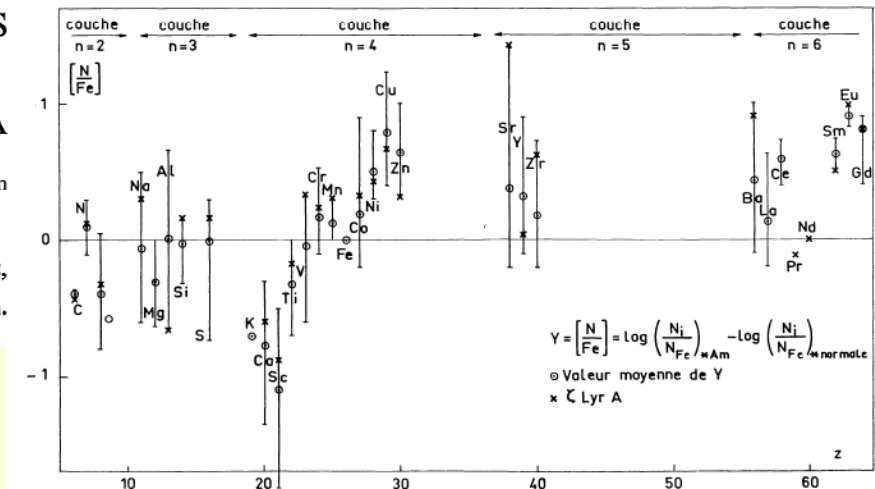


FIG. 13.
Abondances des éléments dans ζ Lyr A, rapportées à l'abondance du fer, et à une étoile normale.

Collaborations: J.C. Pecker, R. Cayrel, H. Van Regemorter, N. Feautrier, M. Seaton, ...

- first clues for atomic diffusion
- but no clear model yet ...
radiative accelerations could not be computed

*the
1970's*

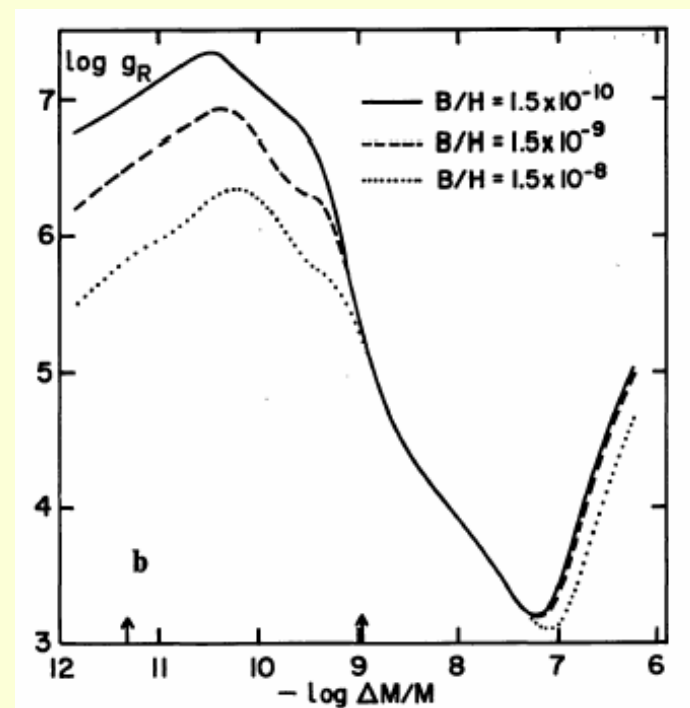
Models of Am/Ap stars

Am, Ap stars: models of atomic diffusion

Astron. Astrophys. 76, 287–296 (1979)

Radiation Forces and the Abundance of Boron in Normal and Peculiar Stars of Type A and B

J. Borsenberger¹, G. Michaud², and F. Praderie¹



- accurate NLTE calculation of radiative forces
- using full atomic models (radiative rates, collision rates, line broadening)
- importance of NLTE treatment in the atmosphere
- models of Am/Ap stars with atomic diffusion without adjustable parameter !

————→ demonstration of validity of diffusion theory

*the
1970's*

Nonradiative heating

1970-1971: Françoise spends one year at JILA, Boulder

Nonradiative heating in stellar atmospheres

Analytical formulation including NLTE effects

collaborations: R.N. Thomas, J.C. Pecker

THE ASTROPHYSICAL JOURNAL, 172:485-490, 1972 March 1
ON ESTIMATES OF THE NONRADIATIVE ENERGY INPUT TO
THE SOLAR CHROMOSPHERE FROM THE H⁻ EMISSION

F. PRADERIE* AND R. N. THOMAS†



other collaborations: D. Mihalas, J. Linsky, P. Conti, ...

*from the 1960's
to the 1970's*

First conclusions

Model atmospheres

Radiative transfer

Françoise has opened a new approach to stellar physics (at least in France) :

- model atmospheres
- radiative transfer
- importance of NLTE effects
- atomic/molecular physics calculations: bridges astrophysicists / atomic physicists

We owe her most of the developments of these fields in France

*the
1970's*

A milestone: the first UV spectra

1. back in the 1960's, collaboration with R.M. Bonnet:
first solar UV spectra (rocket experiments)
need for improved atomic data
calculation of UV spectra

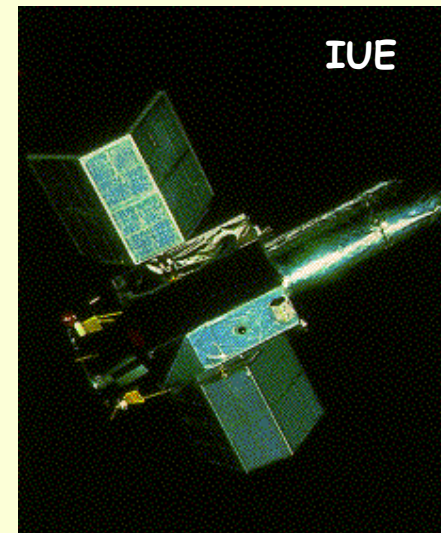
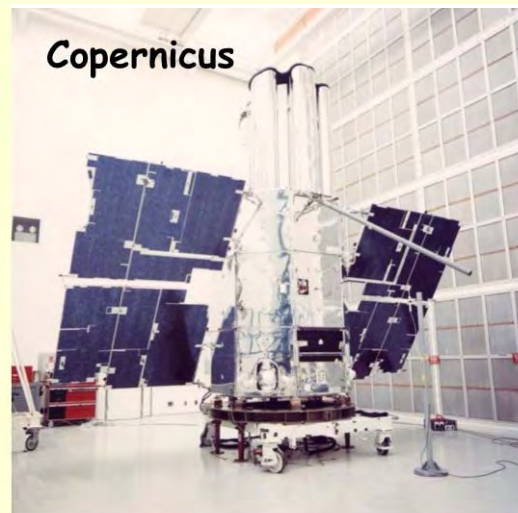
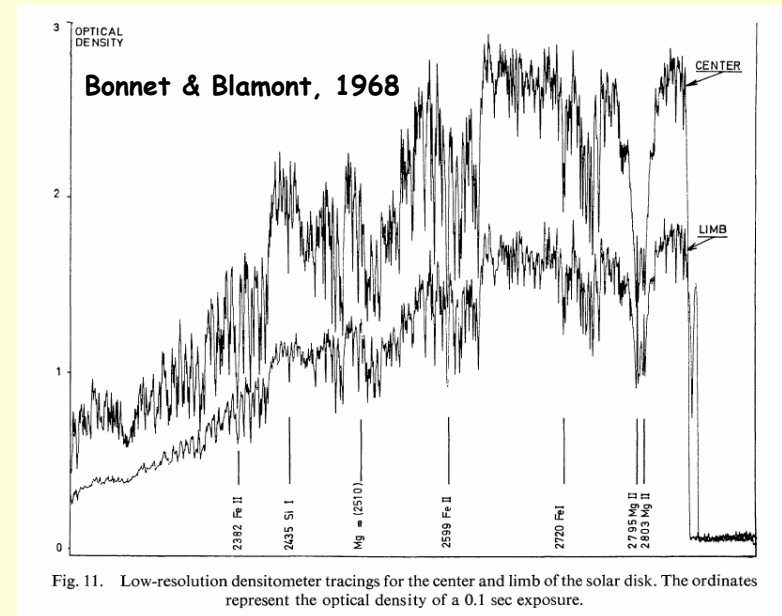
2. first UV satellites:

TD1 - 1972

Copernicus - 1972

IUE - 1978

- stellar UV spectra
- new revelations on stellar atmospheres



*the
1980's*

UV spectra of A-type stars: a gold mine !

collaborations: C. Jamar, P. Kunasz, D. Mihalas, A. Talavera, L. Crivellari, P. Felenbok, C. Catala

activity of A-type stars: a surprise ($\text{Ly}\alpha$)

winds in A-type stars: A-supergiants, PMS Herbig Ae/Be stars

modeling these winds: NLTE calculation of UV lines - comoving frame approach (Catala's thesis)

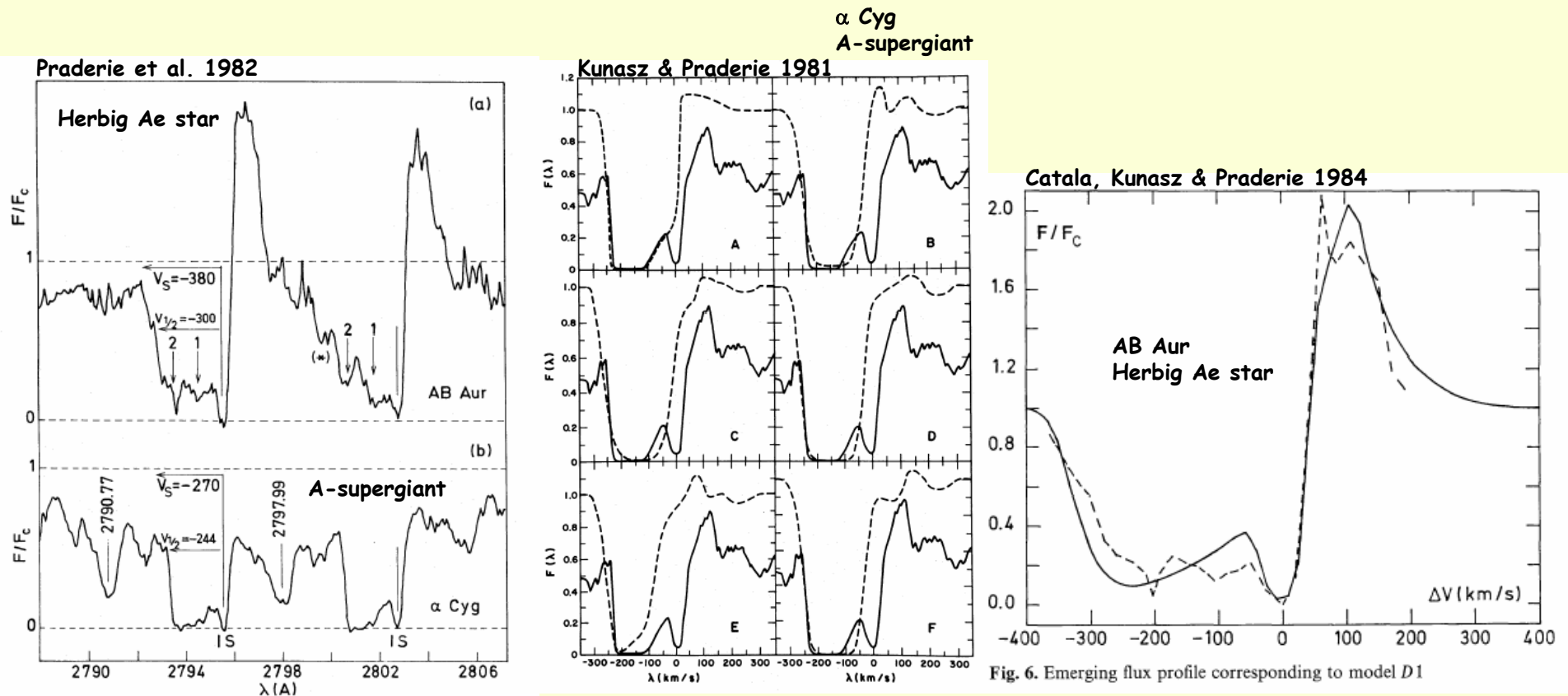


Fig. 6. Emerging flux profile corresponding to model D1

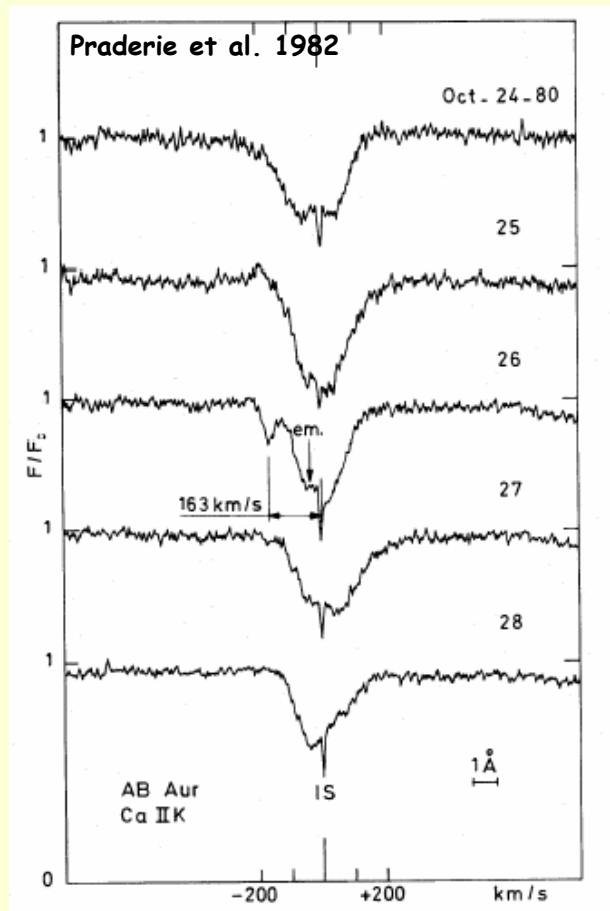
*the
1980's*

A second milestone: 1st light at CFHT

Visible high resolution, high S/N spectra of A-type stars

another gold mine !

activity of A-type stars: A-supergiants, Herbig Ae/Be stars



collaborations: A. Talavera, C. Catala, P. Felenbok, A. Boesgaard

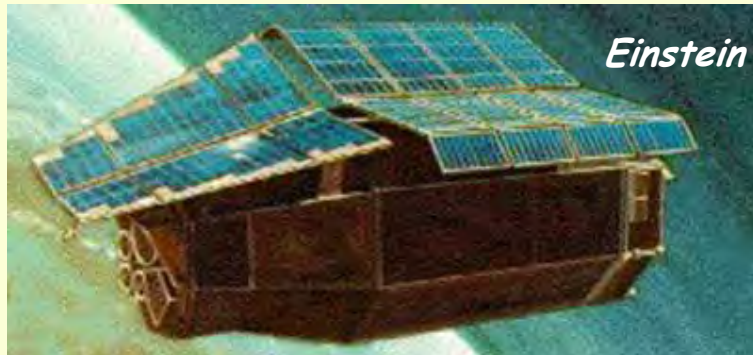
*the
1980's*

A third milestone: 1st X-ray observations

Einstein, Exosat

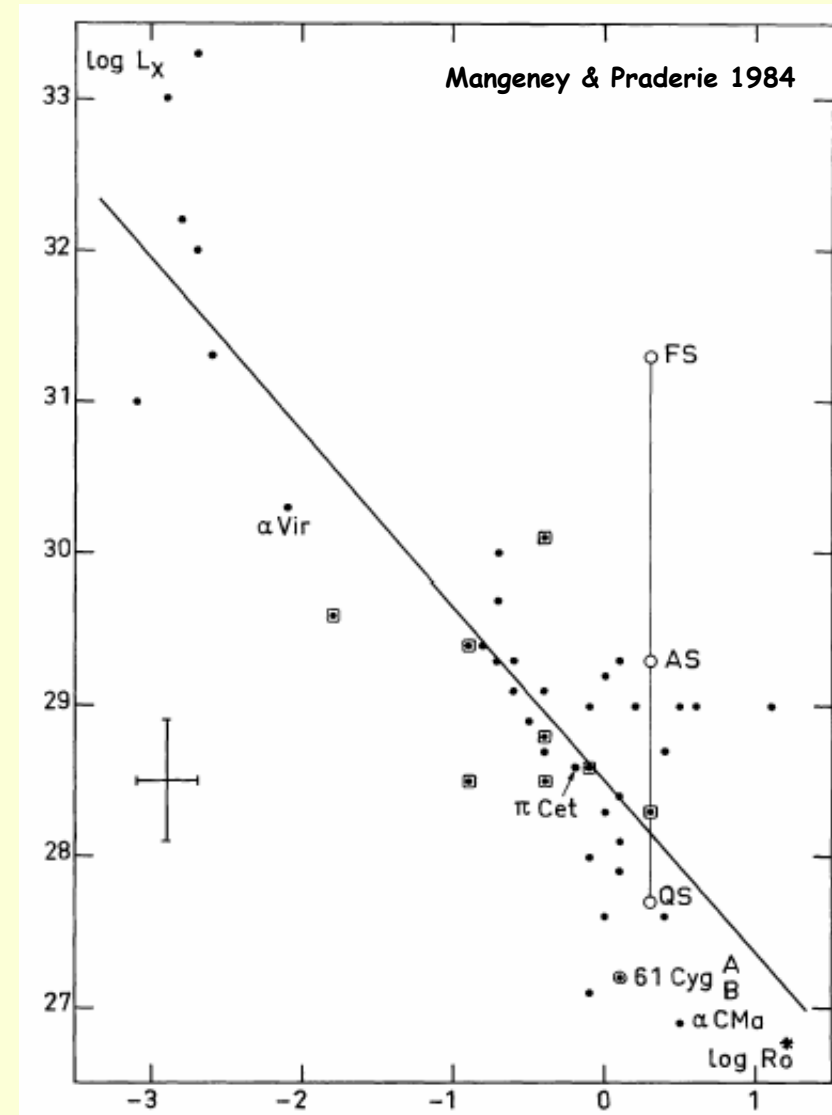
X-ray sources all across the HR diagram

empirical statistical study of stellar
activity through X-ray emission



common mechanism of coronal emission
for all main sequence stars ?

collaboration: A. Mangeney



*from the 1970's
to the 1980's*

The UV, X-ray & high res spectroscopic revolution

in the 1970's and early 1980's,

Françoise was among the first to enthusiastically use novel facilities:

- UV and X-ray satellites
- large modern telescope with high resolution spectrograph

—————→ A-type stars can have strong stellar winds !
A-type stars can be active !
unique kind of activity all across the HR diagram?

*the
1980's*

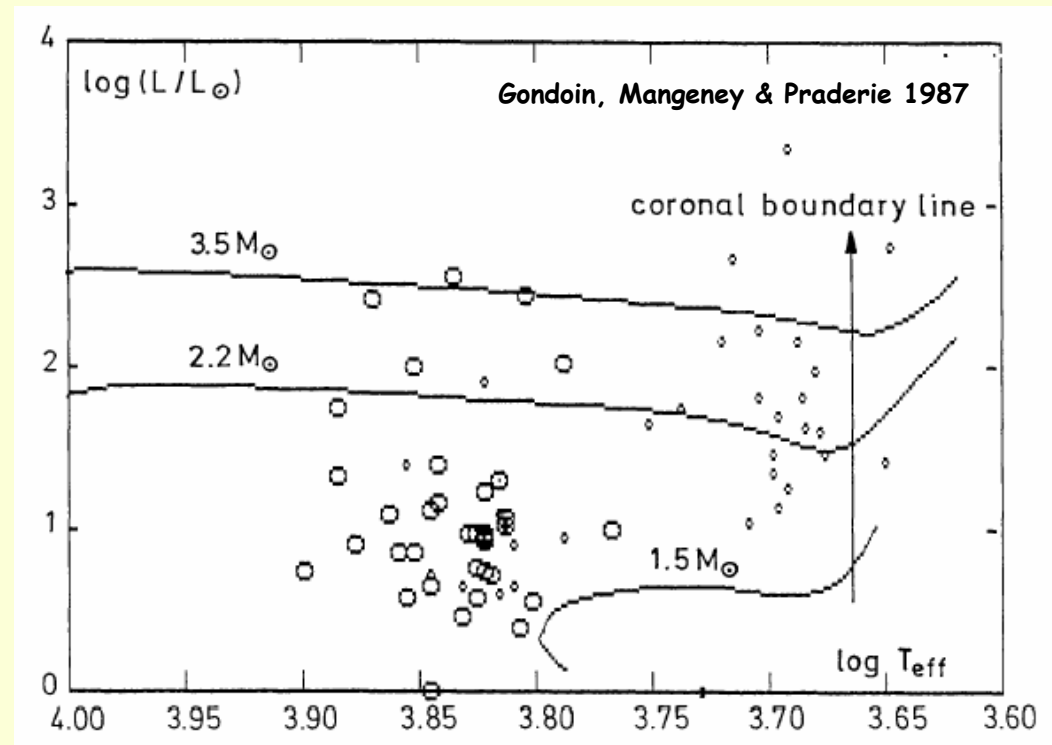
Studying stellar magnetic activity

X-ray activity of giants

coronal dividing line
 \neq rotational velocity dividing line

there is more than rotation
to activity of cool giants :
role of convection?

Gondoin's thesis

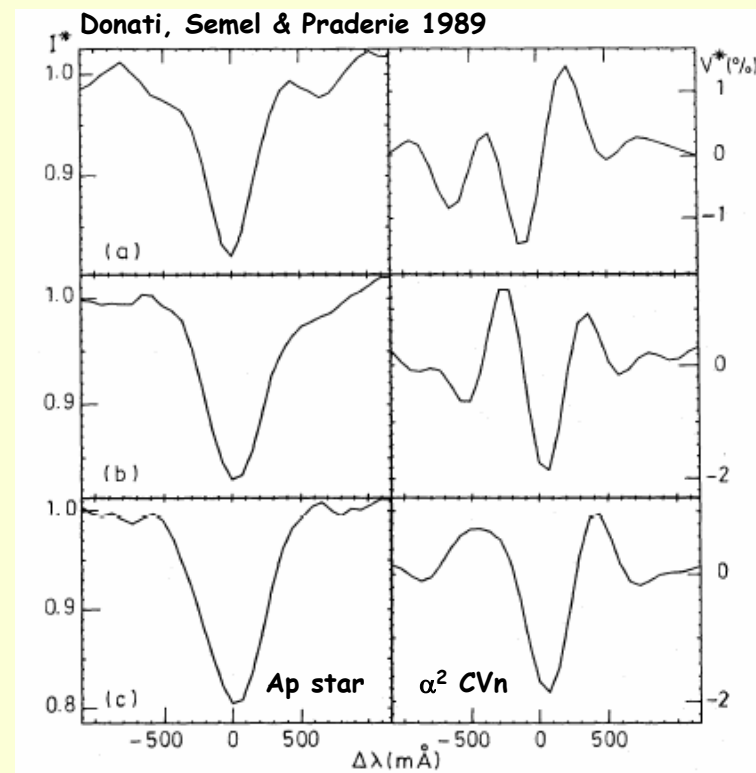


*the
1980's*

Studying stellar magnetic activity

direct measurement of stellar magnetic fields via spectropolarimetry

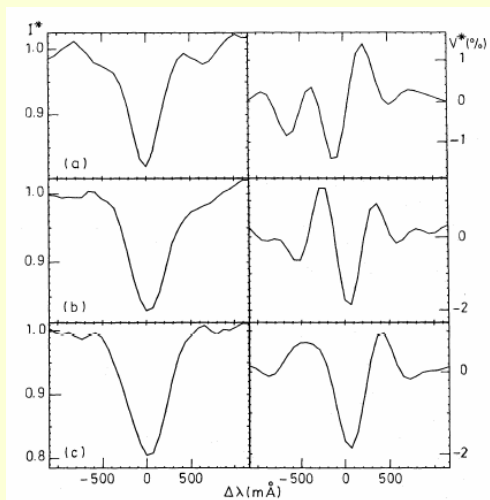
Donati's thesis



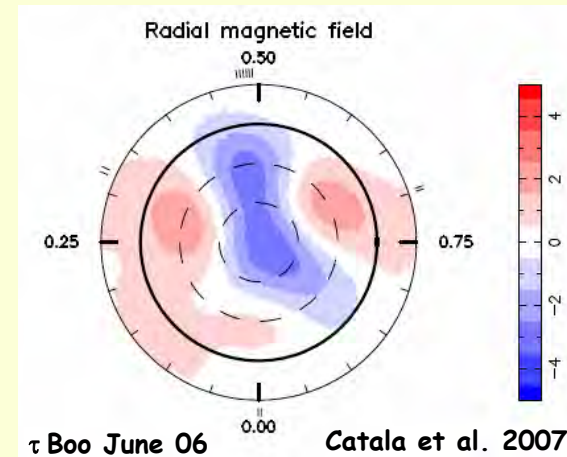
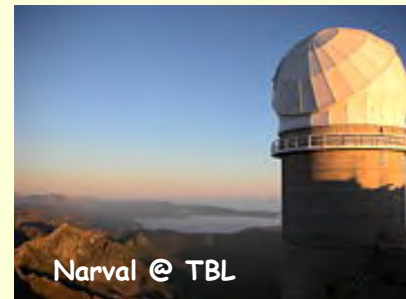
today

Stellar spectropolarimetry: a new tool to study stellar magnetic fields

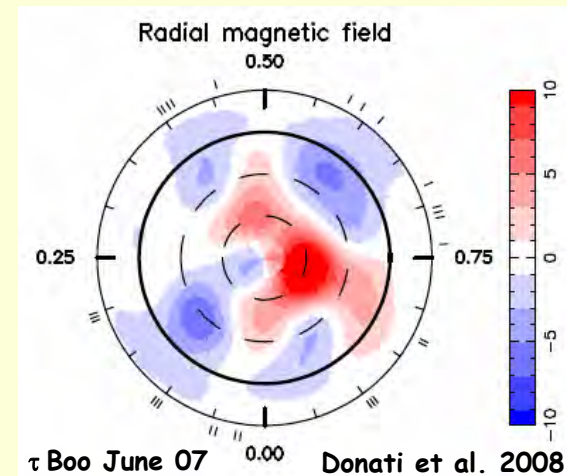
Donati, Semel & Praderie 1989



OHP + experimental polarimetric setup



short activity cycle in a hot Jupiter host



- and also:
- magnetism of T Tauri stars
 - magnetism of solar twins
 - magnetism of hot stars

today

Stellar spectropolarimetry: a new tool to study stellar magnetic fields

Today, french astronomers are at the forefront of research in the field of spectropolarimetry and stellar magnetic fields.

- ESPaDOnS @ CFHT
- Narval @ TBL
- SemelPol @ AAT
- SPIRou @ CFHT (in project)

We owe these achievements to Françoise Praderie and Meir Semel

*from the 1970's
to the 1980's*

Stellar variability

Spectroscopic variability of A-type stars

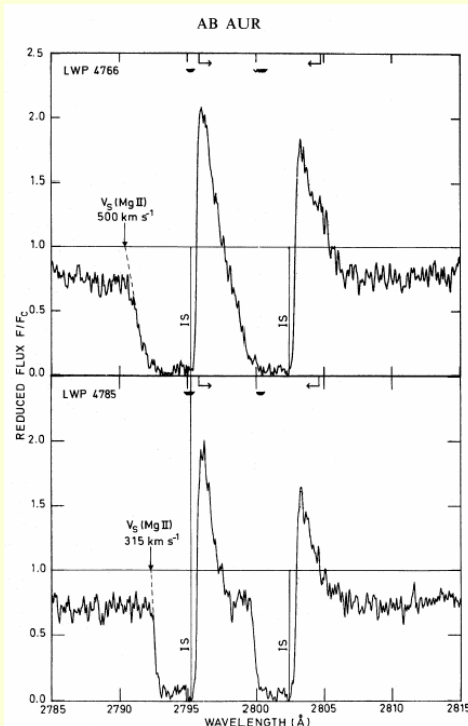
δ Sct stars

in 1970, Françoise participates to a group studying δ Scuti stars - she brings in theoretical approach, and calculates atmospheric models to reproduce observed variability - with J.M. Le Contel, J.C. Valtier, J.P. Sareyan, A. Baglin

Short Period Variable Stars III High Resolution Spectra of the K Line in γ Bootis and Three Other A Type Stars

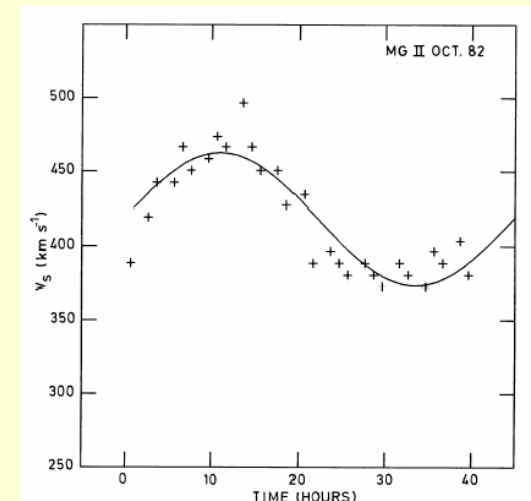
J. M. LE CONTEL, F. PRADERIE, A. BIJAOUTI, M. DANTEL and J. P. SAREYAN
Observatoire de Paris — Meudon

Astron. & Astrophys. 8, 159—167 (1970)



Herbig Ae/Be stars

in the 1980's, Françoise leads a group studying spectroscopic variability of the PMS Herbig Ae/Be stars, from IUE (UV) and CFHT (visible) spectra - clues for magnetic fields - with T. Simon, C. Catala, A.M. Boesgaard, A. Talavera, P. Felenbok, J. Czarny



SHORT-TERM SPECTRAL VARIABILITY IN AB AURIGAE: CLUES FOR ACTIVITY IN HERBIG Ae STARS. I. THE ULTRAVIOLET LINES OF Mg II AND Fe II¹

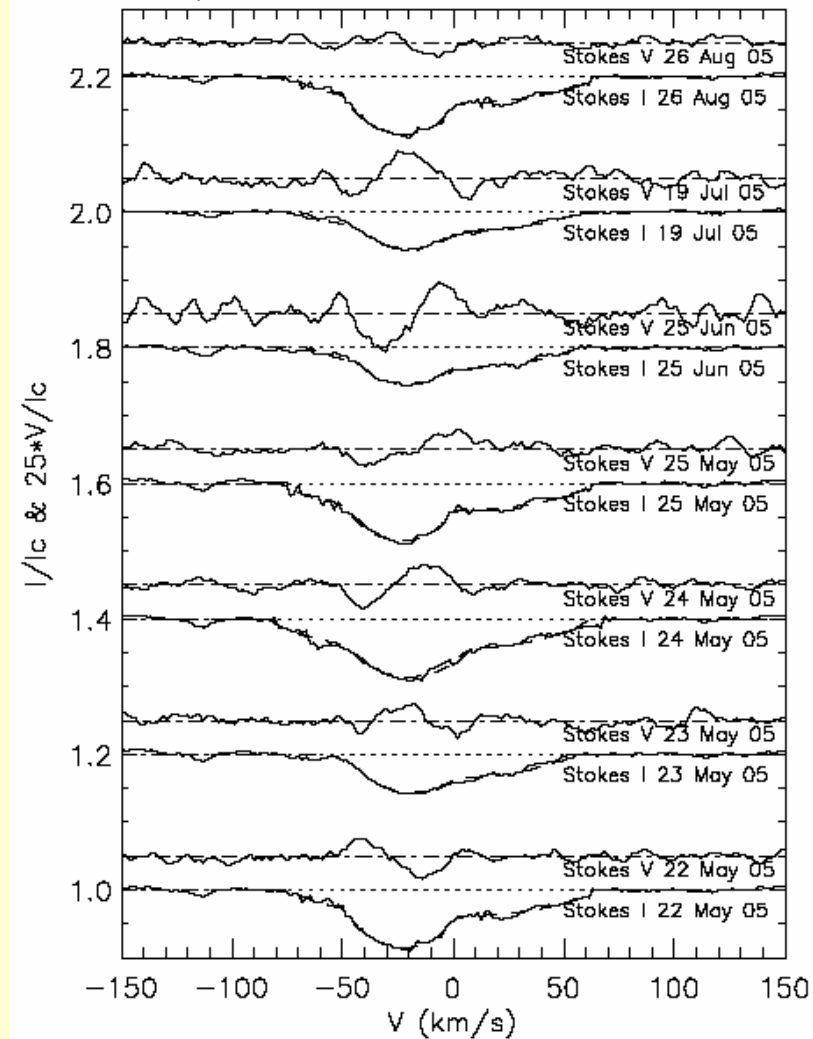
FRANÇOISE PRADERIE,² THEODORE SIMON,³ CLAUDE CATALA,² AND ANN MERCHANT BOESGAARD³

Received 1985 June 21; accepted 1985 September 25

THE ASTROPHYSICAL JOURNAL, 303:311–326, 1986 April 1

20 years later, magnetic fields of Herbig Ae/Be stars are measured at last !

HD 200775, Alecian et al. 2008



*the
1980's*

Stellar microvariability asteroseismology

Stellar activity, and in particular that of A-type stars (e.g. Herbig Ae stars) becomes a strong motivation to study stellar microvariability

Another, equally important motivation to study stellar microvariability, is the study of stellar oscillations

Important turn in Françoise's career

Microvariability and Asteroseismology

Genesis: 1981

May 10, 1981

- election of François Mitterrand
- meeting near Ussel (Corrèze)
of a small group of scientists on the theme
« stellar magnetic activity »:
among them,

Françoise Praderie

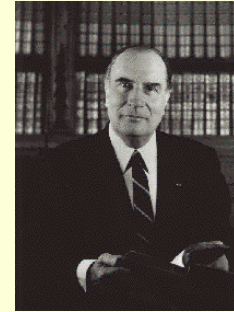
André Mangeney

Meir Semel

Andy Skumanich

Elisabeth Ribes

Philippe Lemaire



dedicate a satellite for **monitoring stellar activity**

June 1981

meeting in Paris: same people + Philippe Delache + Annie Baglin
proposal for monitoring simultaneously **stellar oscillations** and
stellar activity

First proposals: 1981-1983

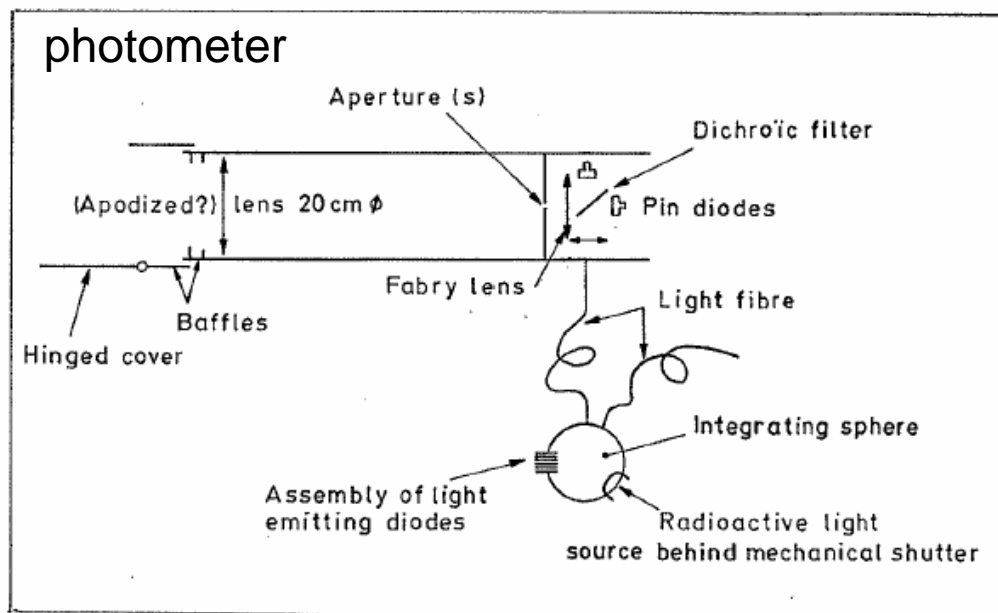
A space mission dedicated to the study of stellar seismology and activity

- stellar oscillations, probing the internal structure
- rotational modulation of activity tracers, measuring surface rotation
- topology of surface magnetic fields
- vertical structure of atmospheres

Initial instrumental concept:

- visible photometer (20 cm): variability to one ppm precision \wedge use stability of space
- UV spectrograph (40 cm telescope, 0.2 Å resolution):
monitoring Ca II K, Mg II k, He II 1640, CIV 1550

First proposals: 1981-1984



spectrometer

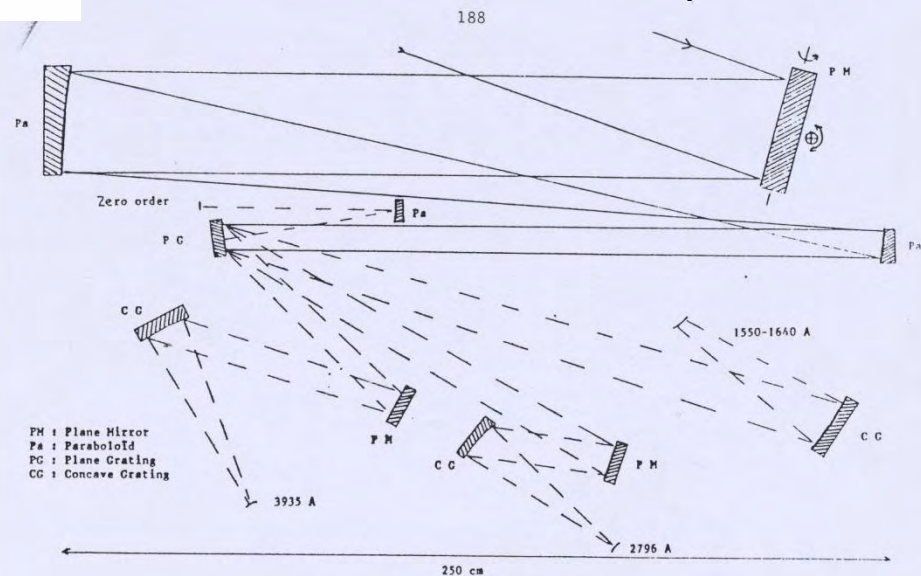


FIGURE III - Spectrograph optical scheme

First proposal: 1981

EVRIIS

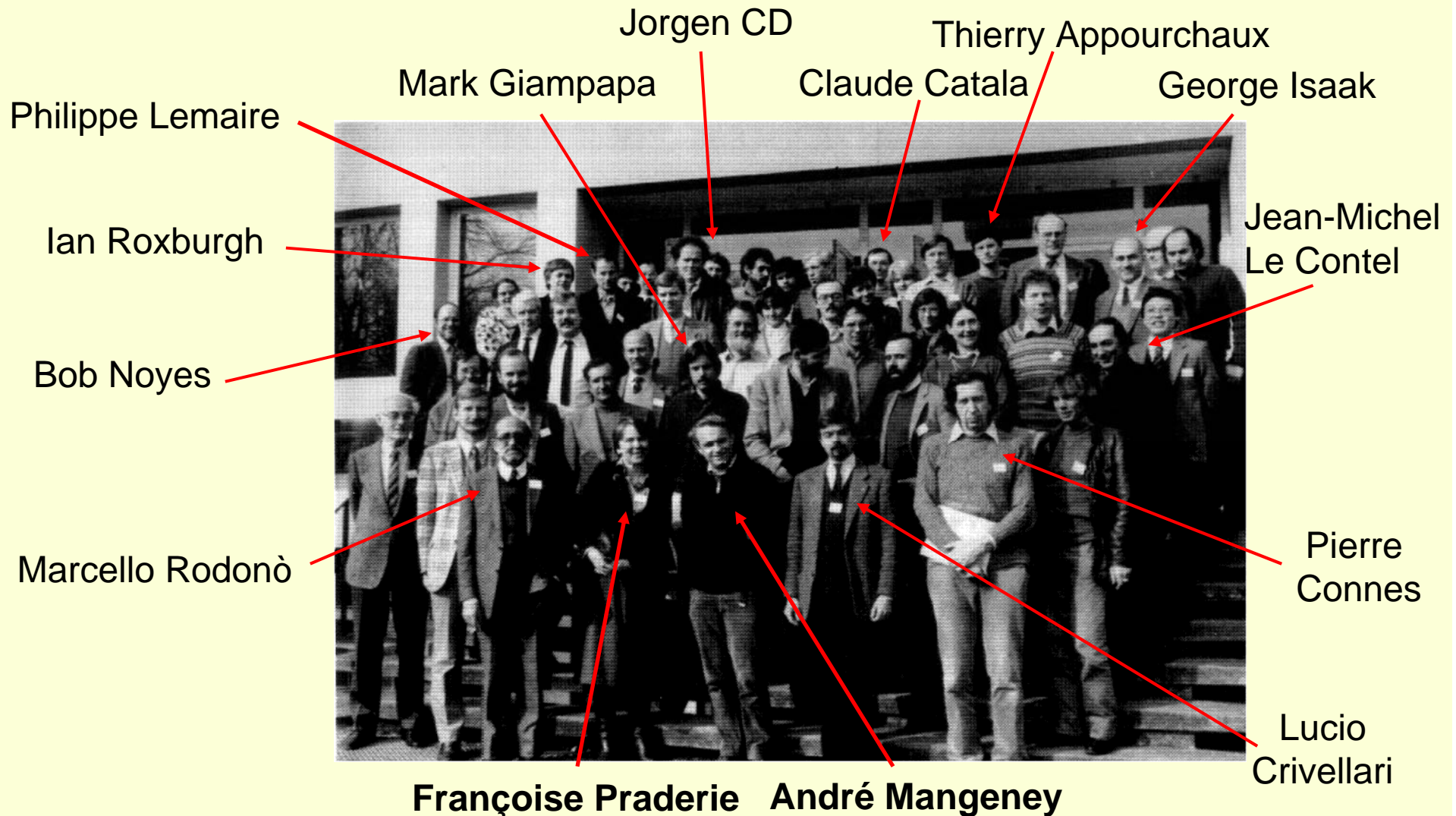


proposal at CNES prospective seminar (Les Arcs, 1981)
phase-0 (1982)

involving the international community

March 1984

space research prospects in stellar activity and variability
Observatoire de Paris - Meudon



First proposals: 1981-1984

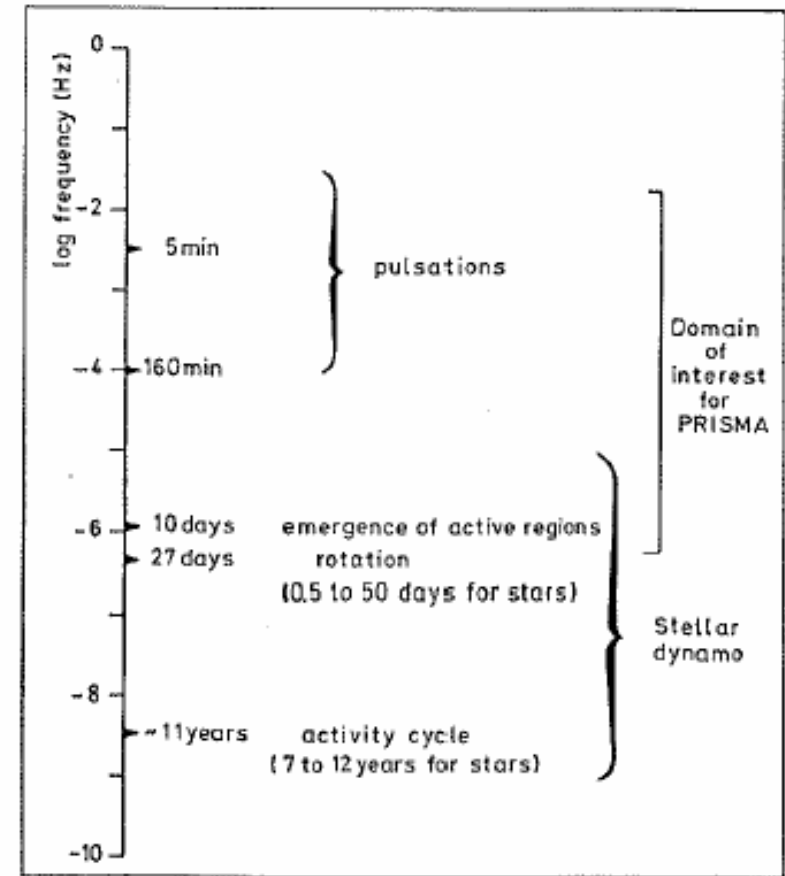
A PROPOSAL TO STUDY THE VARIABILITY AND ACTIVITY OF STARS

PRISMA

Probing Rotation and Interiors of Stars : Microvariability and Activity

Project Leader : Françoise PRADERIE

OBSERVATOIRE DE PARIS



PRISMA 1
PSIVA



unsuccessful

The heritage



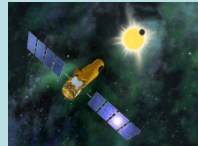
EVRIS:
1981-1996



9 cm photometer, onboard Mars 96,
collaboration with Soviet Union, then Russia
PI Françoise TM 1988, then Annie
lost after orbit injection failure



1993-today

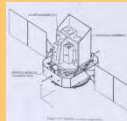


27cm photometer, 1st proposal 1993,
new design 1996 (wide field: seismology + exoplanets)
launch 12/2006

seismology + activity

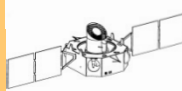


PRISMA2:
1989-1993



wide field photometry (visible) + spectroscopy (UV+X),
asteroseismology + stellar activity
phase-A study, not selected

STARS:
1993-1996



wide field photometry (visible + UV),
asteroseismology, stellar activity, (+exoplanets)
phase-A study, not selected

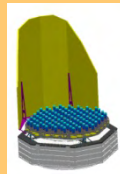
seismology + exoplanets

Eddington:
1998-2003



wide field photometry,
asteroseismology + exoplanets
selected, then cancelled

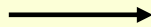
PLATO:
2007-????



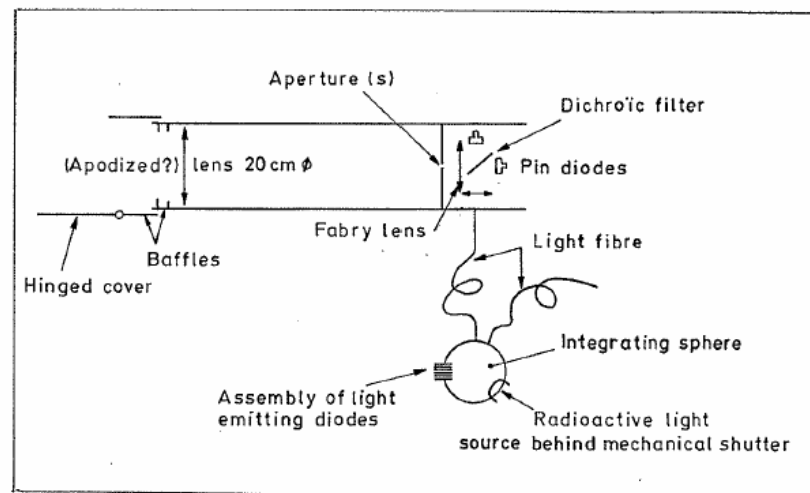
very wide field photometry,
asteroseismology + exoplanets
under study in the frame of « Cosmic Vision »

The microvariability adventure

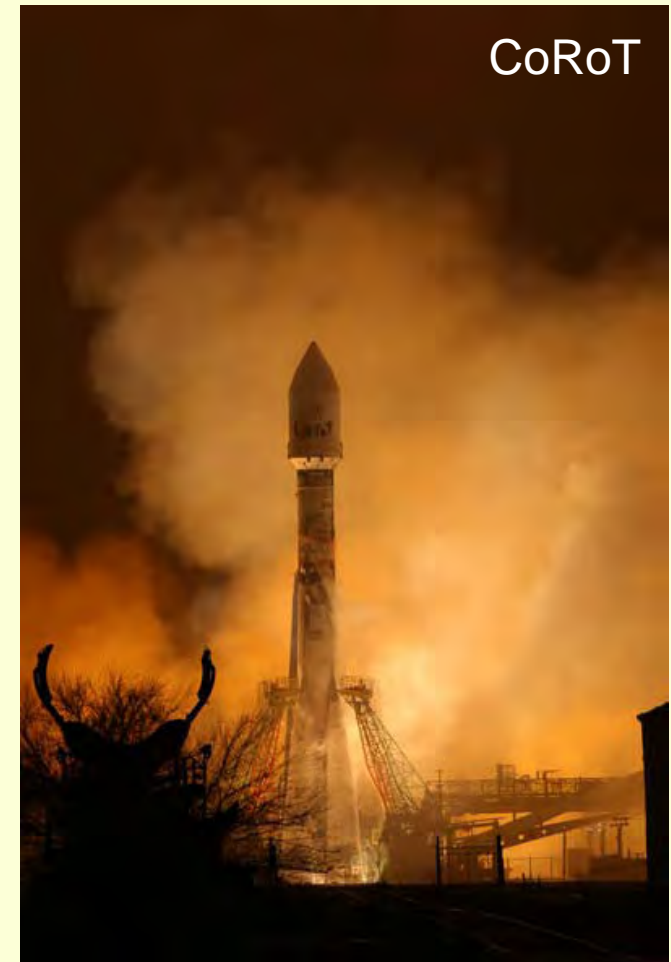
***Françoise Praderie & Annie Baglin at the origin of the long path
to stellar microvariability***



EVRIS initial proposal at CNES: 1981



25 years !



Baïkonour, 27 dec 2006, 15h23

Françoise Praderie

Curious

Critical sense

Rigorous

In depth investigator

Honesty

Very high standards

Sense of justice

Courage



deserve our respect and admiration

***this was Françoise Praderie, an exceptional woman,
of considerable talent and intelligence, who has given
all she had for science, for astronomy, for us all...***