Seismology of rotating gas giant planets

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Looking inside planets with seismic oscillations

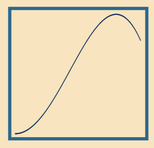
For more info, check out one of my recent talks!
tinyurl.com/dewberrytalk

- Oscillation modes are used to infer intrinsic properties
- Strongly affected by rapid & differential rotation in Saturn and Jupiter
- Non-perturbative approach to rotation: 2.5D numerical (spectral) calculations
  (e.g., Reese et al. 2006; Dewberry et al. 2021)

f-modes: the most gravitationally important oscillations

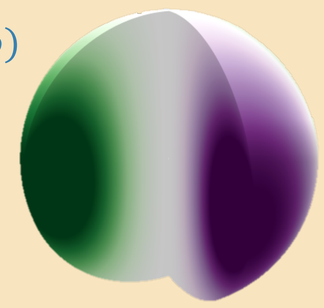
Non-rotating planet: $\delta\Phi(\mathrm{r},\theta,\phi,t) = \mathrm{e}^{-i\sigma t}\Phi^{\ell}(r)Y_{\ell}^{m}(\theta,\phi)$

$\Phi^2(r)$ = radial eigenfunction

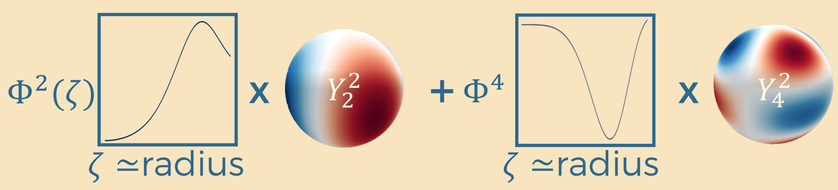


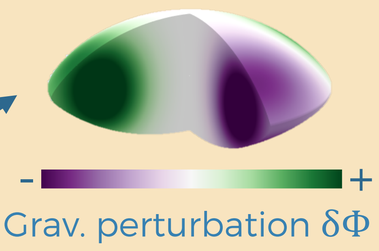
x

Spherical harmonic



Rotating planet: $\delta\Phi(\mathrm{r},\theta,\phi,t) = \mathrm{e}^{-i\sigma t}\sum_{\ell=m}\boldsymbol{\Phi}^{\ell}\boldsymbol{Y}_{\ell}^{\boldsymbol{m}}$



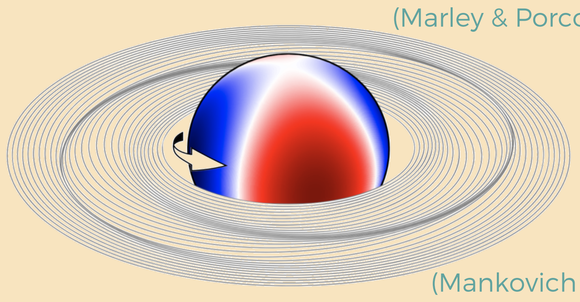


Seismology with Saturn's rings

For more info, check out Dewberry et al. (2021)!
tinyurl.com/dewberry2021

f-mode $\delta\Phi$ → waves in rings

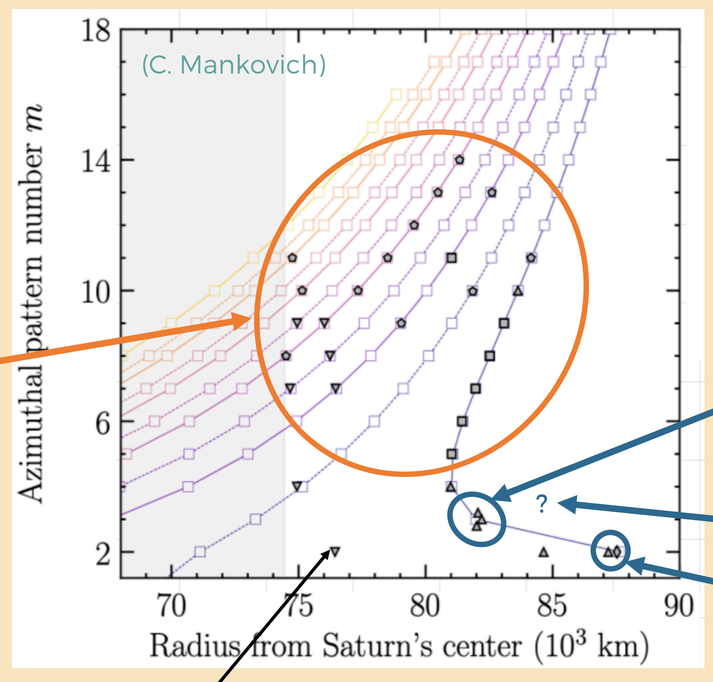
(Marley & Porco 1993)



(Mankovich 2020)

High-degree f-modes constrain Saturn's rotation:

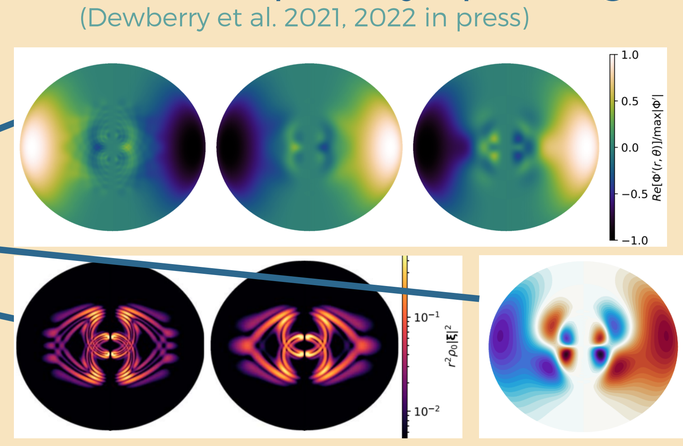
- Bulk angular velocity
  (Mankovich et al. 2019)
- Zonal wind structure
  (Dewberry et al. 2021, 2022 in press; Mankovich et al. 2022 in prep)



Observed waves: Hedman+13, 14, 16; French+16, 19, 21

Traces of internal structure in low-degree ring seismology:

- Extra $m = 2,3$ waves
  (Fuller 2014; Mankovich & Fuller 2021)
- Fine frequency splitting
  (Dewberry et al. 2021, 2022 in press)

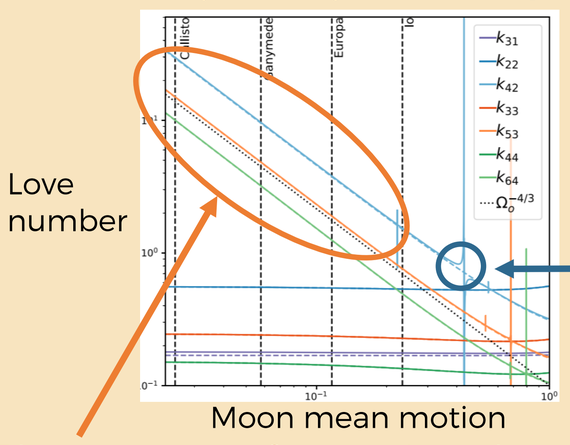


A seismic perspective on tidal interactions

For more info, check out Dewberry & Lai (2022)!
tinyurl.com/dewberry2022

Decomposing dynamical tidal response into oscillations provides insight into:

Tesseral ($\ell > m$) blow-up (Wahl+20)

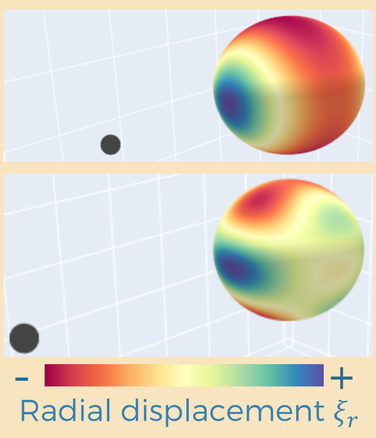


Blow-up due to f-modes' overlap with multiple ℓ in rotationally flattened planets
(Dewberry & Lai 2022; see also Idini & Stevenson 2022a)

Jupiter's k_{42} tension? (Durante+20)

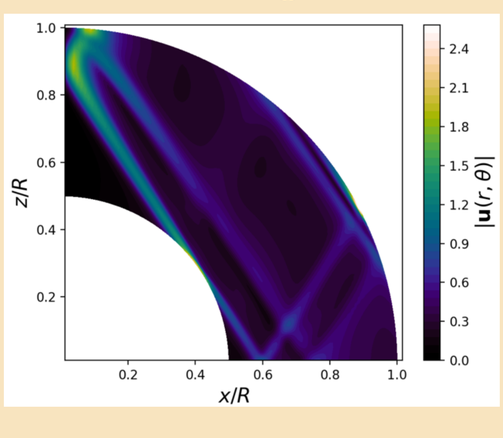
Far from resonance:

Close to resonance:



Moon-oscillation mode resonances can alter high-degree response
(Dewberry & Lai 2022; Idini & Stevenson 2022b)

Rapid moon migration? (Lainey+20)



Resonances can also enhance tidal dissipation and alter orbital evolution
(Ogilvie 2013)

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