2017年度岡山ユーザーズミーティング

木星自由振動観測プロジェクト 進捗報告

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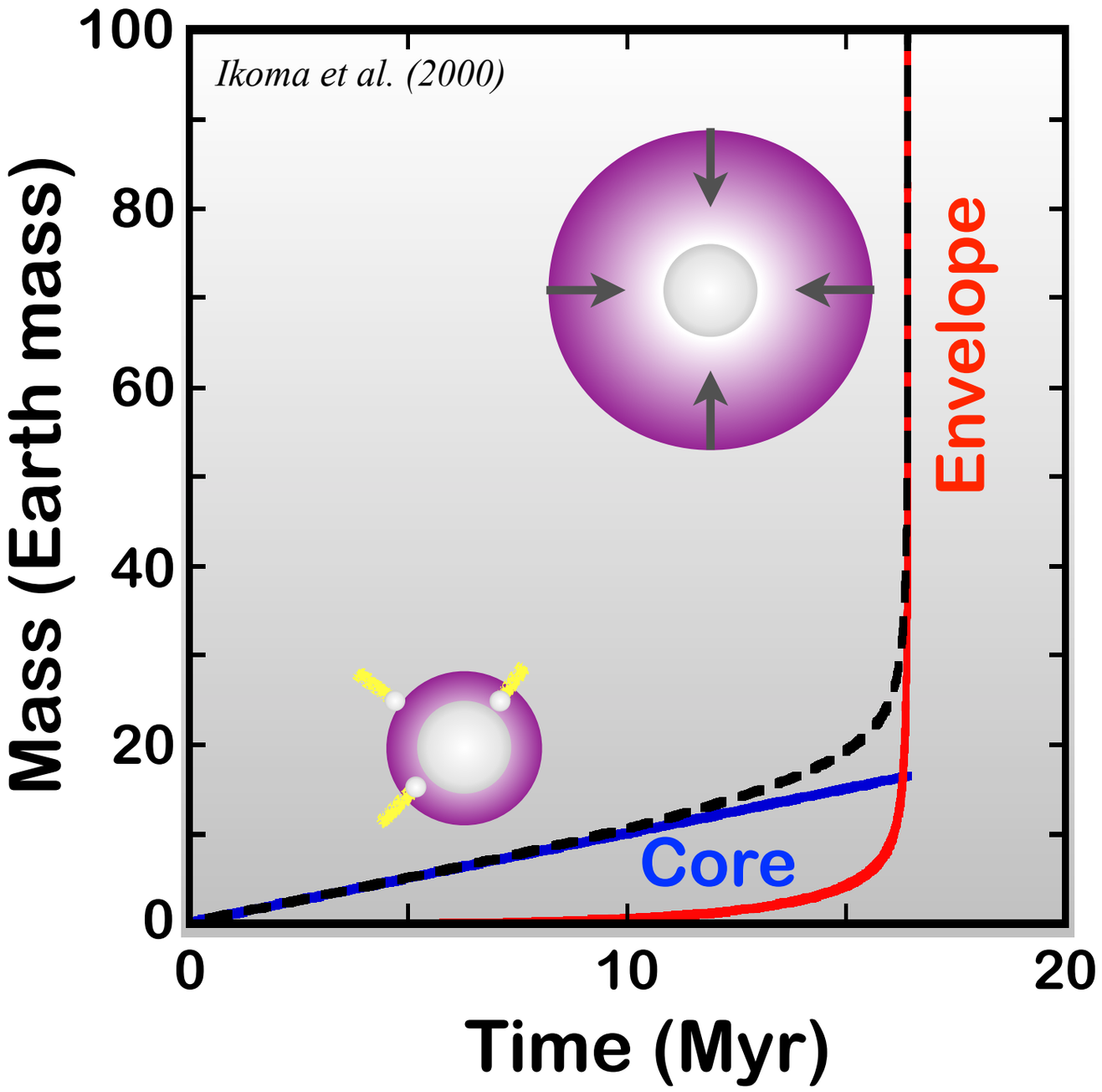
科研費・基盤研究(A) H29-32年度

ドップラー振動撮像装置を用いた木星表面振動観測：内部構造と起源の解明に向けて
（代表：生駒大洋）

2017年9月4日(月) 10:43-10:56, 国立天文台三鷹

Conventional Jupiter-Formation Model



Two Separate Phases

Phase 1 - Core growth

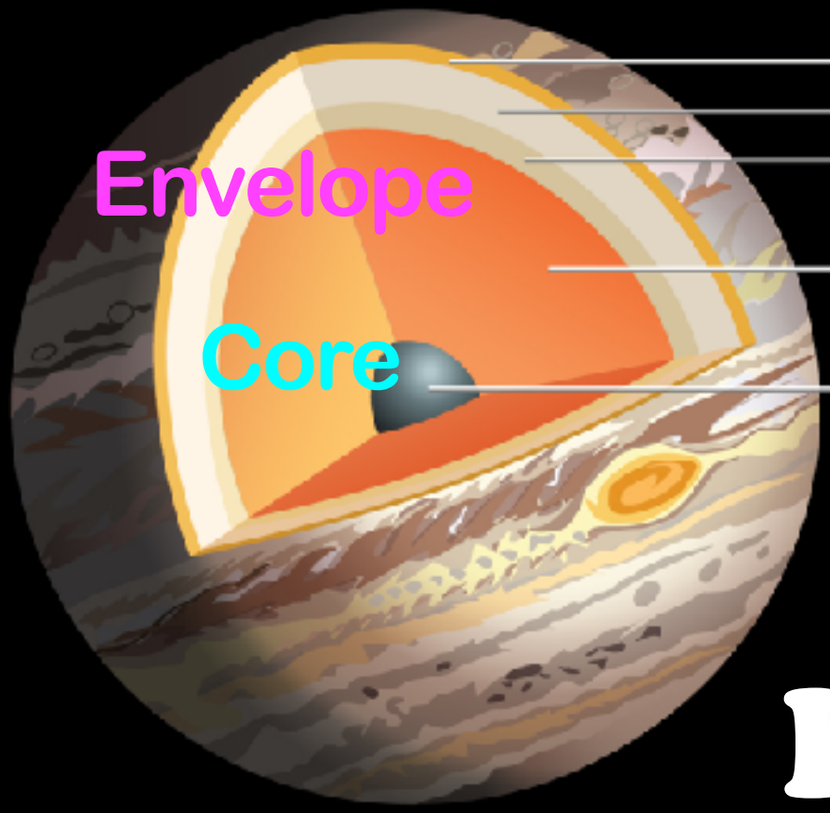
... Cores grow via accretion of 10-100km planetesimals.

*** *Critical Core Mass* ***

Phase 2 - Envelope growth

... Strong gravity of the critical core triggers runaway gas accretion.

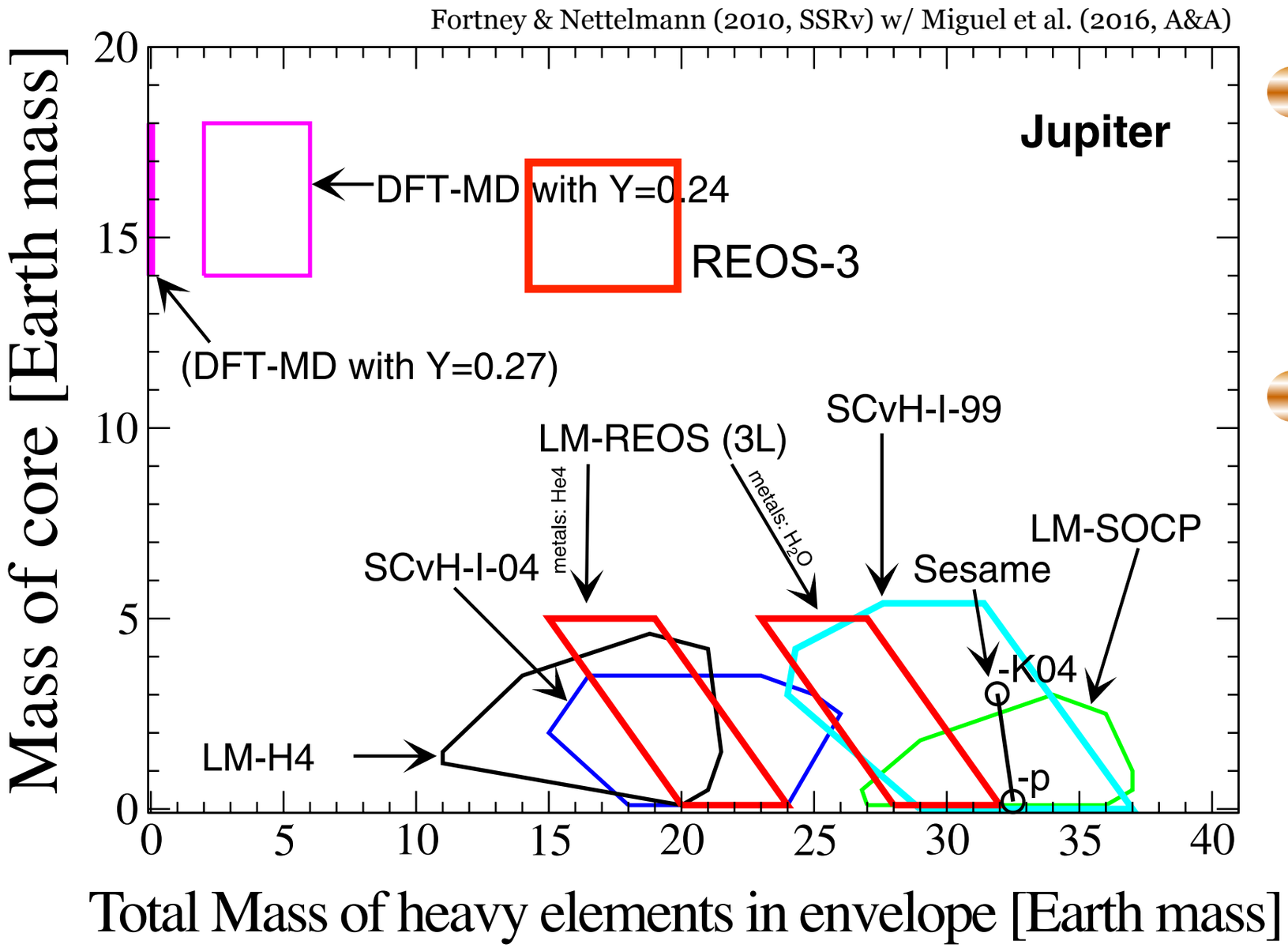
Mass of the core is a clue to the origin of Jupiter.



Key Questions

- *Is a high-density core present at the center? How massive is it?*
- *Is there a clear boundary b/w core & envelope?*
- *How much heavy elements are contained in the envelope?*
- *Where does the molecular/metallic transition occur in the envelope?*

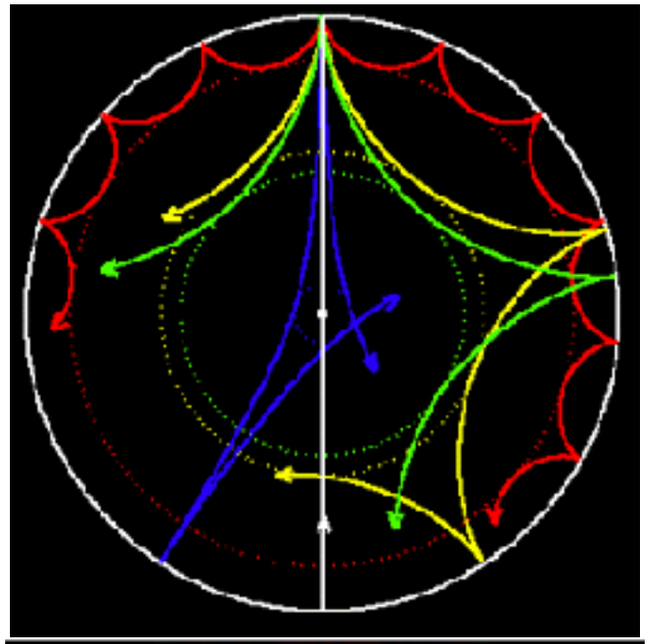
Conventional Estimate of Core Mass

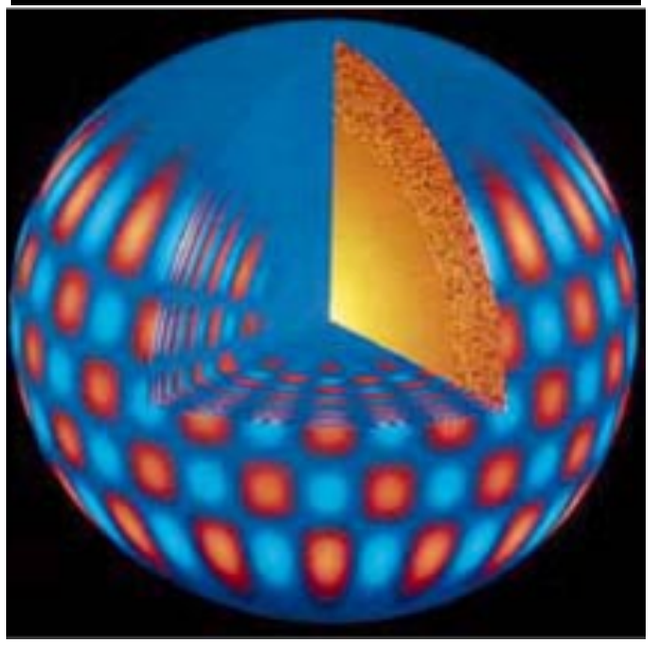


- The interior structure has been inferred from measured gravitational moments.
- Gravitational moments are sensitive not to deep envelope structure, but to outer-envelope structure.

Big uncertainty about internal composition of Jupiter

Jovian Seismology





Radial displacement

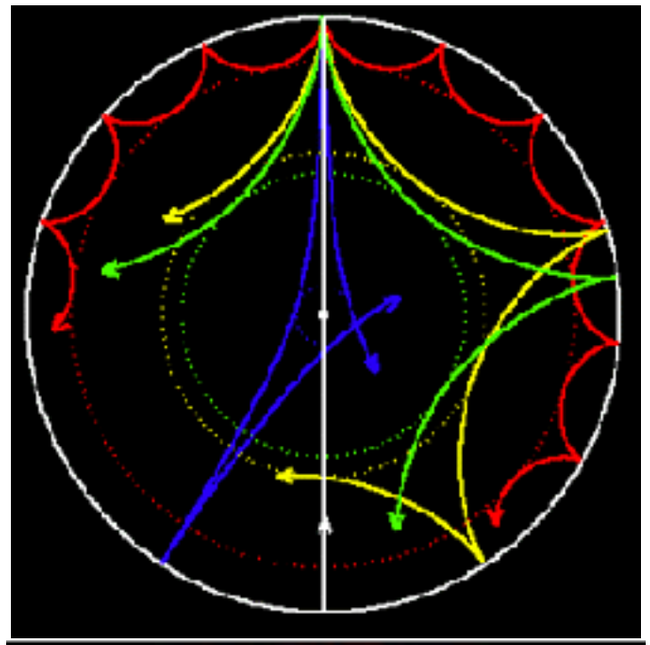
$$\xi_r(r,\theta,\phi,t) = a(r)\, Y_\ell^m(\theta,\phi) \exp(-2\pi i \nu t)$$

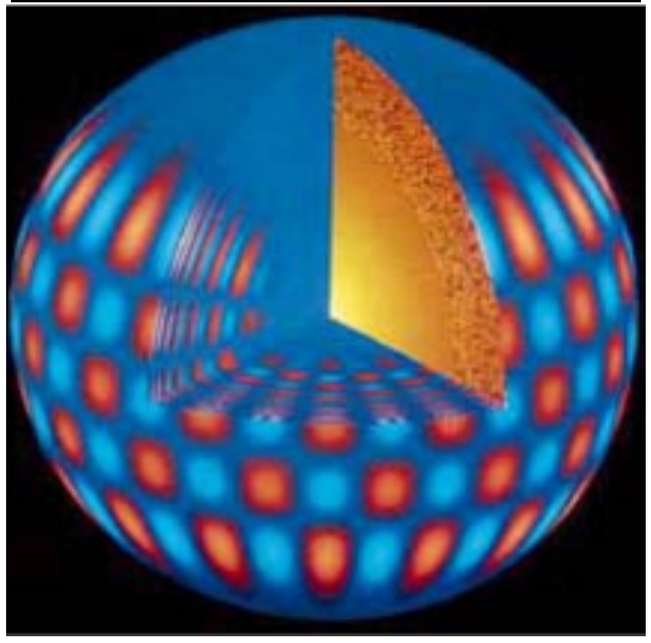
- Spherical harmonics

$$Y_\ell^m(\theta,\phi) = (-1)^m \sqrt{\frac{2\ell+1}{4\pi}\frac{(\ell-m)!}{(\ell+m)!}}\, P_\ell^m(\cos\theta) \exp(im\phi)$$

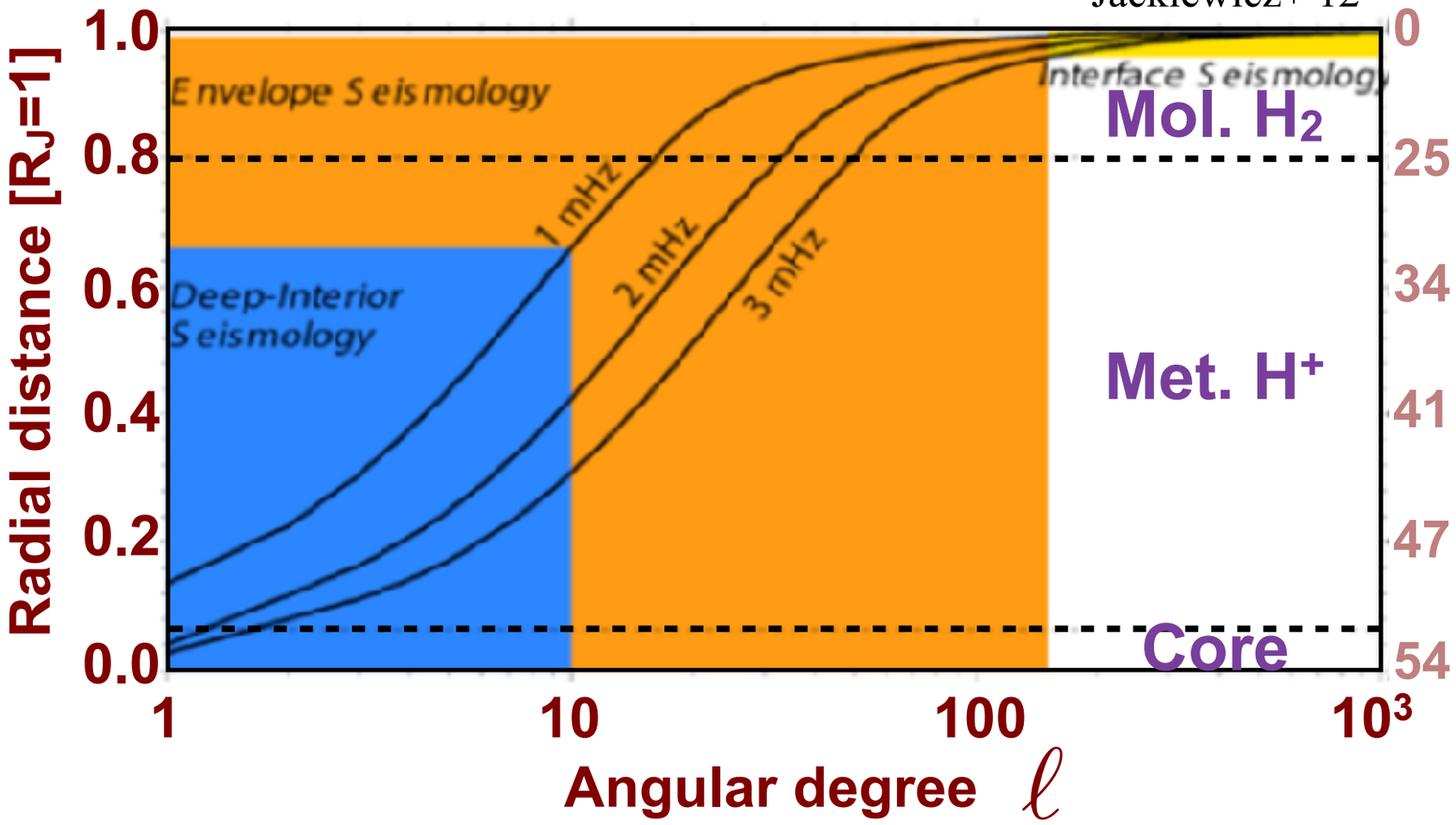
m	-3	-2	-1	0	1	2	3
$\ell = 0$							
$\ell = 1$							
$\ell = 2$							
$\ell = 3$							

Jovian Seismology





Jackiewicz+ 12



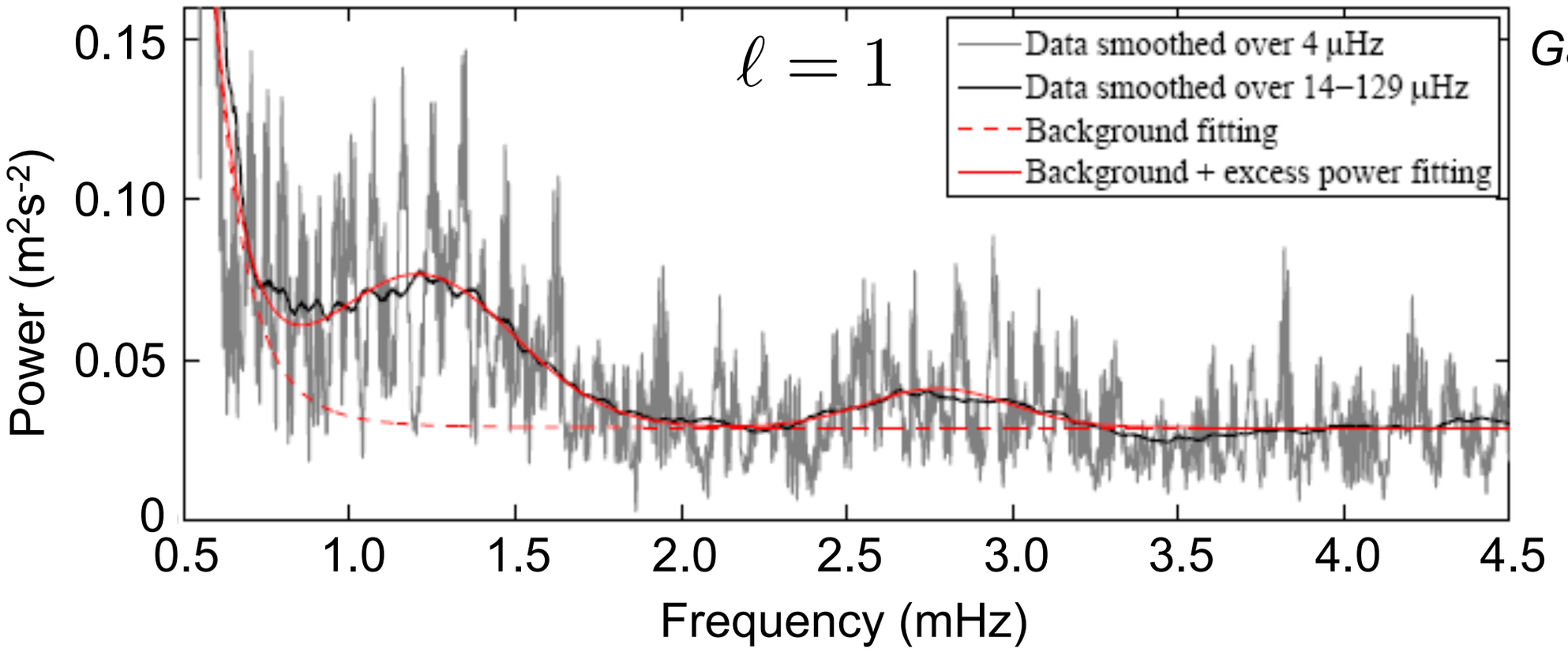
Turning point radius & sound speed

$$\frac{c^2(r_t)}{r_t^2} = \frac{4\pi^2\nu^2}{\ell(\ell+1)}$$

The core is sensed by modes of frequency > ~2 mHz & low degree.

Previous Detection

The SYMPA Project

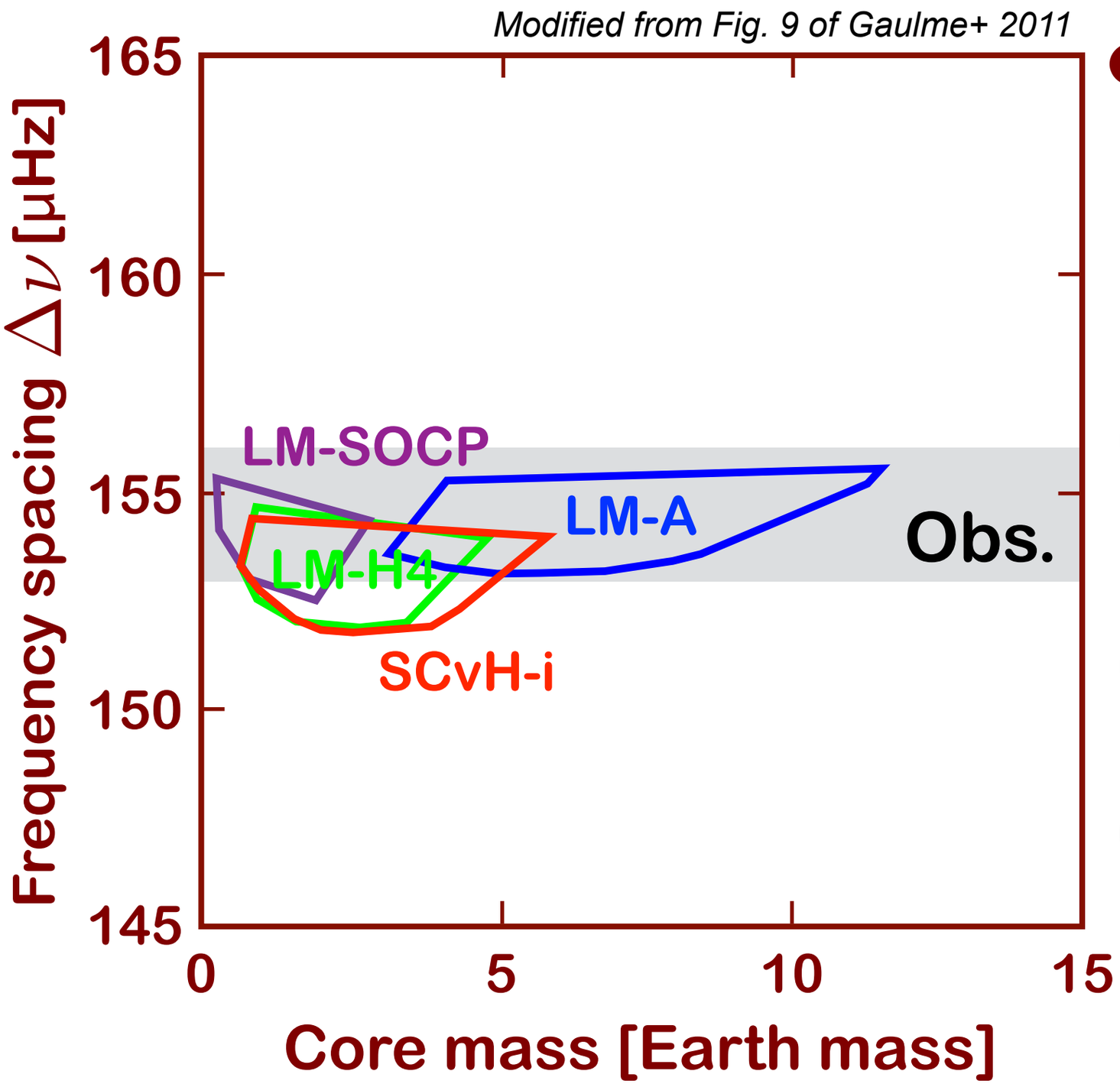


Gaulme+ 2011

Detected global oscillations of Jupiter!

- Two excesses are found around frequencies of 1.2 mHz and 2.8 mHz.
- Frequency spacing $\Delta\nu$ is ~ 0.16 mHz.

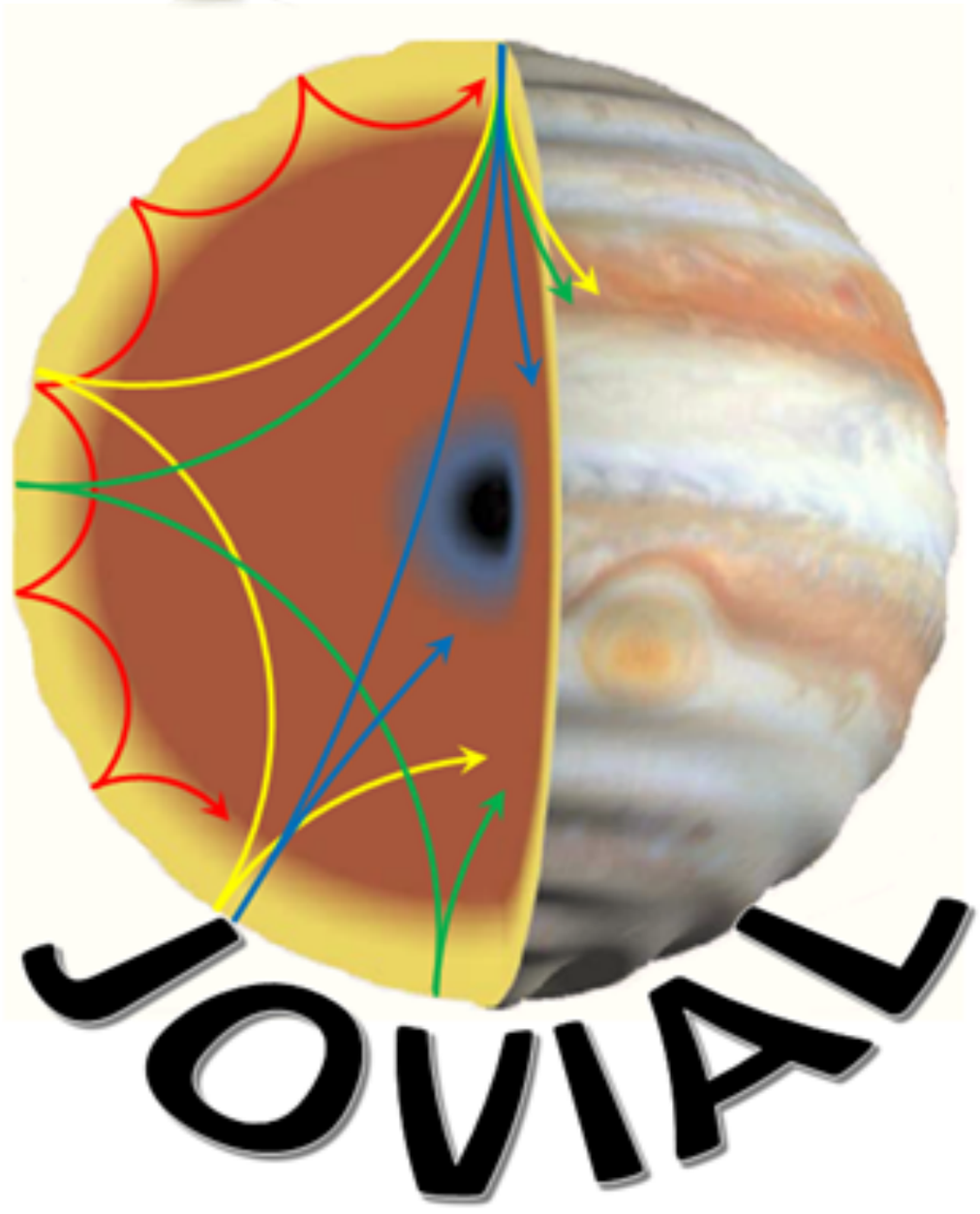
Previous Detection



Comparison with models

$$\Delta\nu = \left(2 \int_0^{R_\mathrm{J}} \frac{\mathrm{d}r}{c} \right)^{-1}$$

- The inferred value agrees basically with the theoretical predictions.
- Useful for validating Jupiter models
- More accurate determination of Δν can constrain the core mass more definitively.



Jovian Oscillations through radial Velocimetry ImAging observations at several Longitudes

F.-X. Schmider (Obs. Cote d'Azur), P. I.

JOVIAL Network Observation

Continuous observations from 3 sites

> 50% duty cycle over two weeks

The Japanese Team

科研費・基盤研究(A) H29-32年度
ドップラー振動撮像装置を用いた木星表面振動観測
～内部構造と起源の解明に向けて～

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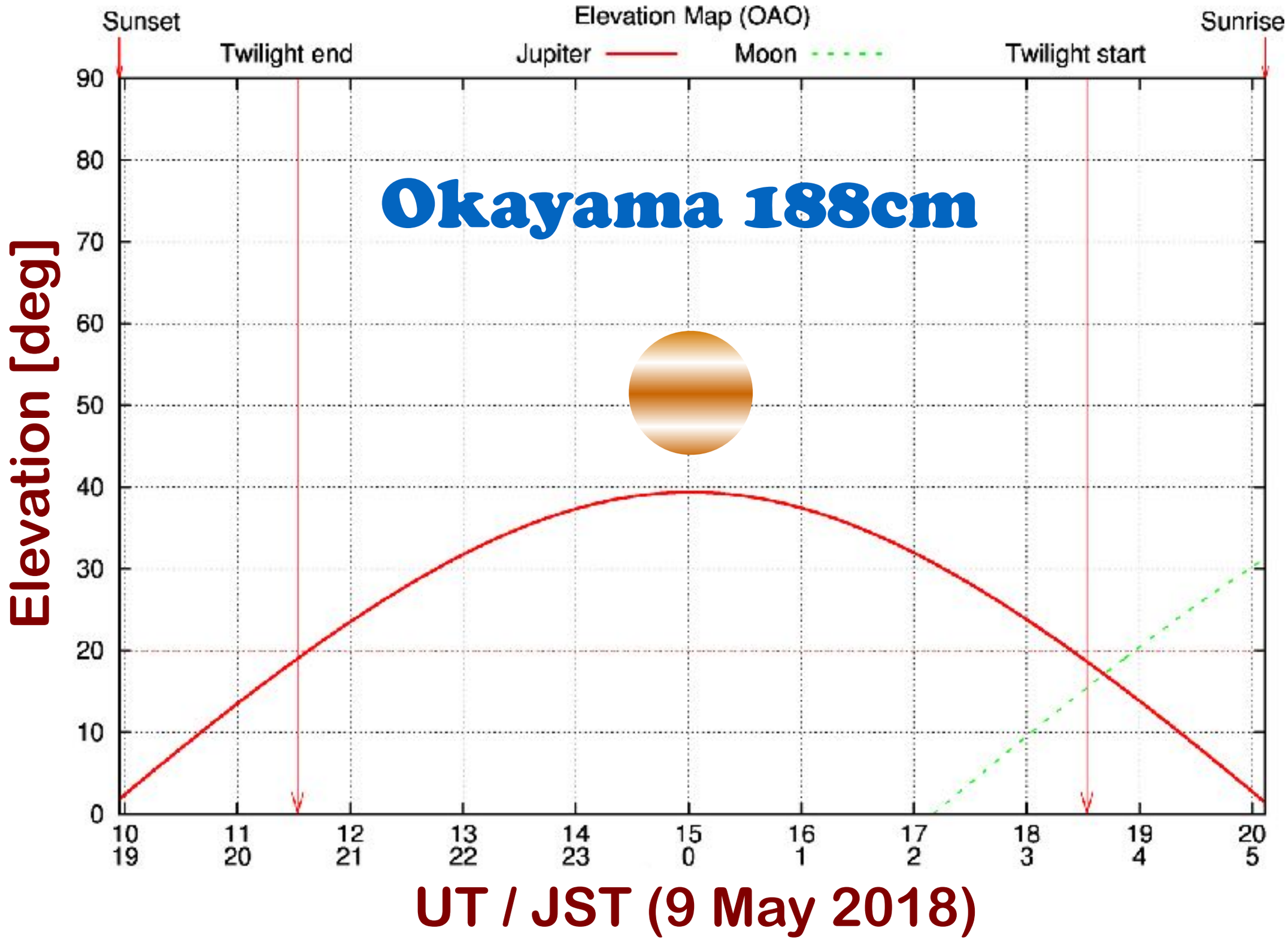
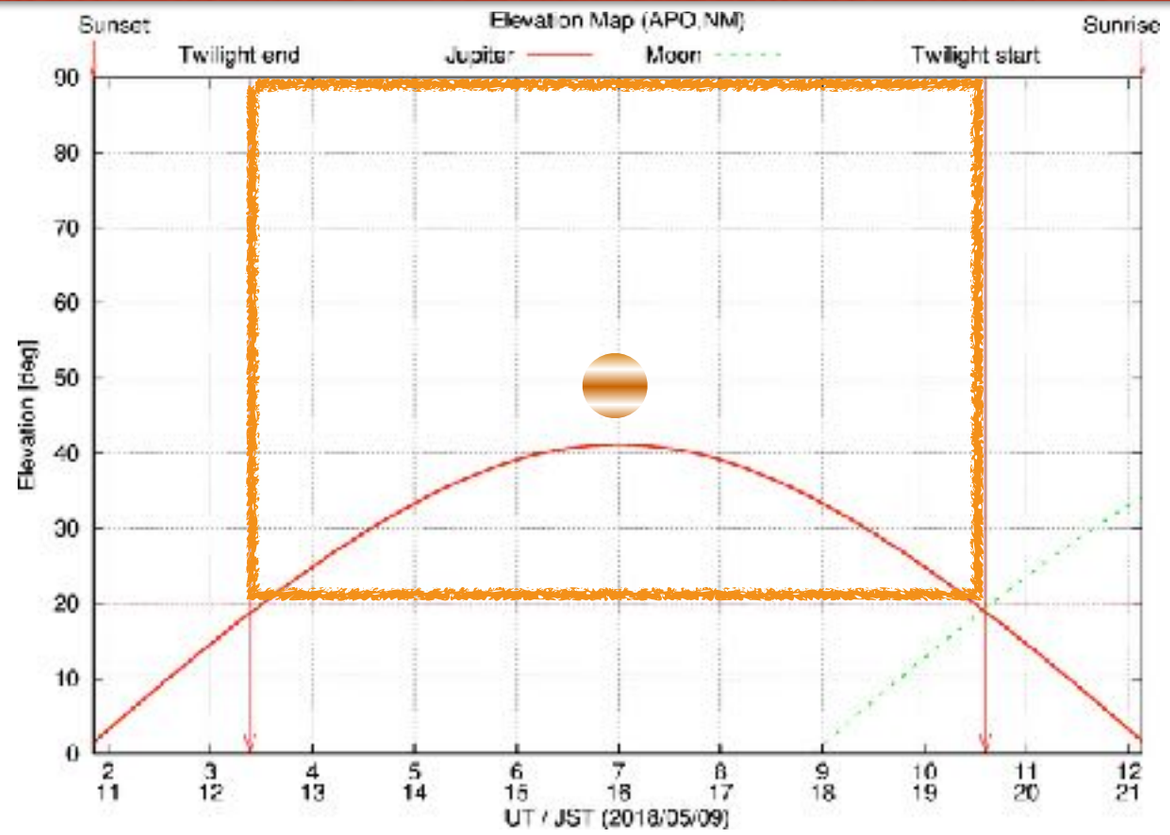
特任研究員
國友 正信(東京大学)

Observation in May, 2018

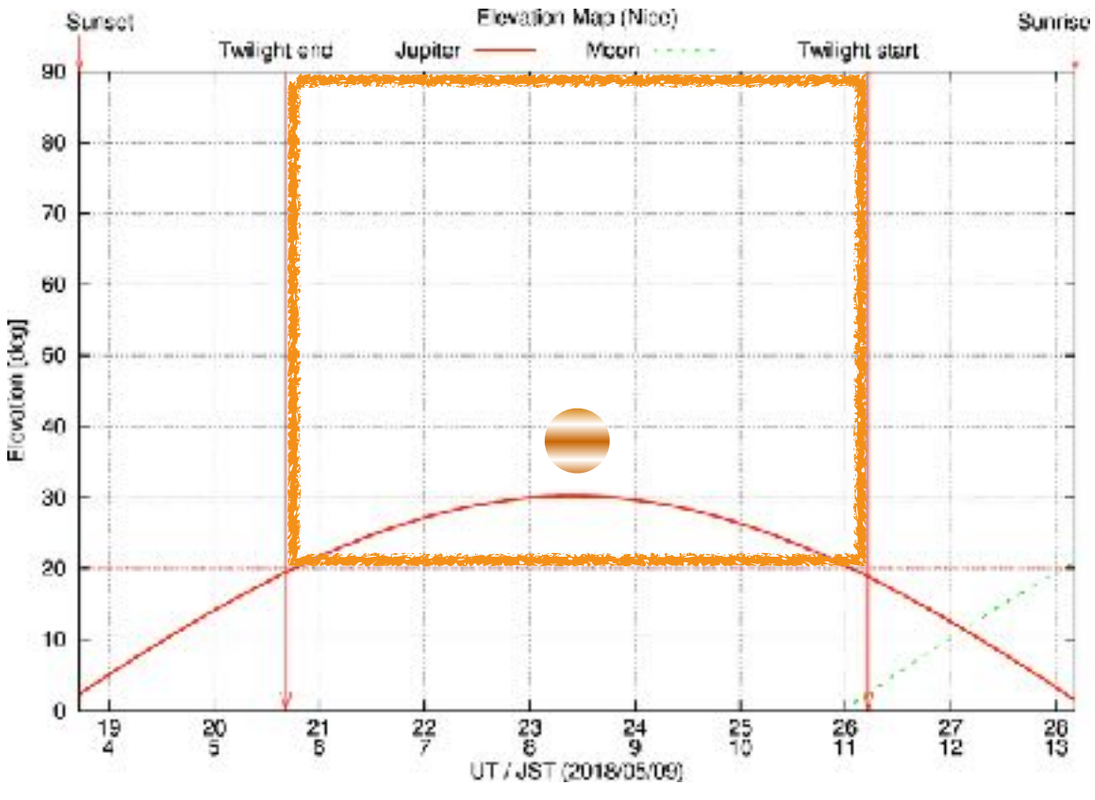


Jupiter's Elevation

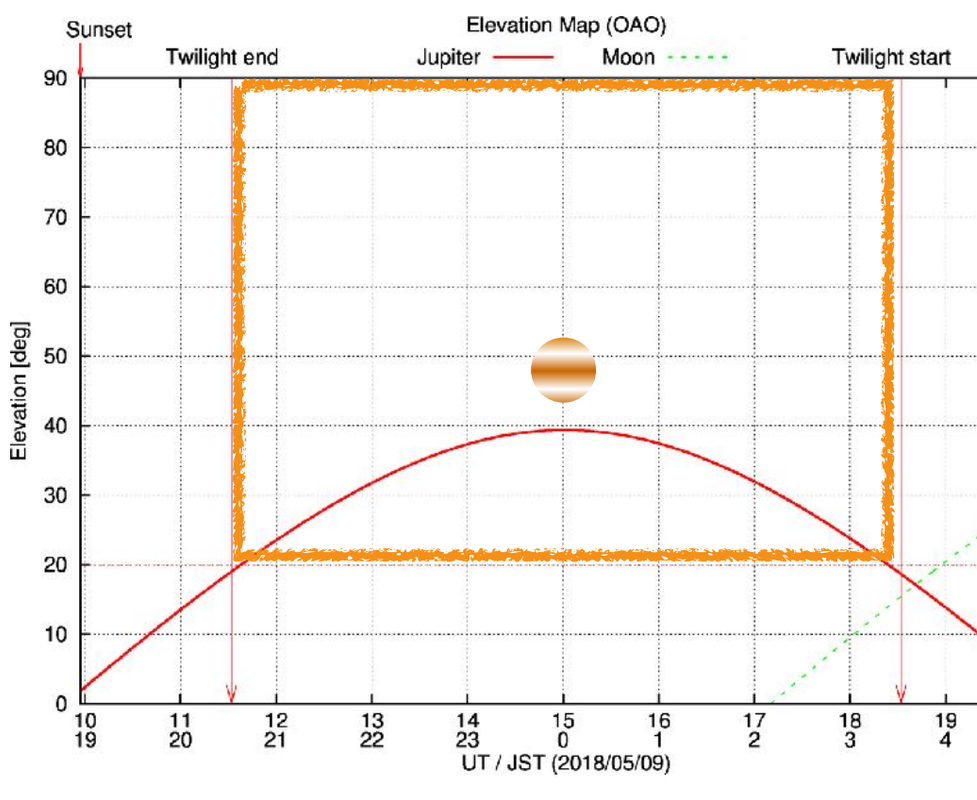
Apache point



Nice

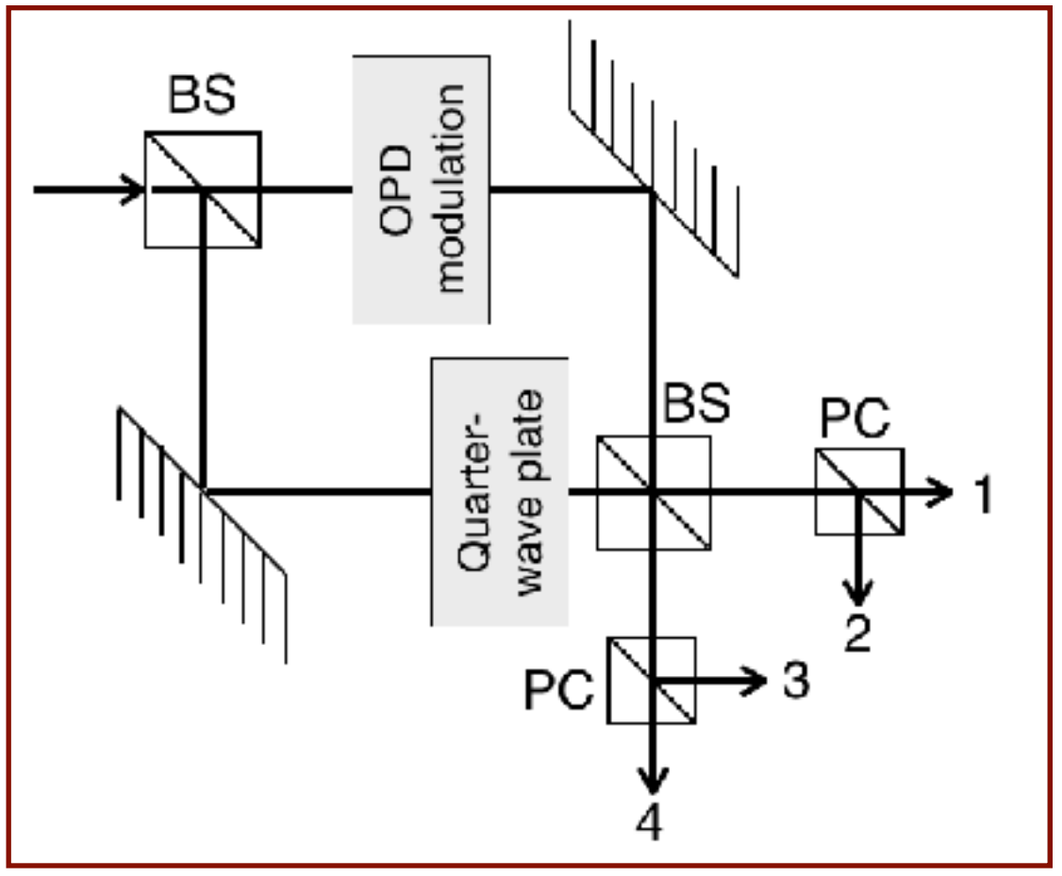


Okayama

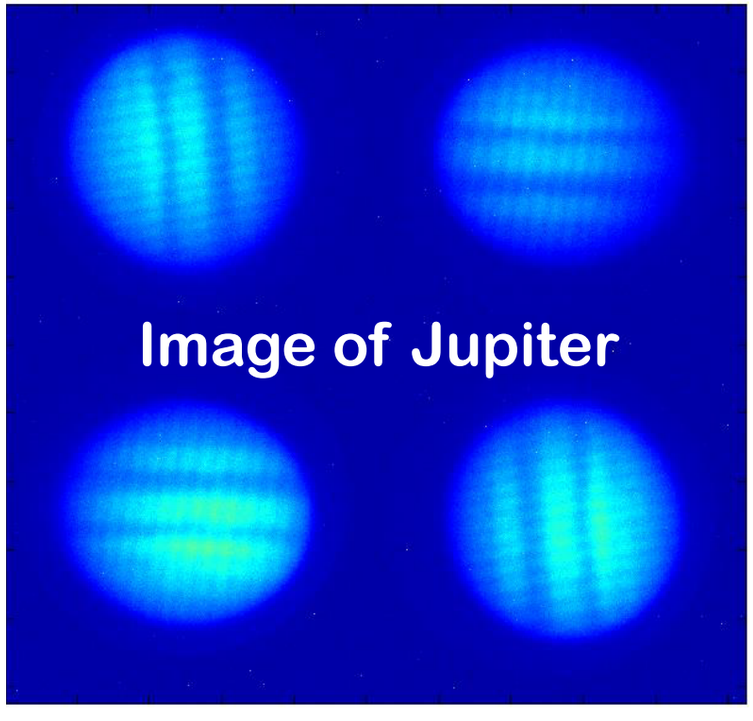


The Instrument

Doppler Spectro-Imager



- Mach-Zehnder interferometer
- Measures the Doppler shift of reflected solar lines at 517nm
- Linear combination of the interferograms leads to a radial velocity map.
- Noise level < 4cm/s in 2 weeks
  Velocity accuracy ~ 20m/s/" in 1h



The Okayama 188cm

Tentative Schedule

2018.3-4

- Transport & install of the instrument
- Test observation

2018.5

- Observation

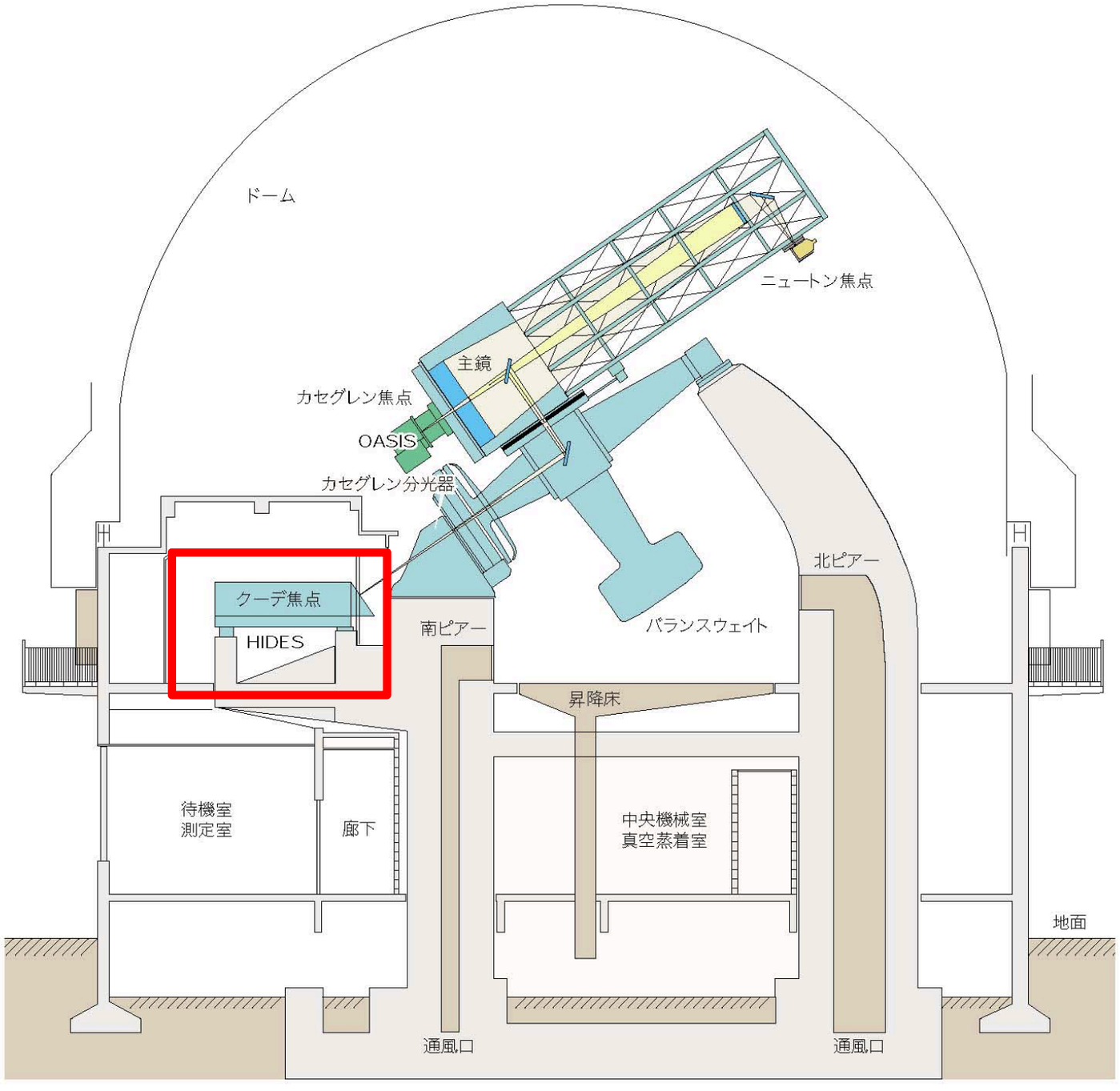
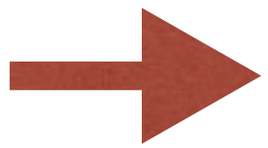


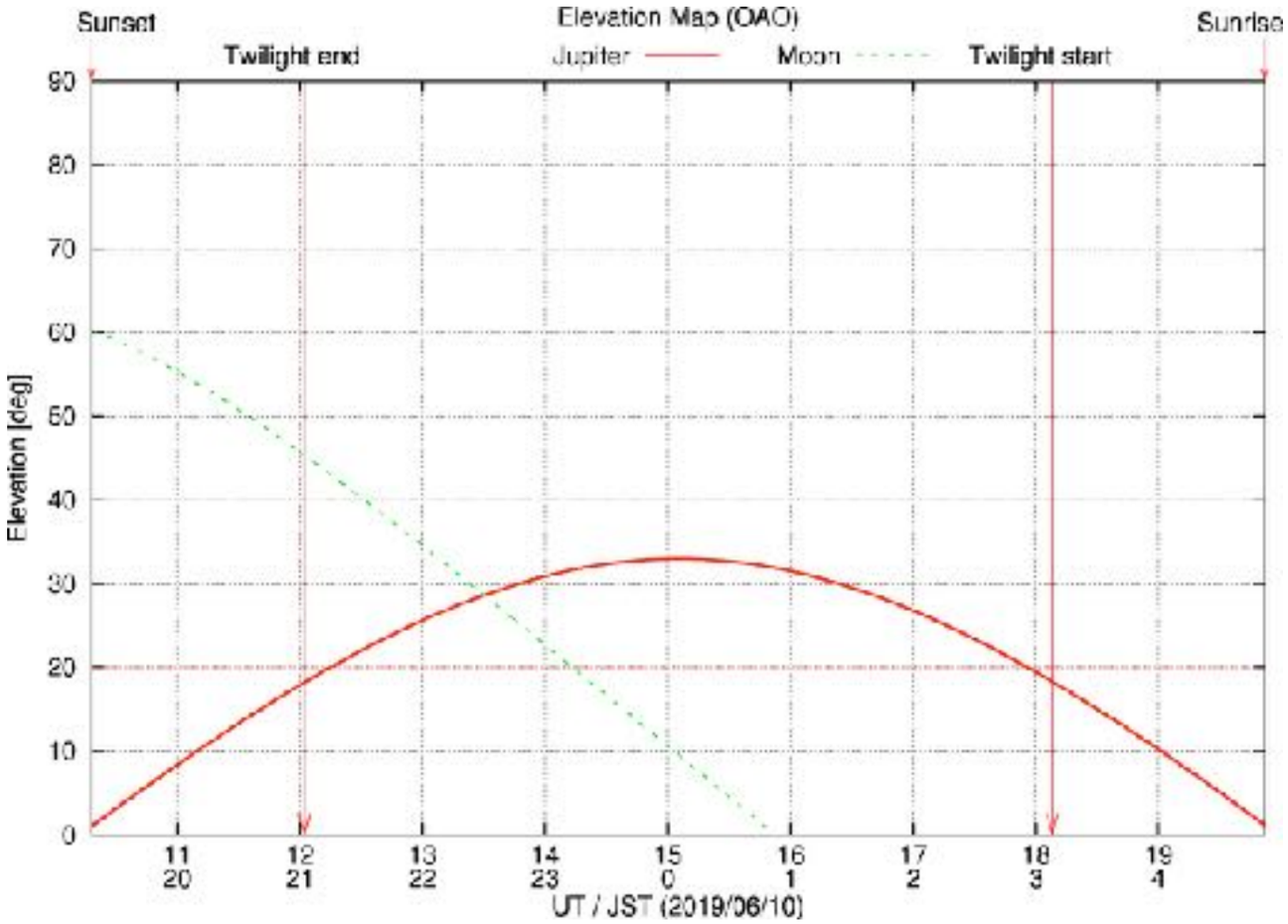
図2－1　188cm反射望遠鏡ドーム概略図

Observation in June, 2019

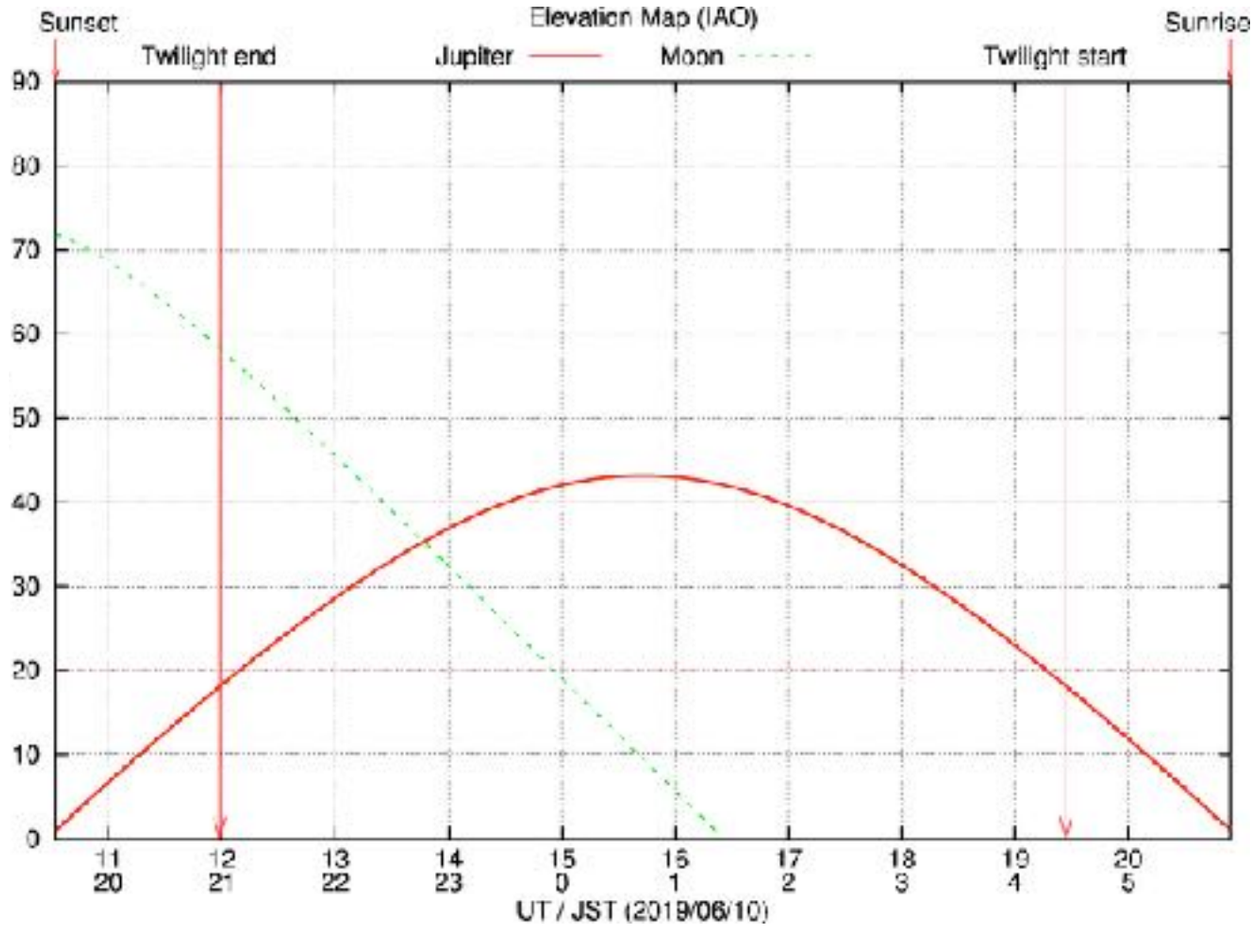
Okayama 188cm



Ishigaki 105cm



UT / JST (10 June 2019)



UT / JST (10 June 2019)

Summary

- The internal structure, especially the mass of the core and the distribution of heavy elements in the envelope, provides crucial constraints to the origin of Jupiter.
- Conventional inference of the interior based on gravitational moments contains a large uncertainty regarding the internal composition.
- Our network observations of Jovian oscillations at Okayama/Ishigaki, Nice, & New Mexico, which are scheduled in May 2018 & June 2019, is expected to narrow down the uncertainty greatly.

Stay tuned!