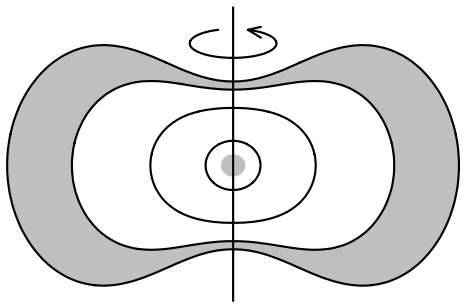
Outline

Physical phenomena

Physical phenomena

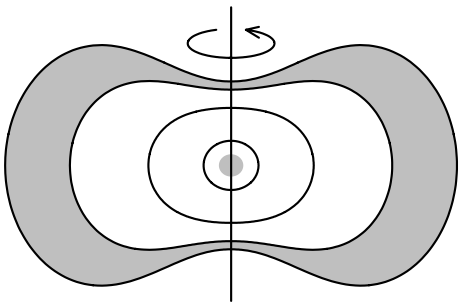
- centrifugal deformation



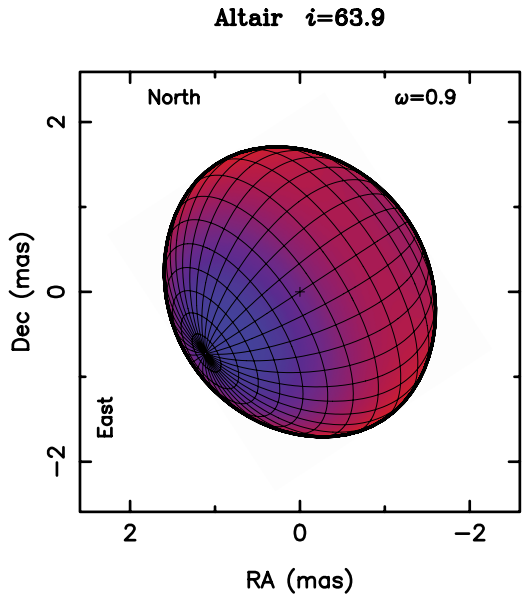
(MacGregor et al., 2007)

Physical phenomena

- centrifugal deformation
- gravitational darkening



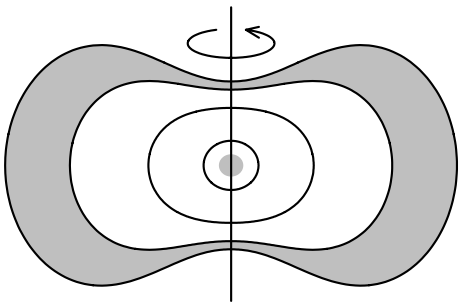
(MacGregor et al., 2007)



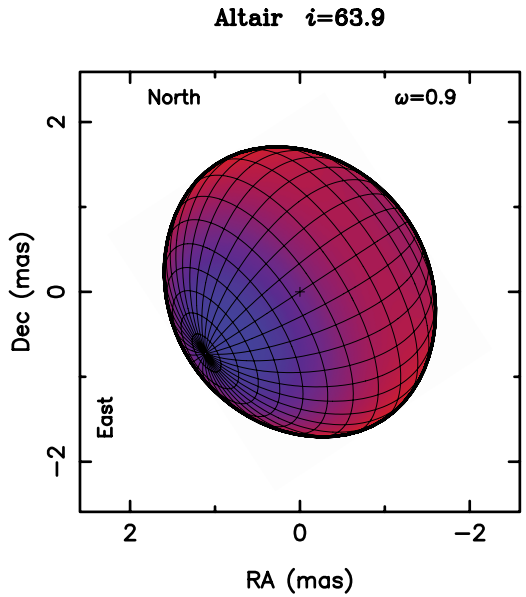
(Peterson et al., 2006)

Physical phenomena

- centrifugal deformation
- gravitational darkening
- baroclinicity



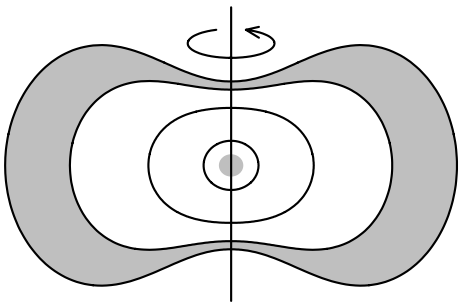
(MacGregor et al., 2007)



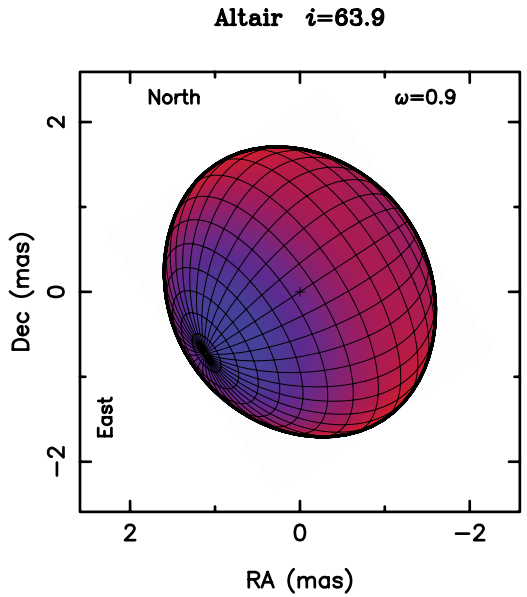
(Peterson et al., 2006)

Physical phenomena

- centrifugal deformation
- gravitational darkening
- baroclinicity
  - differential rotation
  - meridional circulation



(MacGregor et al., 2007)



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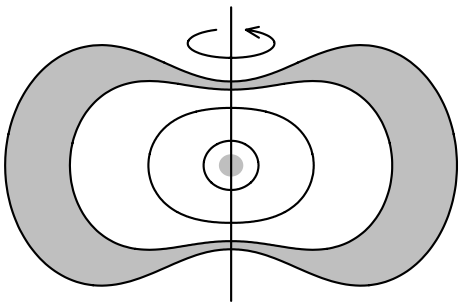
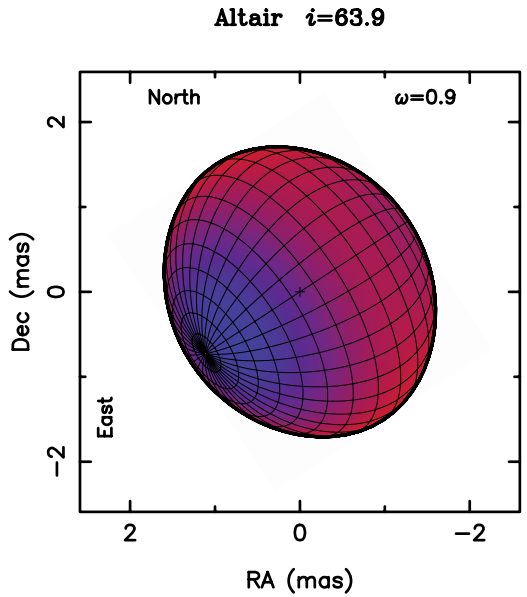
Physical phenomena

- centrifugal deformation
- gravitational darkening
- baroclinicity
  - differential rotation
  - meridional circulation
- transport processes



(MacGregor et al., 2007)

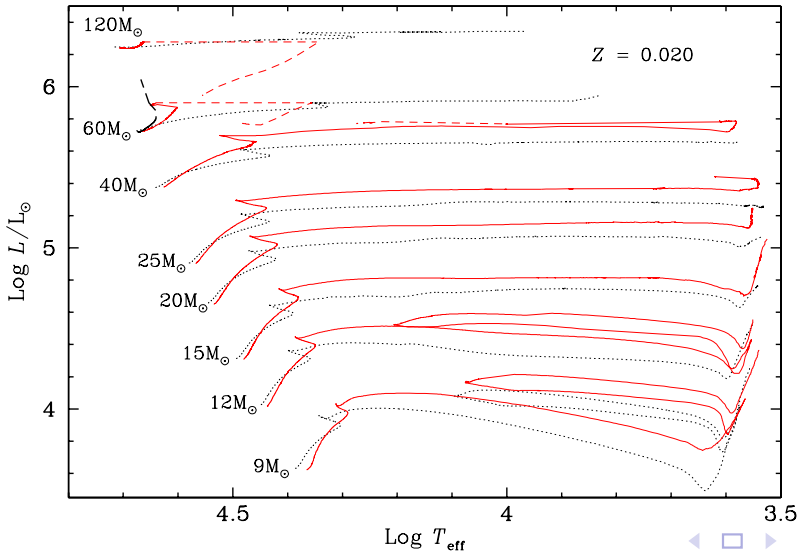


(Peterson et al., 2006)

Recent models

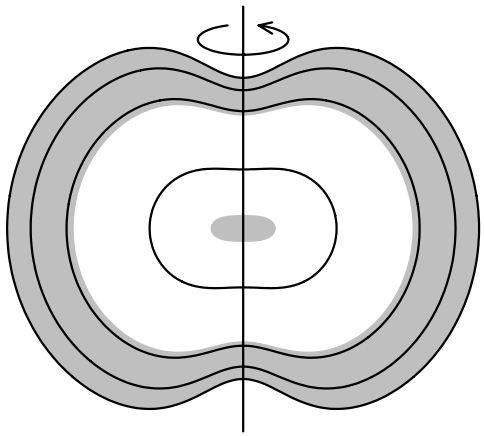
Meynet & Maeder (2000), and other papers

- shellular rotation profile, $\Omega(r)$ *(see Zahn, 1992)*
- 1D formalisme
- stellar evolution
- transport processes (chemical elements and angular momentum)



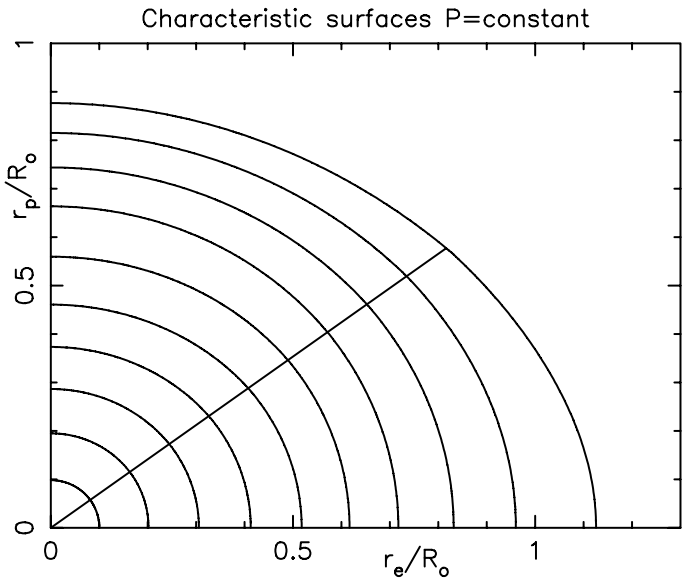
Jackson et al. (2004, 2005), MacGregor et al. (2007)

- barotropic models
- conservative rotation profile: $\Omega(s)$
- attempt to describe Achernar



(MacGregor et al., 2007)

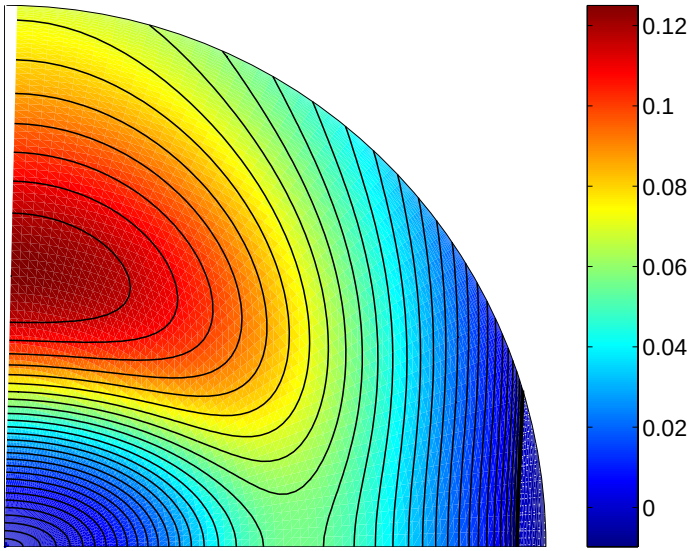
- Roxburgh (2004)
  - barotropic uniformly rotating model
- Roxburgh (2006)
  - transforms 1D models into 2D models
  - arbitrary 2D rotation profile
  - thermal equilibrium not solved



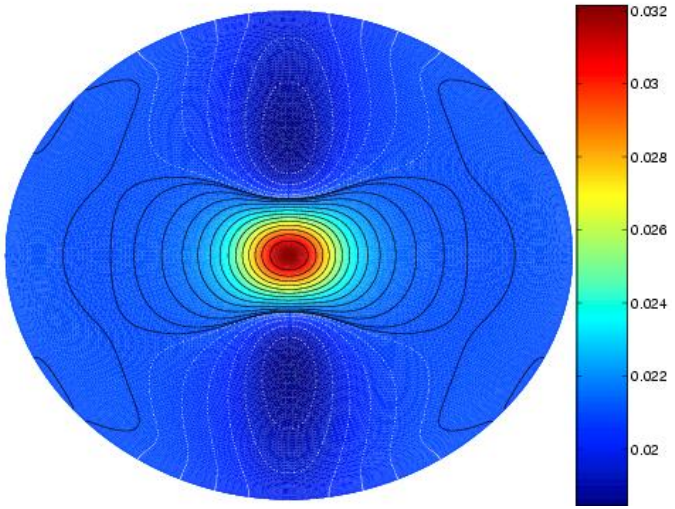
(Roxburgh, 2006)

The ESTER project

- Rieutord (2006)
  - boussinesq model with baroclinic flows
- Espinosa & Rieutord (2007)
  - compressible baroclinic model in spherical container



(Espinosa & Rieutord, 2007)



(Courtesy of M. Rieutord)

Pulsation modes

- many uncertainties remain in models
  - need for observational constraints

Pulsation modes

- many uncertainties remain in models
  - need for observational constraints
- difficulties
  - pulsation modes are not given by a single spherical harmonic: this is a 2D eigenvalue problem
  - unfamiliar mode geometry and frequency spectrum

The frequency spectrum

- Inadequacy of perturbative methods at rapid rotation rates

The frequency spectrum

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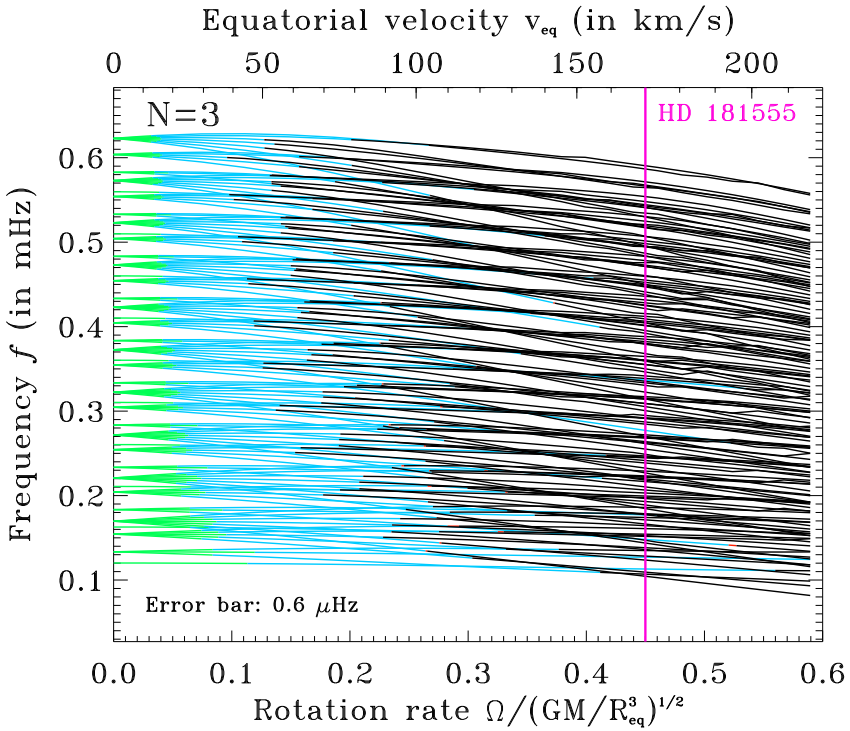
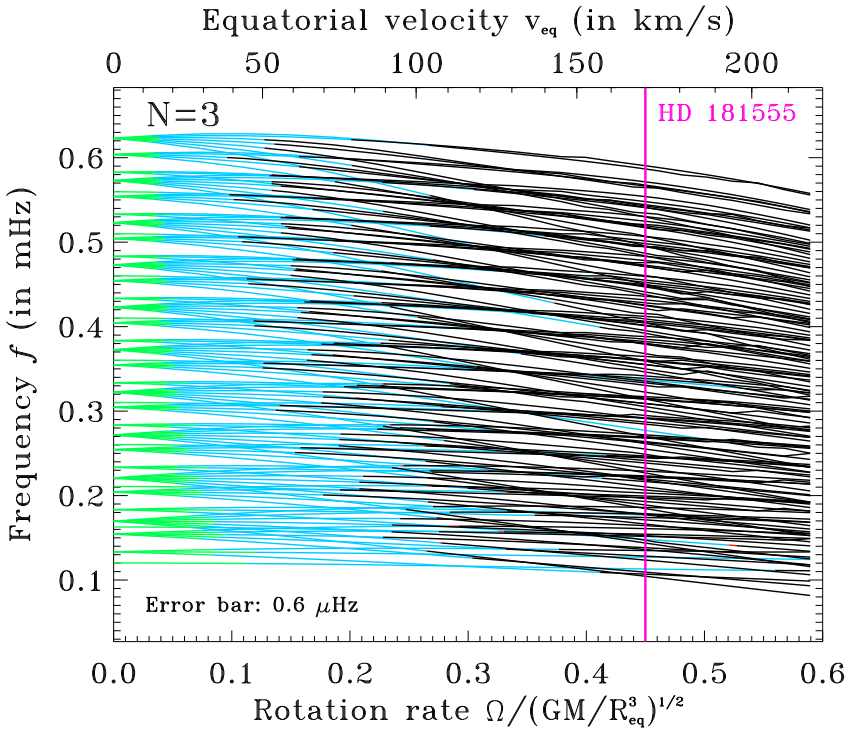
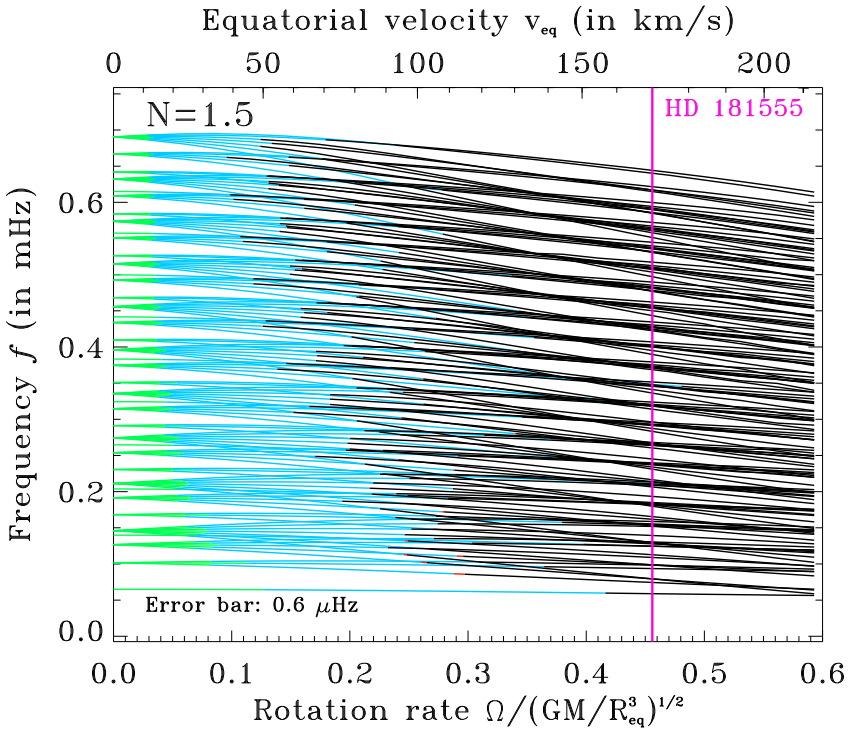


(Reese et al., 2006)

The frequency spectrum

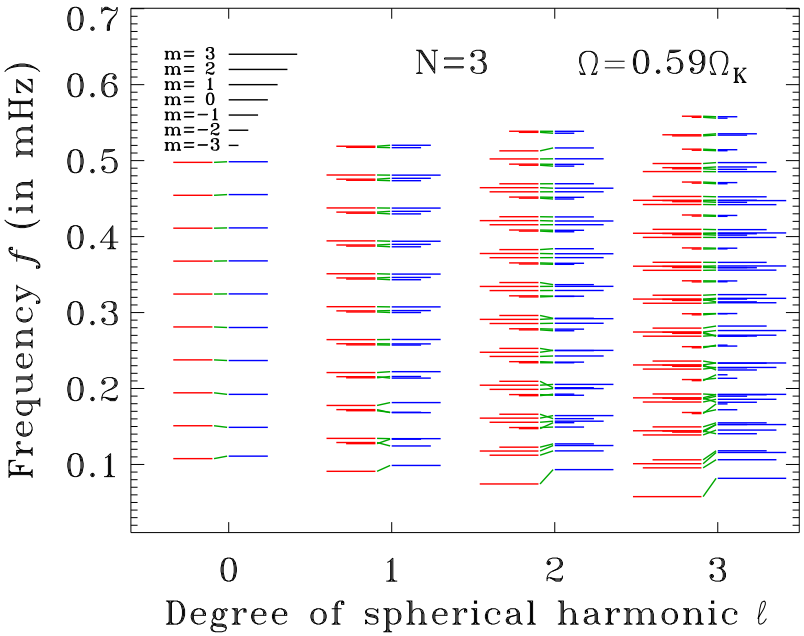
- Inadequacy of perturbative methods at rapid rotation rates

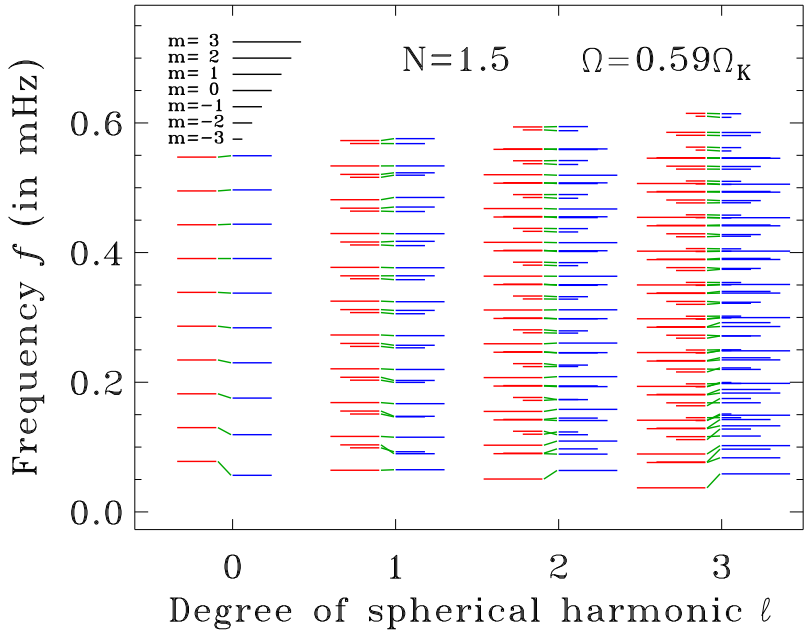




(Reese et al., 2006)

A new frequency organisation

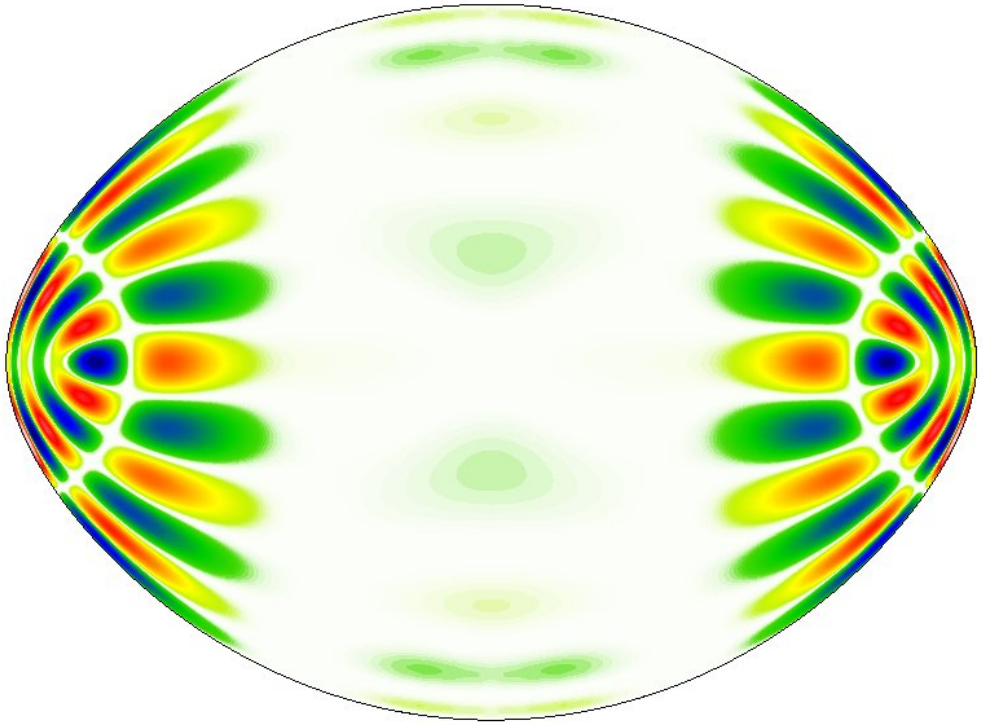




(Lignieres et al., 2006, Reese et al., in preparation)

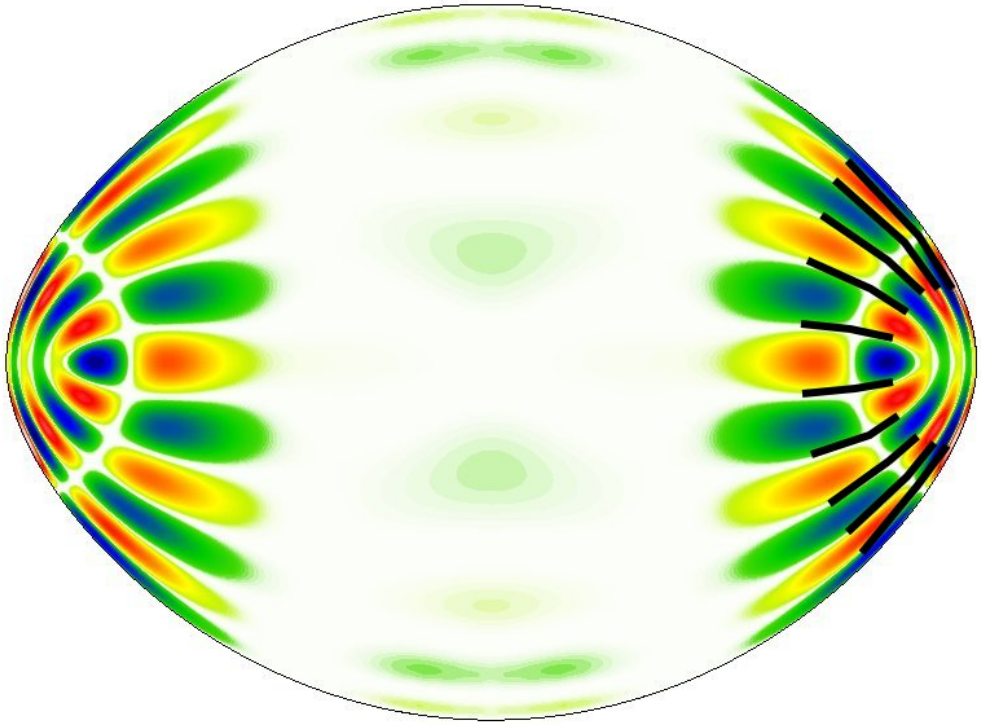
$$\omega_{n,\ell,m} = n\Delta_n + \ell\Delta_\ell + |m|\Delta_m + \alpha^{\pm}$$

Mode geometry



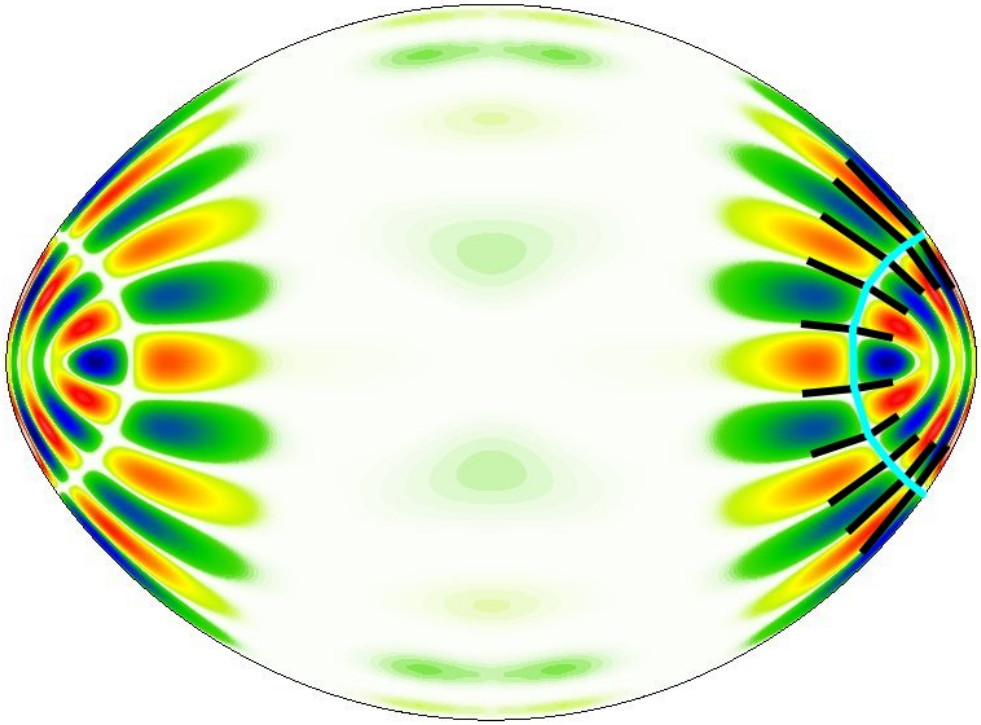
- mode energy concentrated around equatorial region

Mode geometry

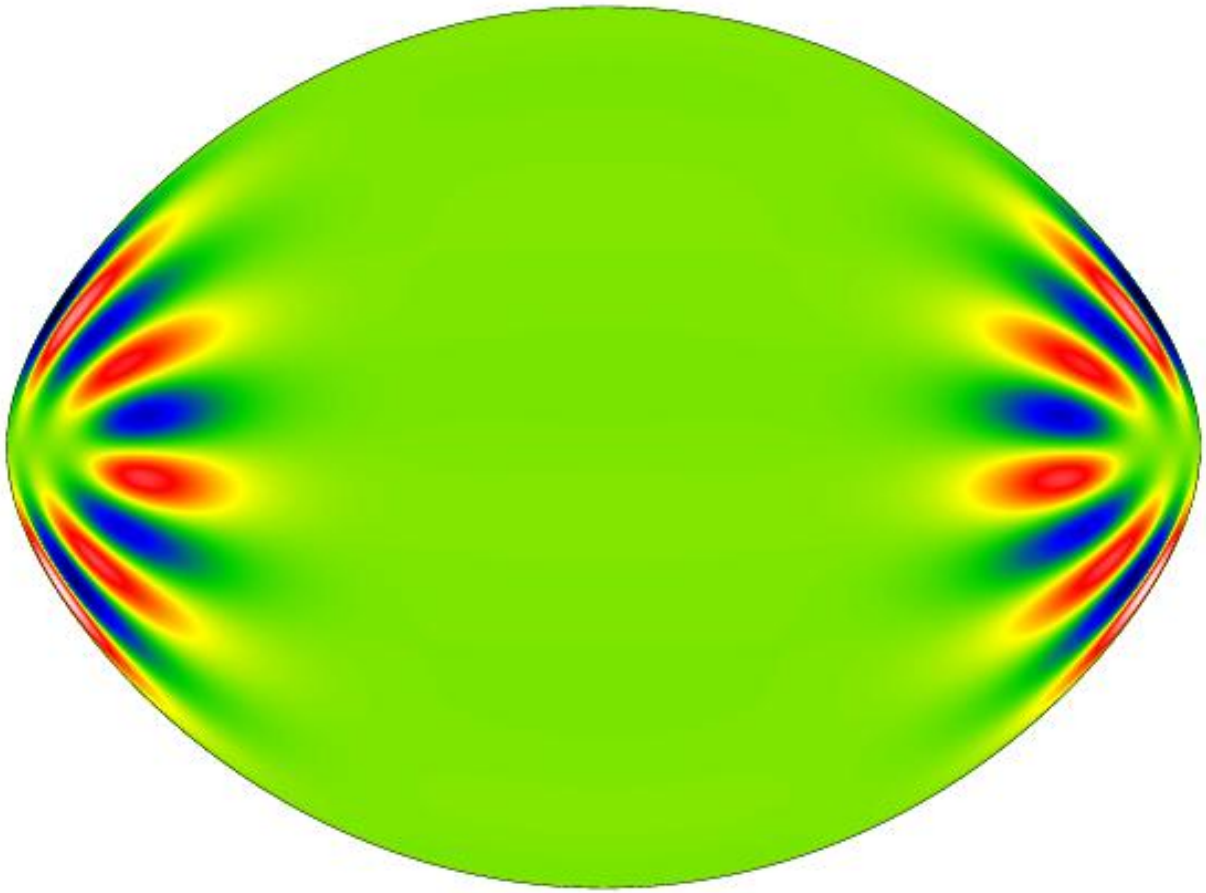


- mode energy concentrated around equatorial region
- there are 10 "radial" nodes ($\tilde{n} = 10$)

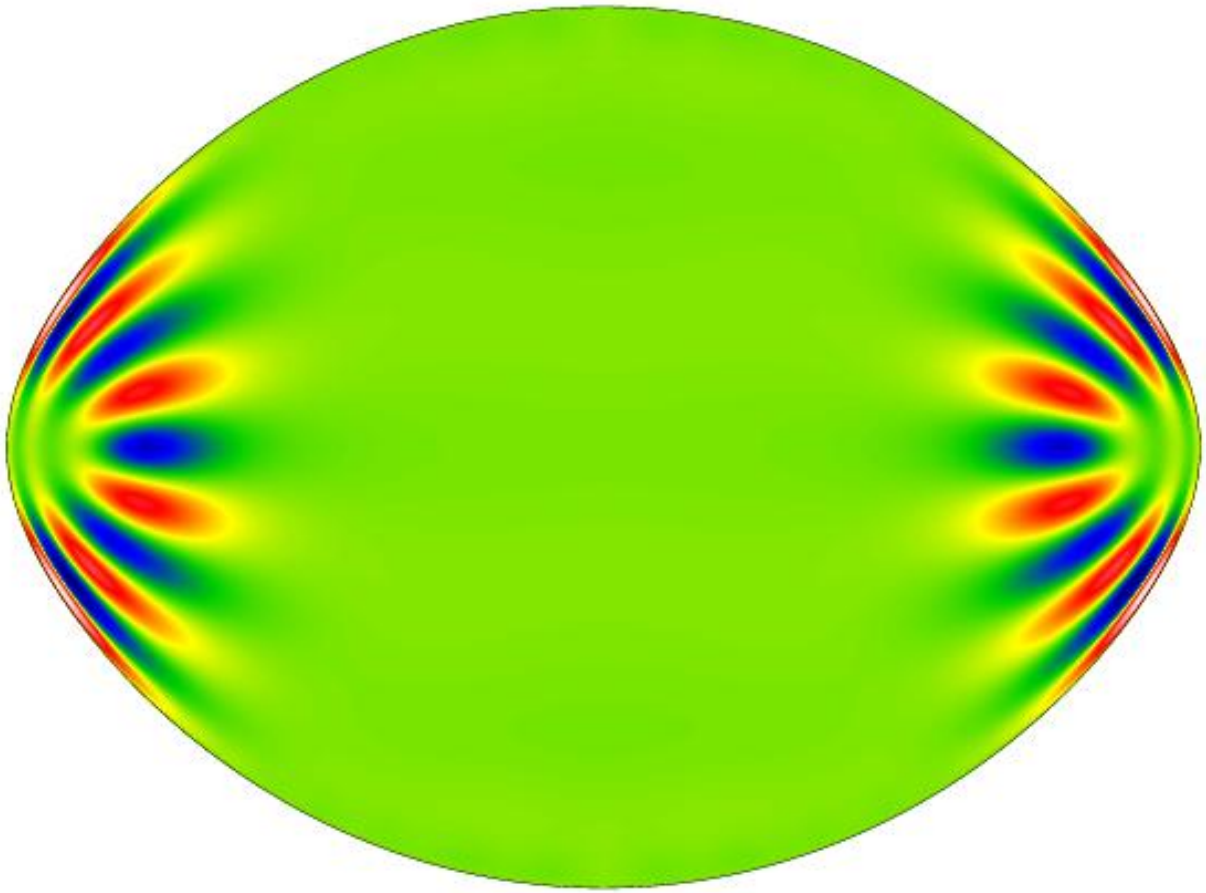
Mode geometry



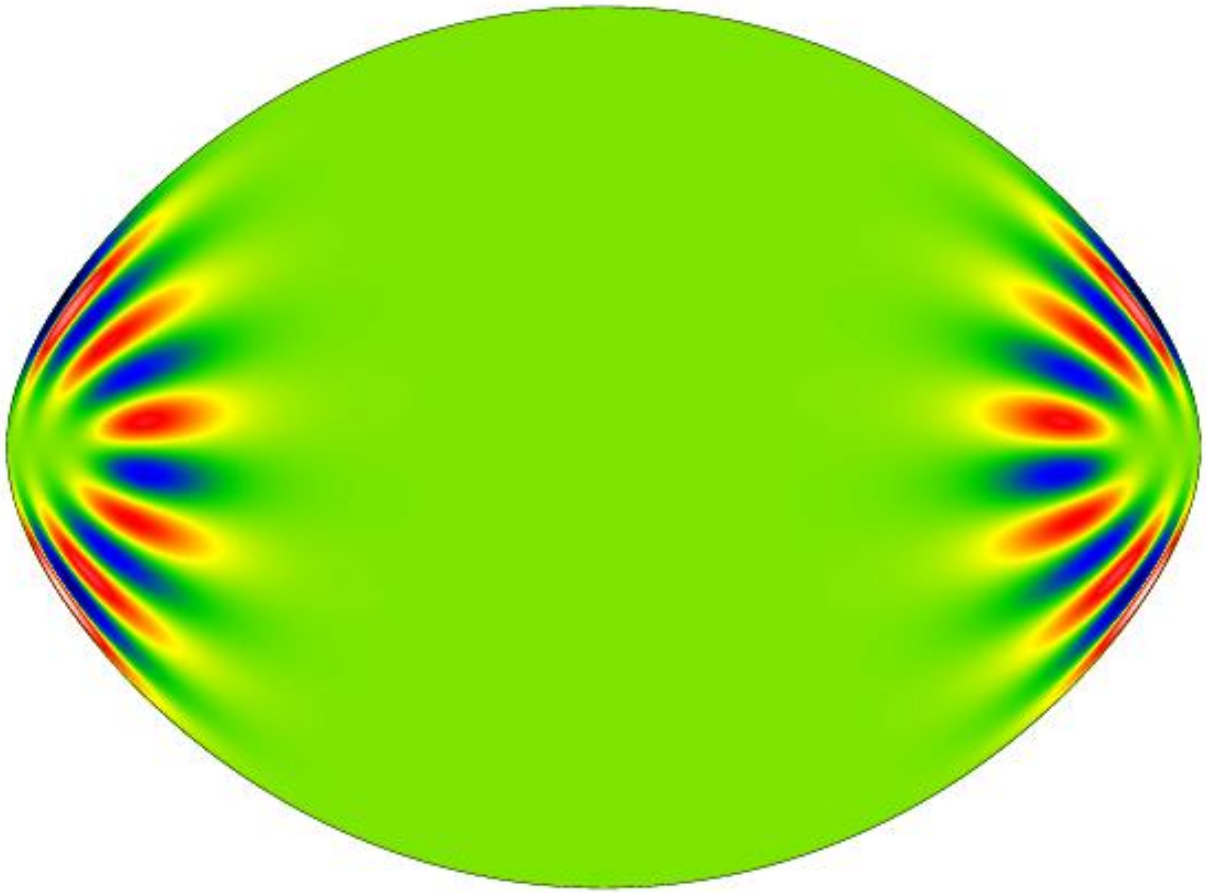
- mode energy concentrated around equatorial region
- there are 10 "radial" nodes ($\tilde{n} = 10$)
- there is 1 "latitudinal" node ($\tilde{\ell} = 1$)



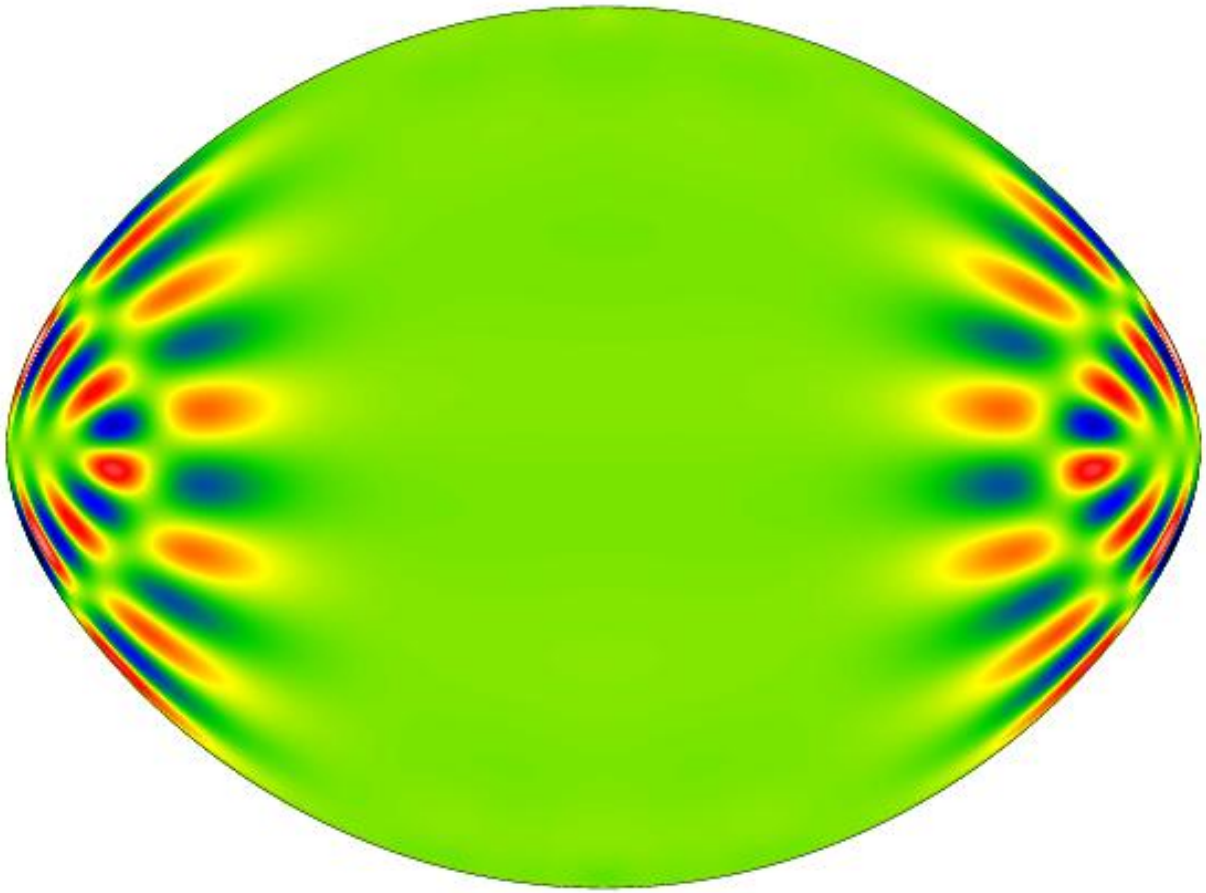
$$\tilde{n} = \quad 9, \quad \tilde{\ell} = 0$$



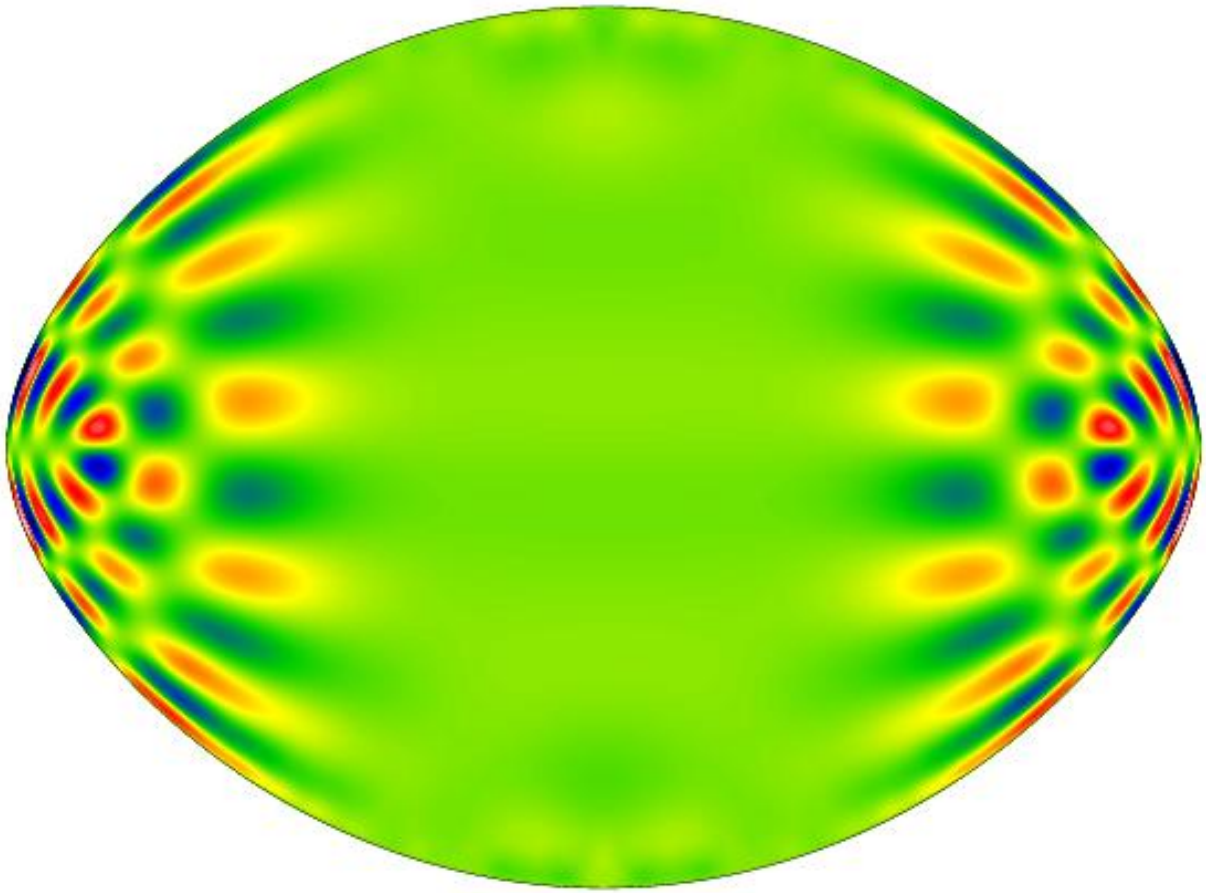
$$\tilde{n} = 10, \quad \tilde{\ell} = 0$$



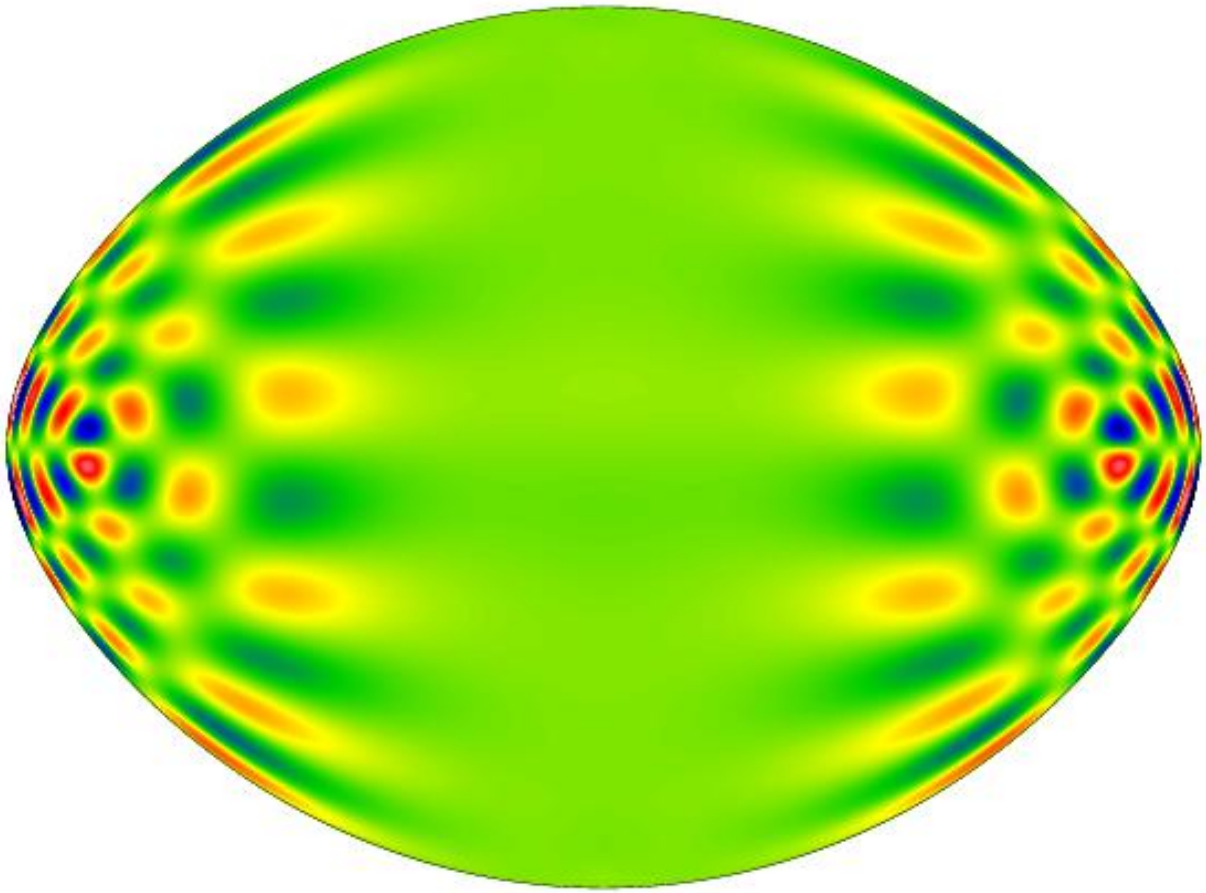
$$\tilde{n} = 11, \quad \tilde{\ell} = 0$$



$$\tilde{n} = 11, \quad \tilde{\ell} = 1$$

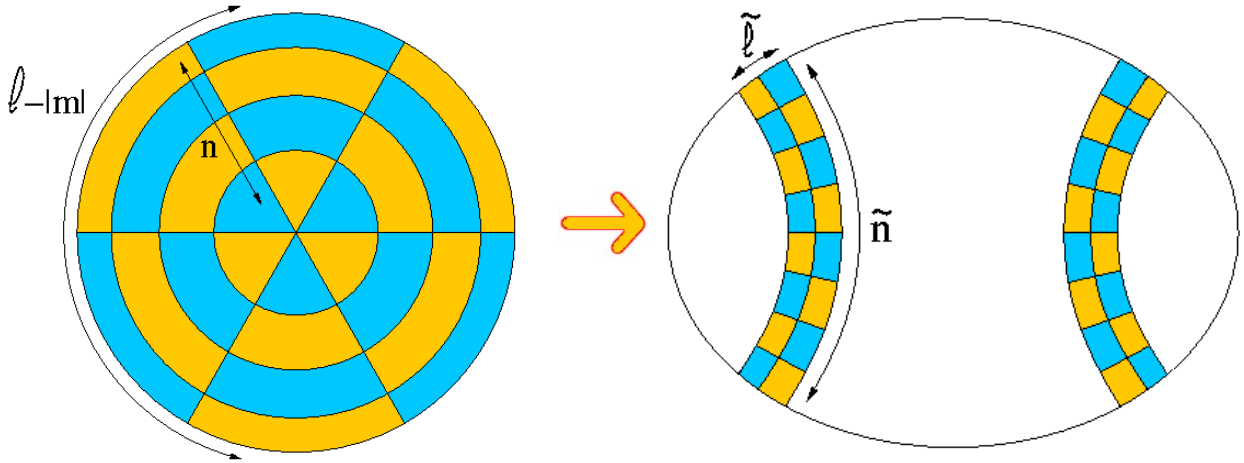


$$\tilde{n} = 11, \quad \tilde{\ell} = 2$$



$$\tilde{n} = 11, \quad \tilde{\ell} = 3$$

Question: what is the link between this mode geometry and the geometry of modes in non-rotating stars?



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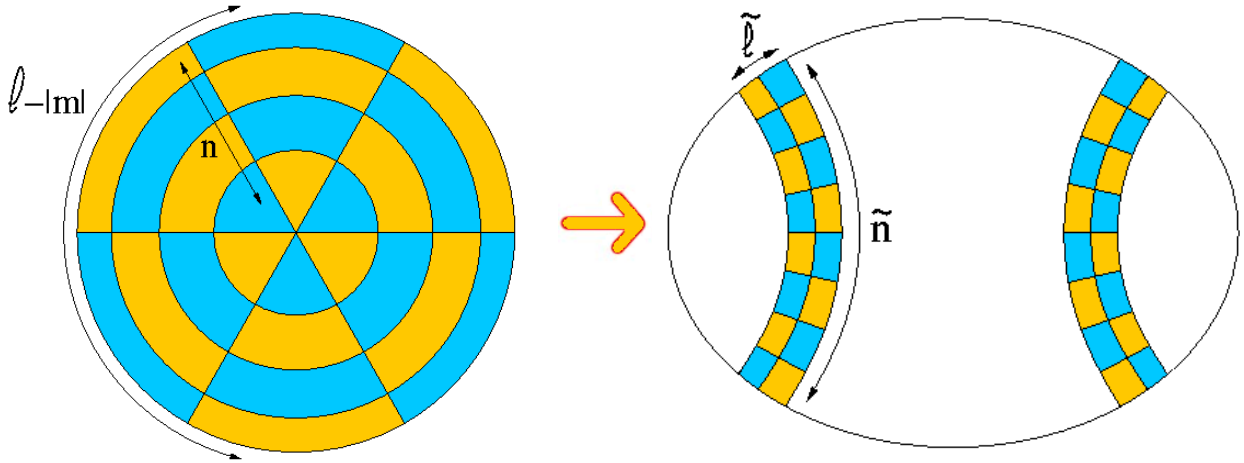

$$\begin{aligned} \tilde{n} &= 2n + \varepsilon, \\ \tilde{\ell} &= \frac{\ell - |m| - \varepsilon}{2}, \\ \varepsilon &\equiv \ell + m \ [2] \end{aligned}$$

$$\omega_{n,\ell,m} = \tilde{n}\tilde{\Delta}_n + \tilde{\ell}\tilde{\Delta}_\ell + |m|\tilde{\Delta}_m + \tilde{\alpha}$$

What needs to be done:

- search for asymptotic patterns using realistic stellar models
- search for equidistant patterns in observed pulsation spectra
- improve stellar models
- do detailled asteroseismic comparisons