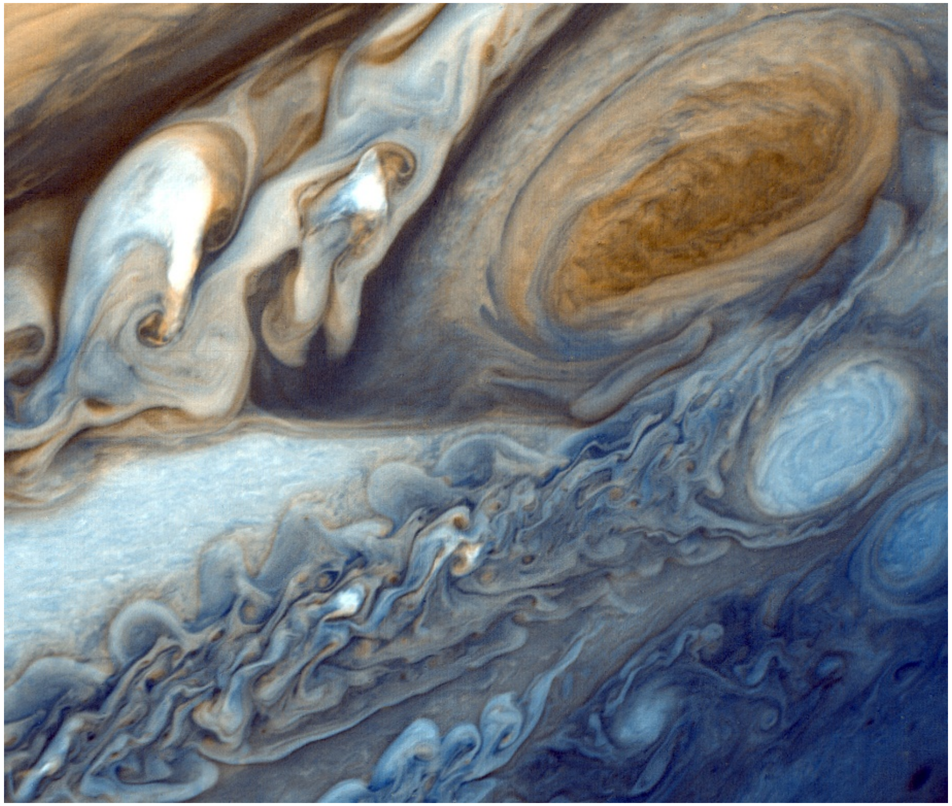
Welcome to the JOVIAL Kick-off meeting

JOVIAL

Jovian Oscillations through radial Velocimetry ImAging observations at several Longitudes



JOVIAL Kick-off meeting

- Objectives of the meeting
  - Programme

- JOVIAL project overview
- Context
  - History of the project
- Scientific objectives
- Work programme
- Organisation

Objectives of the meeting

- Definition of the scientific objectives
- Position of the project in the scientific context
- Organisation of the science groups
- Technical organisation of the network
- Identify key technical issues (telescope)
- Task responsabilities and planning
- Data policy

Kick-off agenda

Monday, April 18th

Observatoire de Nice, La Nef room

Presentation of the JOVIAL project

Lunch

Science with JOVIAL

Tuesday, April 19th

Observatoire de Nice, La Nef room

Mode physics

Lunch

Instrument Session

Other science/ complementary projects

Meeting Dinner

Restaurant Les Pêcheurs

Kick-off agenda

Wednesday, April 20th

University of Nice, Fizeau building, Room Olivier Chesneau

Technical plans

Visit of the laboratory and the instrument bench

Lunch

Organisation of the project

Discussion

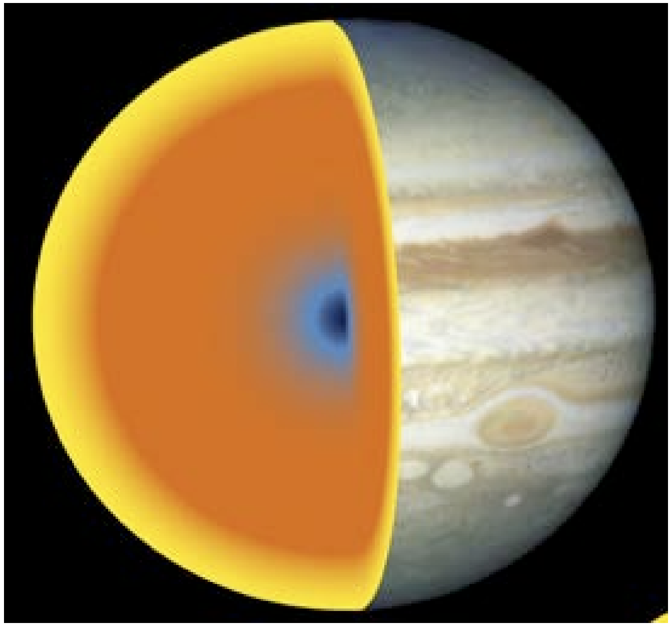
Meeting end

Thursday, April 21th

Calern Observatory

Visit of the observatory

JOVIAL



- Scientific goals
  - Internal structure of giant planets by seismology
  - Study of planetary atmosphere dynamics

- Observation strategy
  - Fourier imaging tachometer
  - Observation network

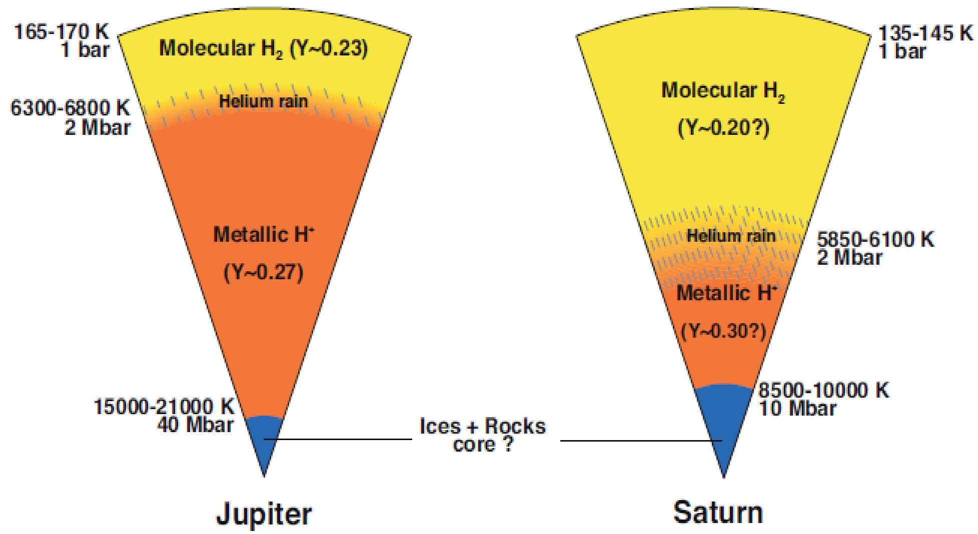
Internal structure of giant planets

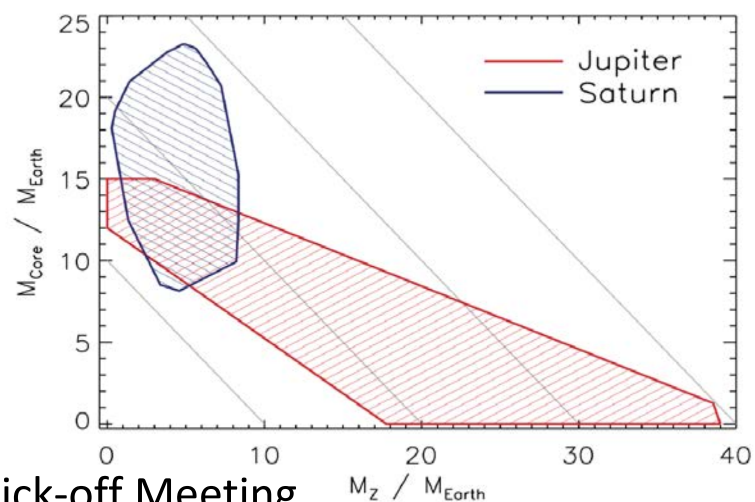
(see T. Guillot & M. Ikoma)

- Only few constraints
  - Mass, radius
  - Gravitational moments
  - Heat flux
  - Surface composition

- Non uniqueness
  - Initial conditions (formation)
  - Evolution (core erosion)
  - Equations Of State

Having access to the internal structure would give unique clues to formation and evolution of the Solar System



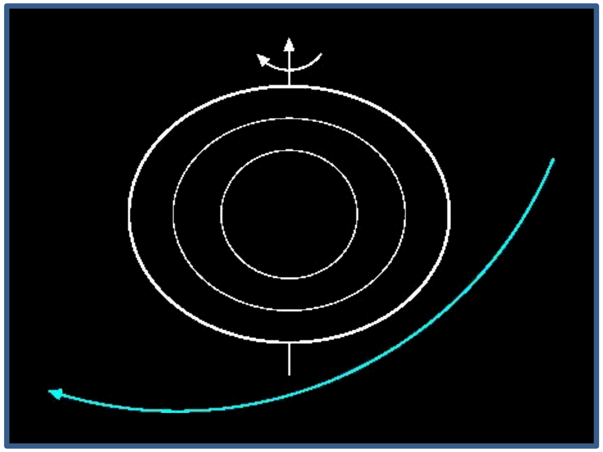


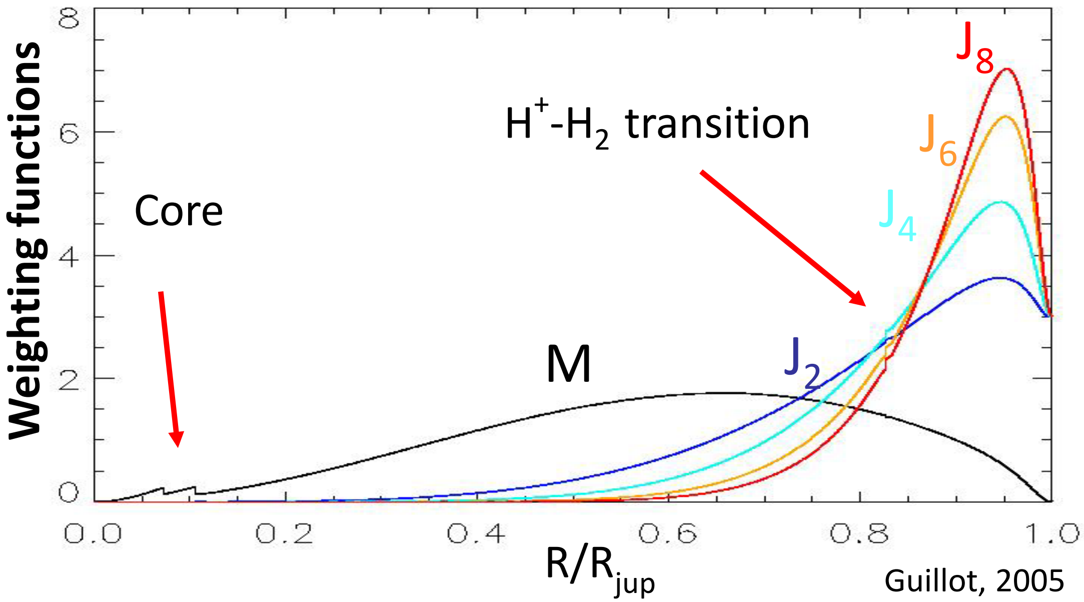
Gravitational moments

JUNO will enter the jovian system in June

Gravitational moments measurements directly probe the outer regions

(see D. Durante)



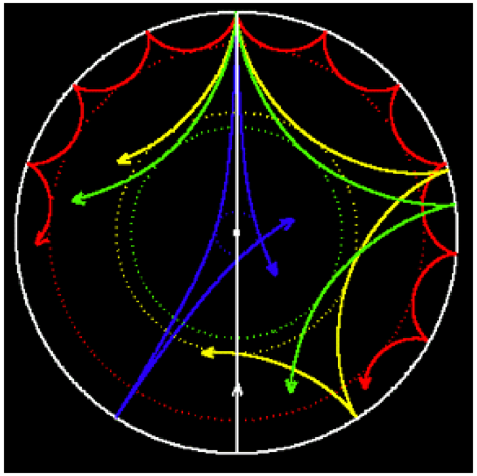


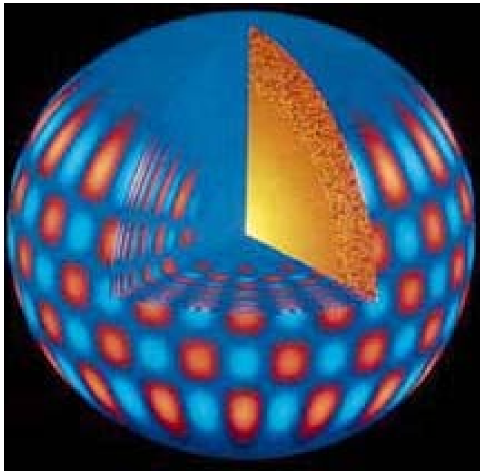
Guillot, 2005

Seismology of giant planets

(see B. Mosser & J. Jackiewicz)

- As terrestrial seismology, asteroseismology allows the study of internal structure
- Modes frequencies depends on density (and rotation)
- Modes of different degrees penetrate to different depth





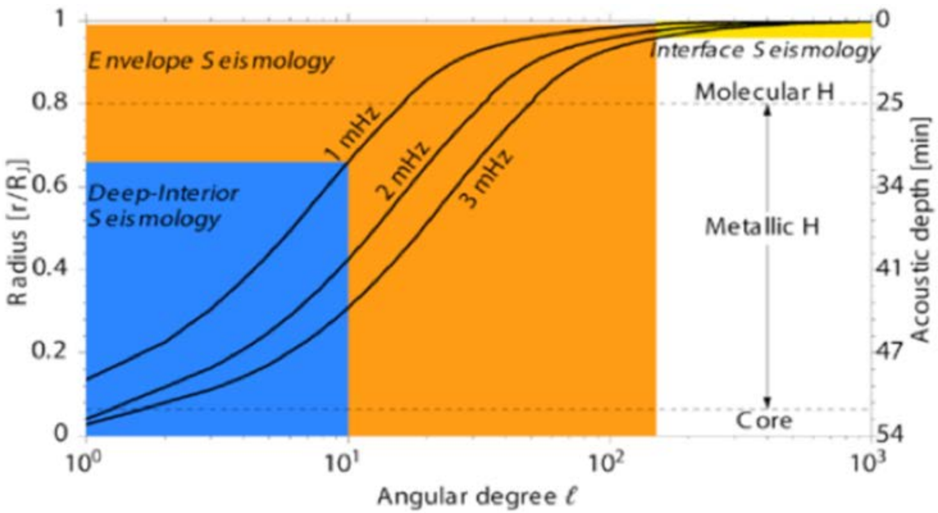
$\nu_{obs} - \nu_{theoretical}$

↓

Inversion method

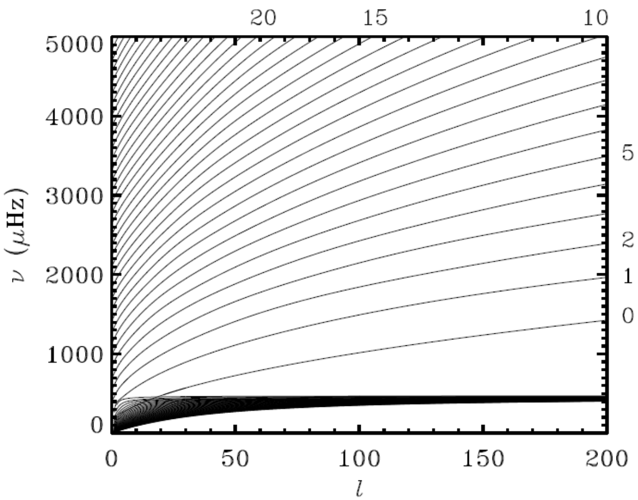
↓

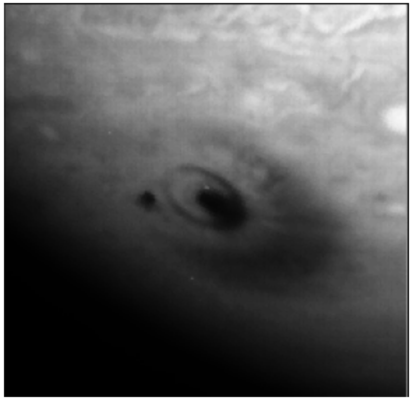
$\rho_{obs} - \rho_{theoretical}$

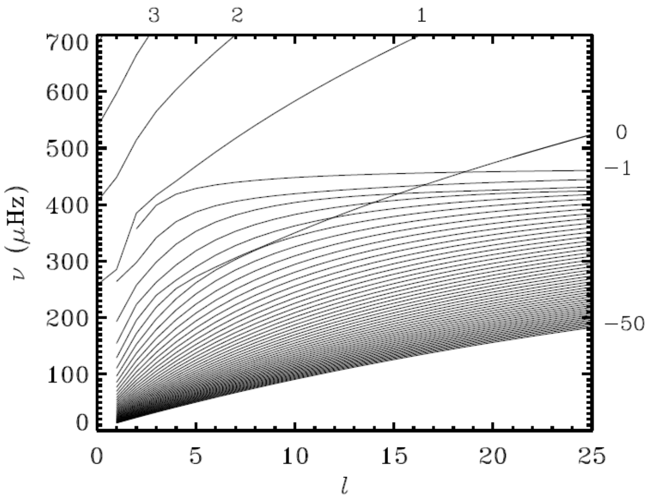


Mode types

- Following the main restoring force, modes could be of different types
- Acoustic modes or p modes
- Gravity modes or g modes
- Surface modes or f modes







Recent results in seismology of giant planets

- Jupiter
    - SYMPA project: 2000 – 2010

  - Gaulme et al 2011

- Saturn
    - Cassini

  - Hedman & Nicholson 2013

Open a new window on the interior of giant planets

Detection of Jovian global oscillations

•Ground based observations with SYMPA

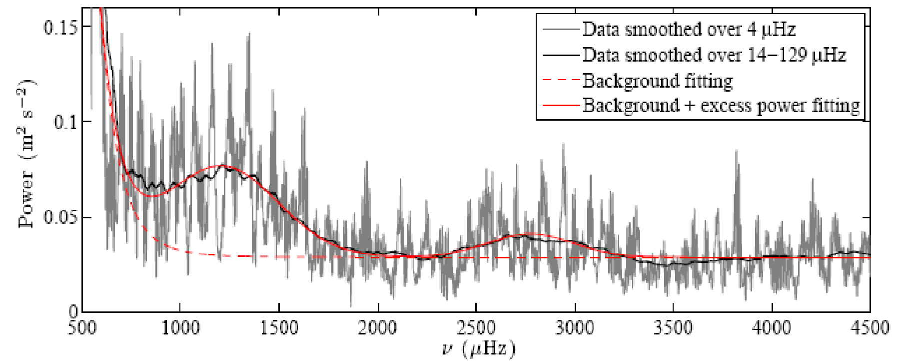
•Power excess in the range [800 – 3000] µHz

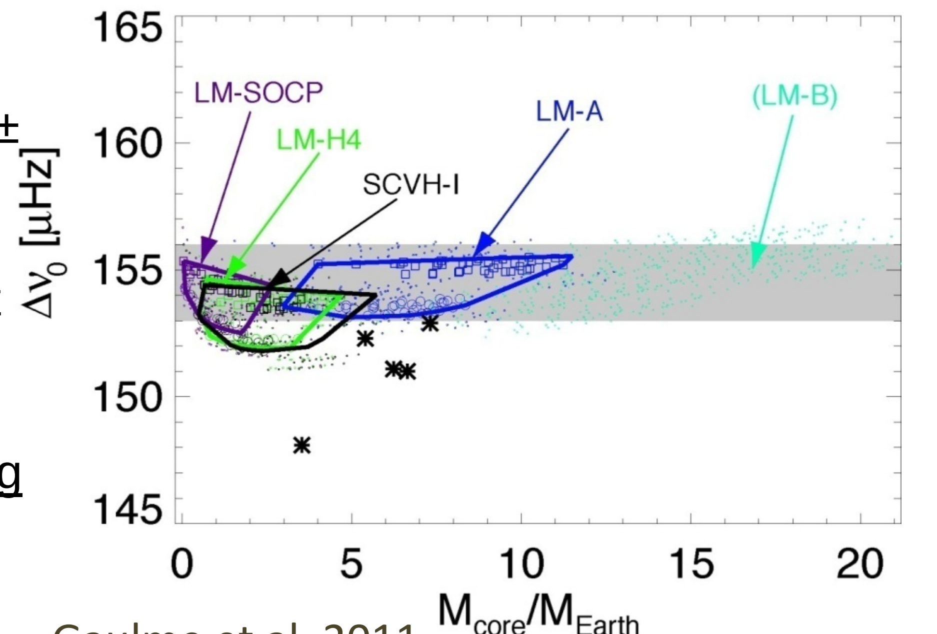
•~ 20 individual peaks with mean amplitude 30 cm/s ± 10 cm/s

•Regularly spaced peaks: $\Delta\nu_0$= 154.5 µHz ± 1.5 µHz

• Fundamental frequency good agreement with most models (mean density)

Individual modes identification requires <u>long continuous observation with good spatial resolution</u>



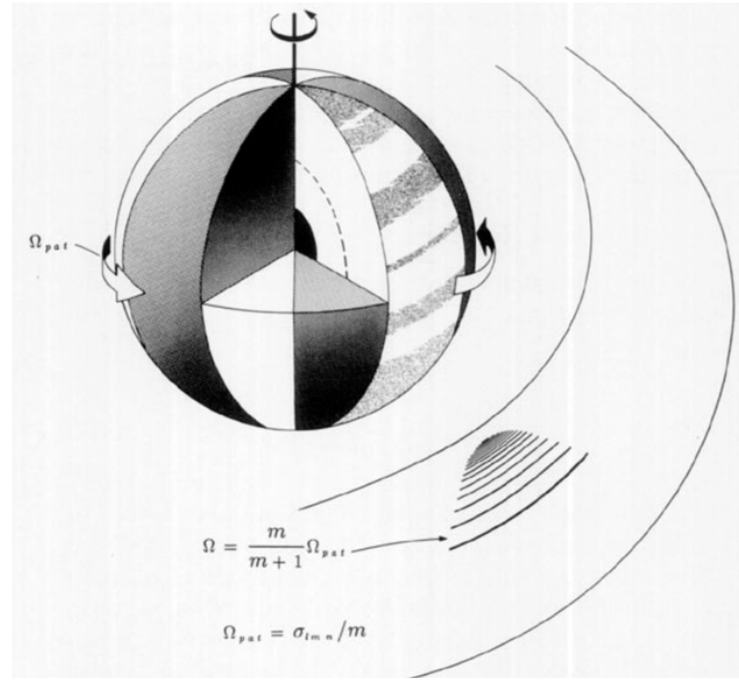


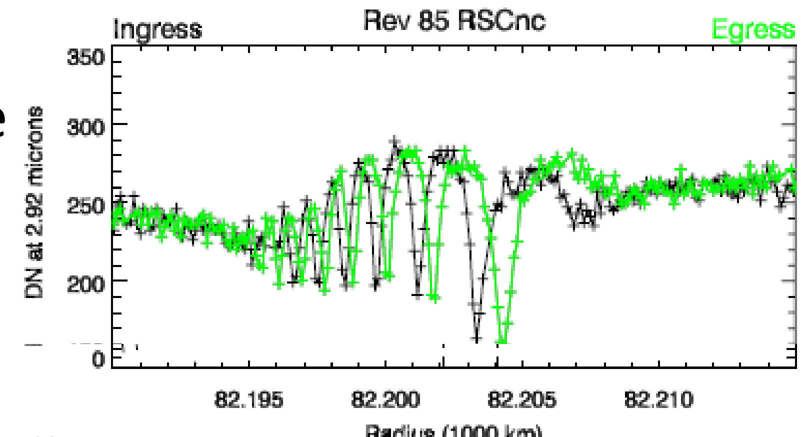
Gaulme et al, 2011

Saturn

- Density waves in Saturn rings

  (Hedman & Nicholson, 2013)
- Compatible with f-modes
- Predicted by Porco & Marley 1991
- Cassini observations of stellar occultations
- Identification of azimutal number
- Saturn f-modes have long life-time
- Consequences on internal structure to be studied
  - See Jim Fuller's talk





Project history

SYMPA project (2000-2010)
Echoes proposal for JUICE mission
Doppler Sismo Imager (R&T CNES 2009 -2013)

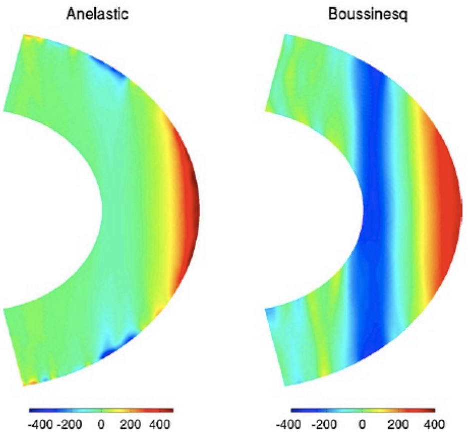
2014: JIVE in NM (NASA-EPSCOR)

2015: JOVIAL selection

- ANR (Agence Nationale pour la recherche) white program
- 4 years project (2016 -2019)
- 420 k€

Probing internal structure

- Complete gravitational moments (JUNO)
- Measure the size of the core
- Investigate H-H2 transition
- Give internal rotation profile

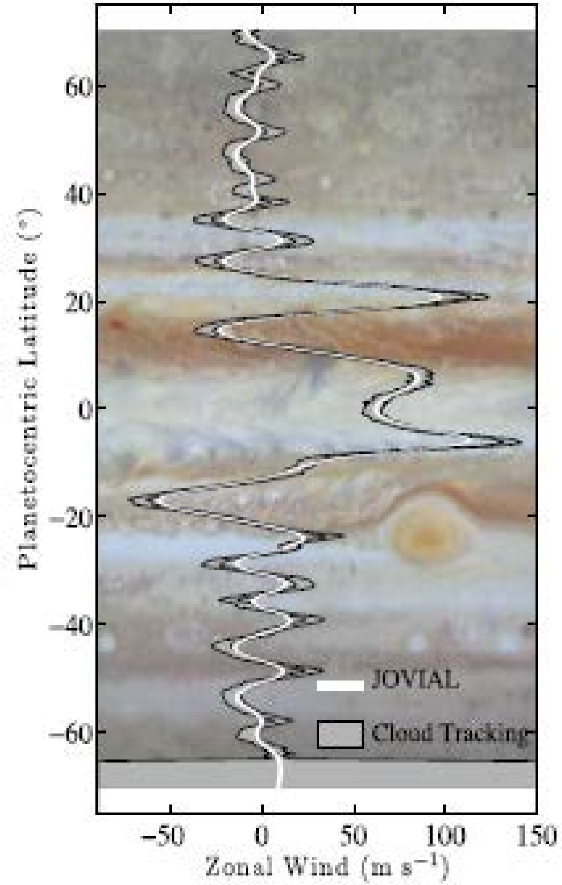


	$\delta\nu(n,l)/\nu(n,l)$	Degree
Core	4 %	$l = 0\text{-}2$
H2-H transition	3-7 %	$l = 15\text{-}25$
Enveloppe dynamics	0.1-0.5 %	$l = 50\text{-}100$

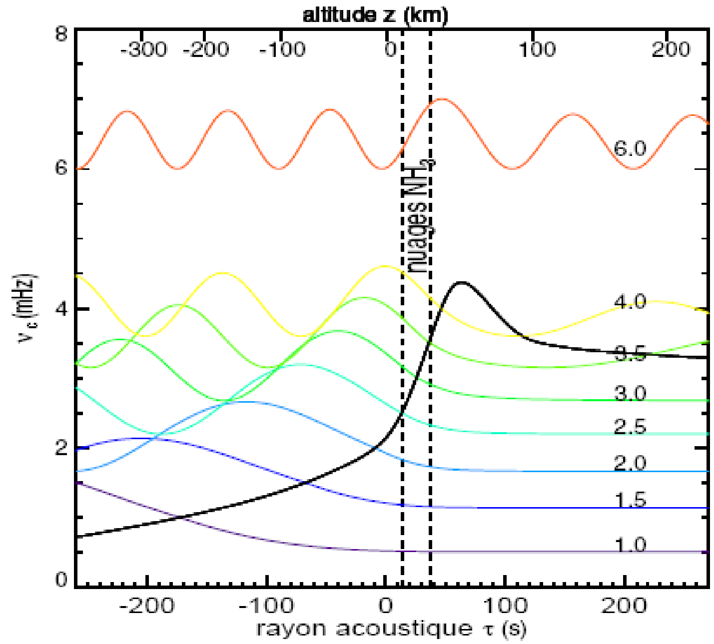
Wind speed measurement

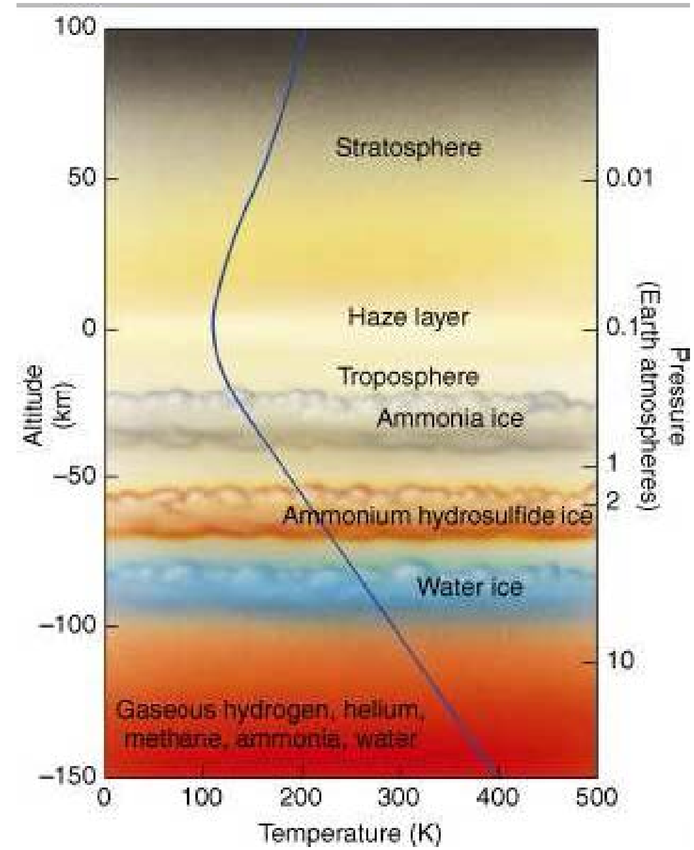
- Cloud-tracking is affected by cloud deformation and waves
- Doppler measurements give true aerosol displacement
- Complete High Angular Resolution follow-up

- See R. Hueso



Detection of acoustic modes





Best detection level: 1 bar

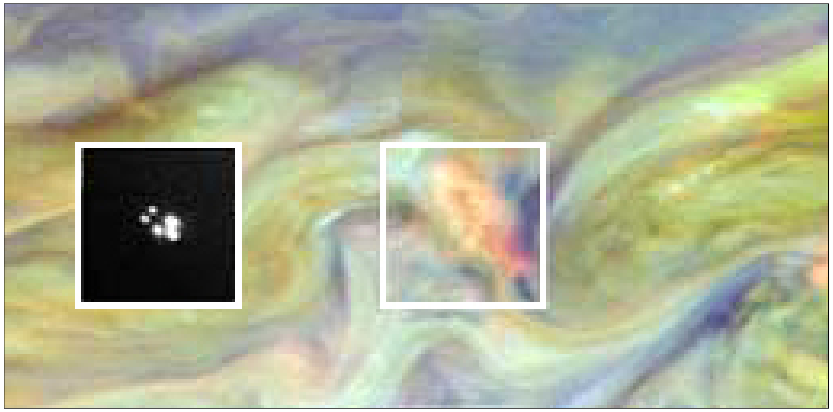
Top of the cloud (visible)

Resolved images and velocity maps

Mode excitation

- Few theoretical works
- Estimation by Bercovici & Schubert for Jupiter: 0.5 m/s
- Energy in convection is sufficient
- Solar mechanism would be inefficient

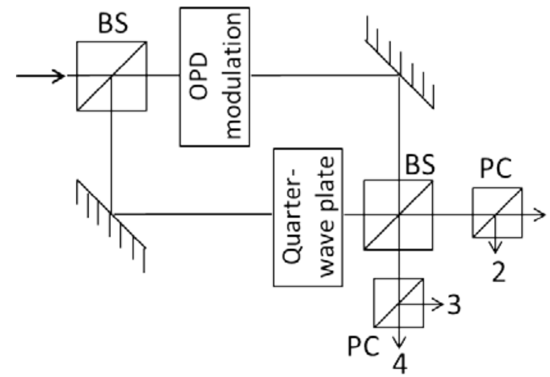
- Other coupling mechanism ?
- Kappa mechanism ?
- Humid convection ?



See Ethan Dedrick's talk

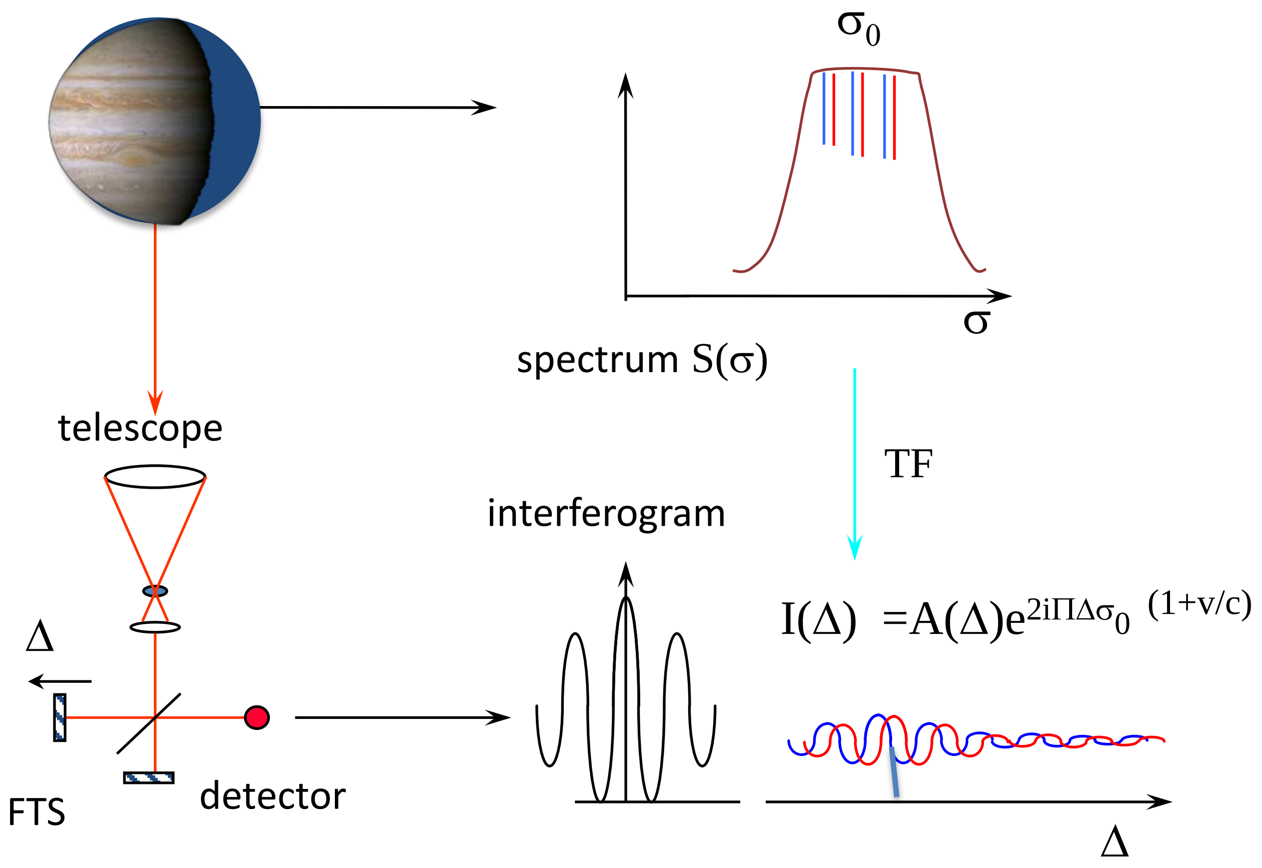
Instrumental Concept

- JOVIAL is a Doppler Spectro-Imager
  - Mach-Zehnder Interferometer:
  - spectral FT at each point of the image
  - Measures the Doppler shift of reflected solar lines

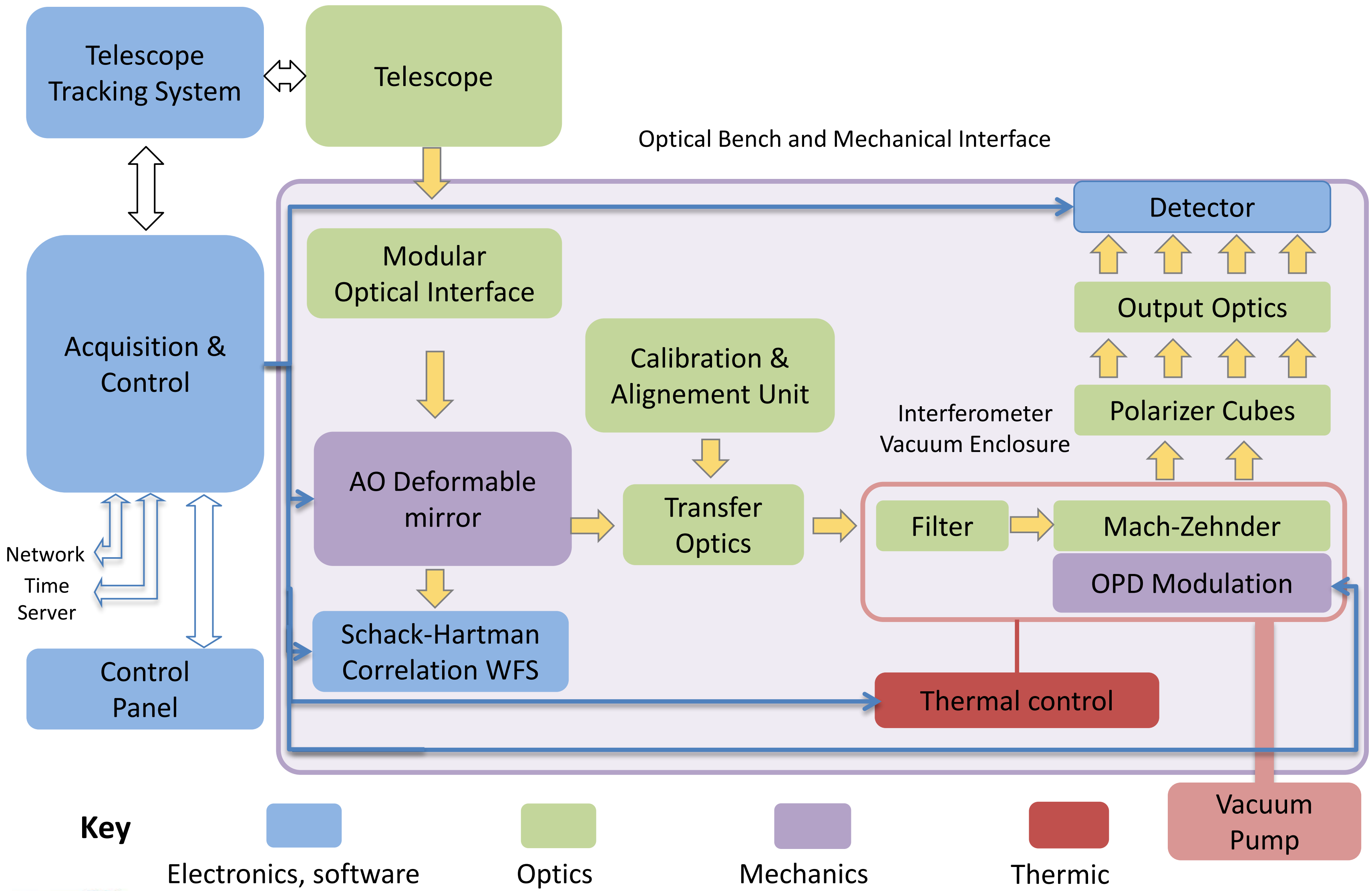


- Optimisation of mesurement stability, precision, resolution
  - Large Field Optique Adaptative
  - Simultaneous multi-sites observations
  - Noise level < 4 cm/s in 2 weeks

Fourier tachometer



Bloc Diagramme



Work programme

- Complete the DSI prototype at Calern with CIAO Adaptive Optics
  - See M. Carbillet & F. Martinache
- Study and realisation of two new MZ and vacuum tanks
- Deliver MZ for JIVE in NM
- Build a complete third instrument with AO
- Develop data processing pipe-line
- Achieve one or more observing runs on Jupiter and Saturn

The JOVIAL network

Goal: Simultaneous observations from 3 sites

Target: Duty-cycle > 50 % over two weeks

Observatoire de Calern (France)

- C2PU: 1 m telescope with DSI prototype

New Mexico (USA)

- Dunn Solar telescope (Sacramento Peak)

Okayama Observatory (Japan)

- Telescope de 1.88 m
- Other options ?

The JOVIAL network

Possible evolutions

- Larger telescopes
- Additional instrument
  - AO for JIVE

- Space mission (see O. Mousis)
  - Saturn
  - Uranus

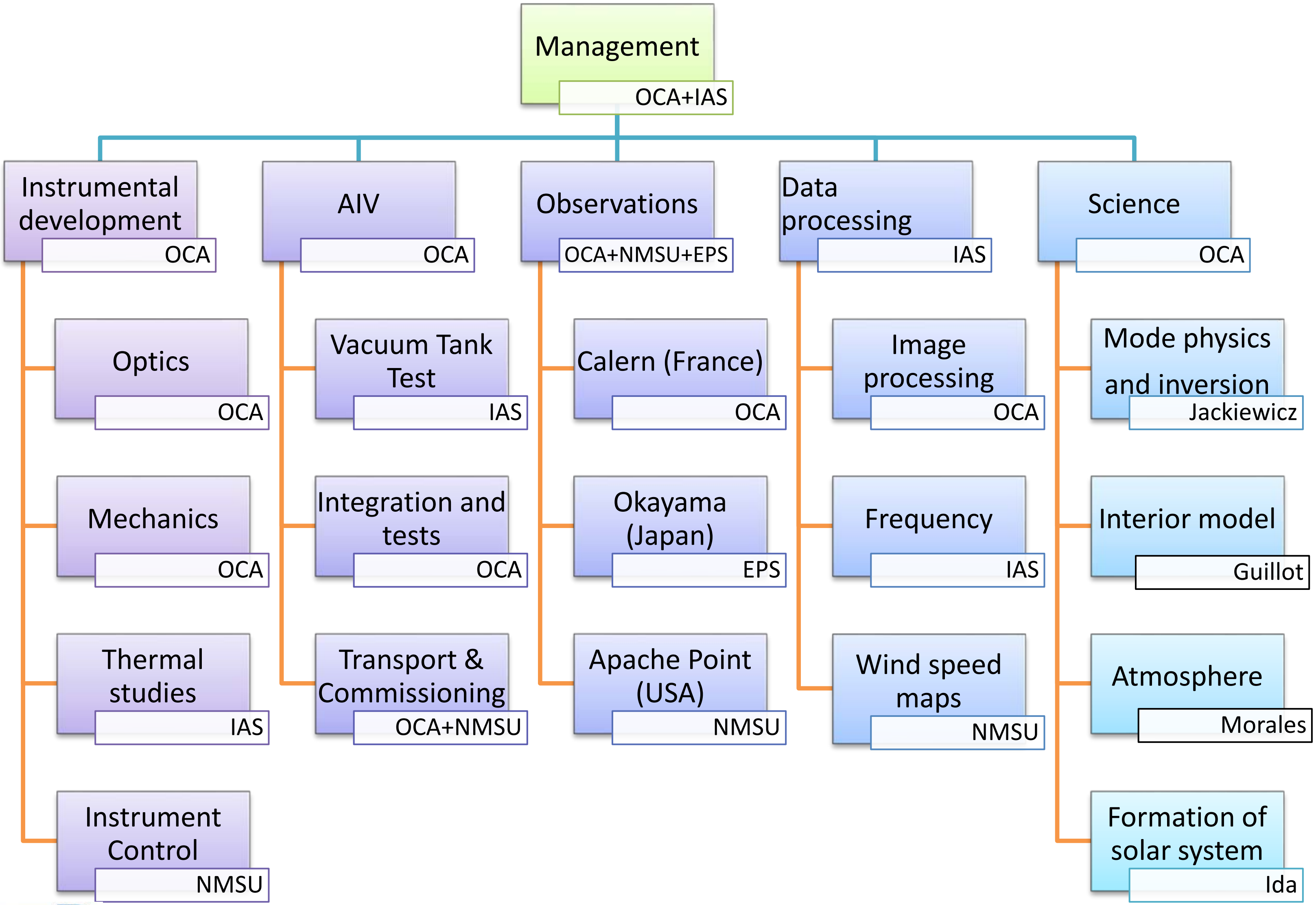
Planning

Kick-off:	April 2016
Instrumental design:	October 2016
Integration and tests:	June 2017
Delivery, commissioning:	December 2017
Observations of Jupiter:	May 2018
Data processing, first results:	June 2019
Observations of Saturn:	July 2019
Archiving, dissemination:	December 2019

Budget

• Instrument study and realisation:	215 k€
• Manpower	
- 3 years non-permanent	130 k€
• Logistics and missions:	45 k€
• Consumable:	30 k€
Total:	420 k€

Organisation



Objectives of the meeting

- Definition of the scientific objectives
- Position of the project in the scientific context
- Organisation of the science groups
- Technical organisation of the network
- Identify key technical issues (telescope)
- Task identification and planning
- Data policy
- Choice of a logo