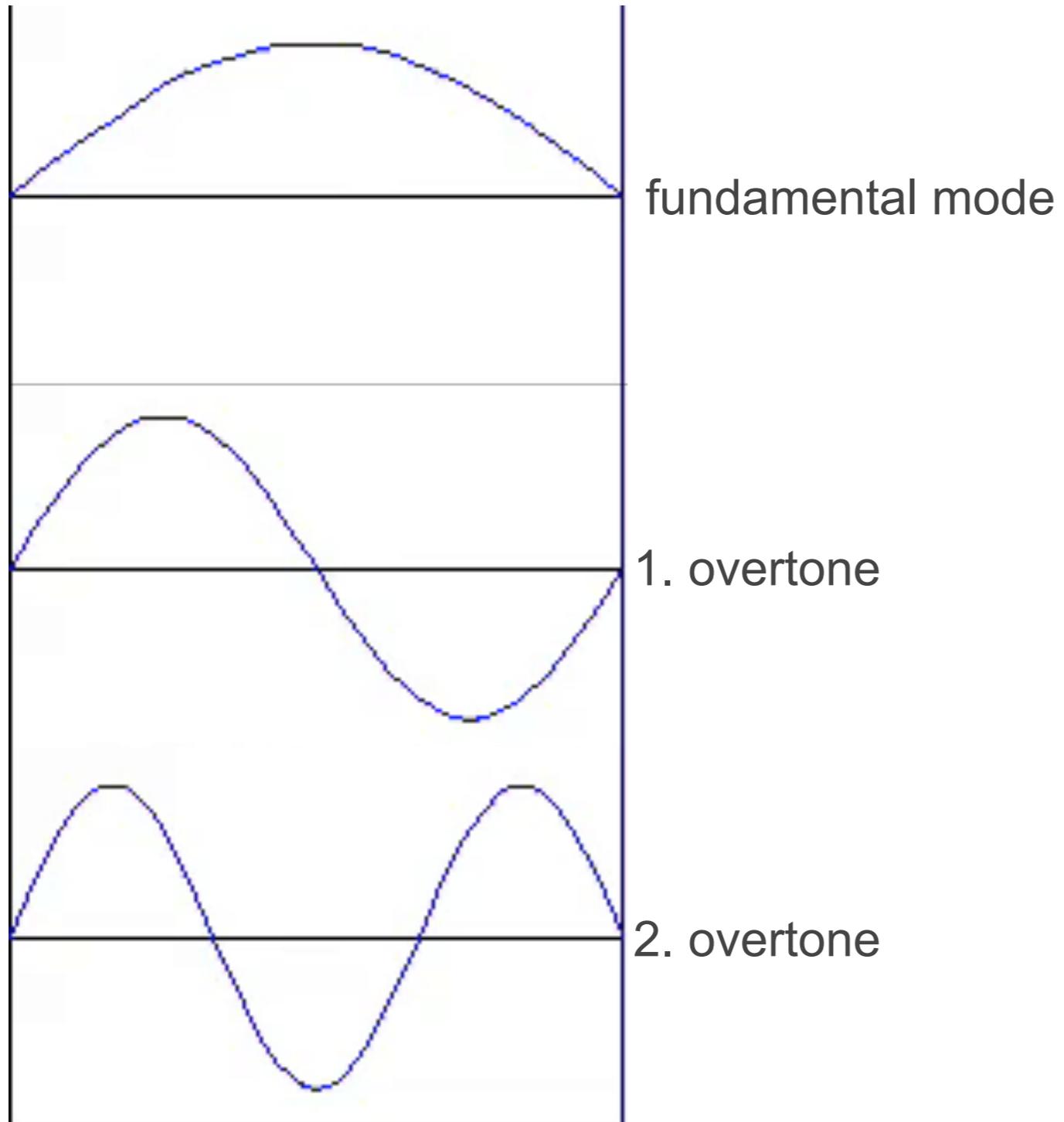
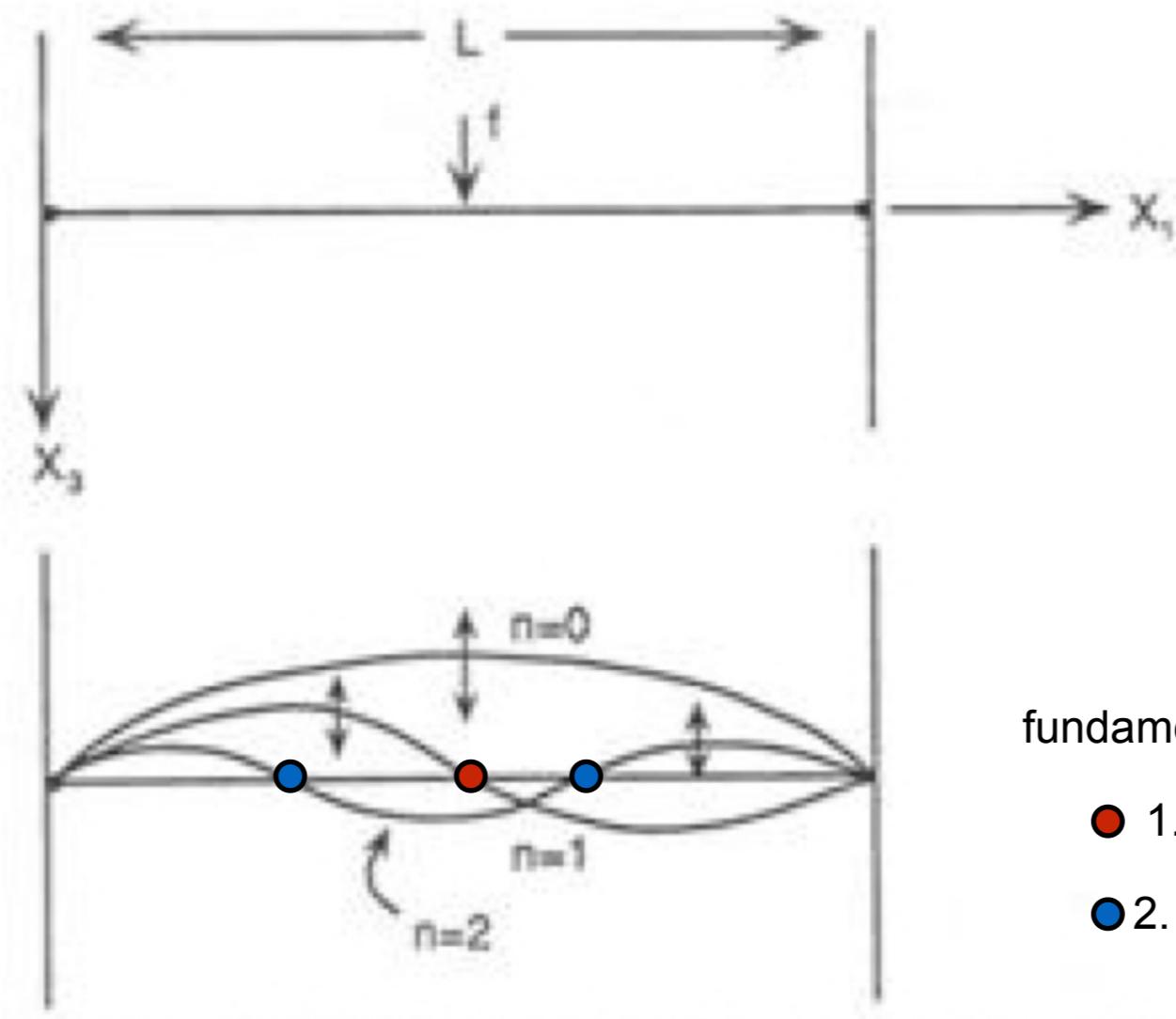


Normal modes



Normal modes of a string





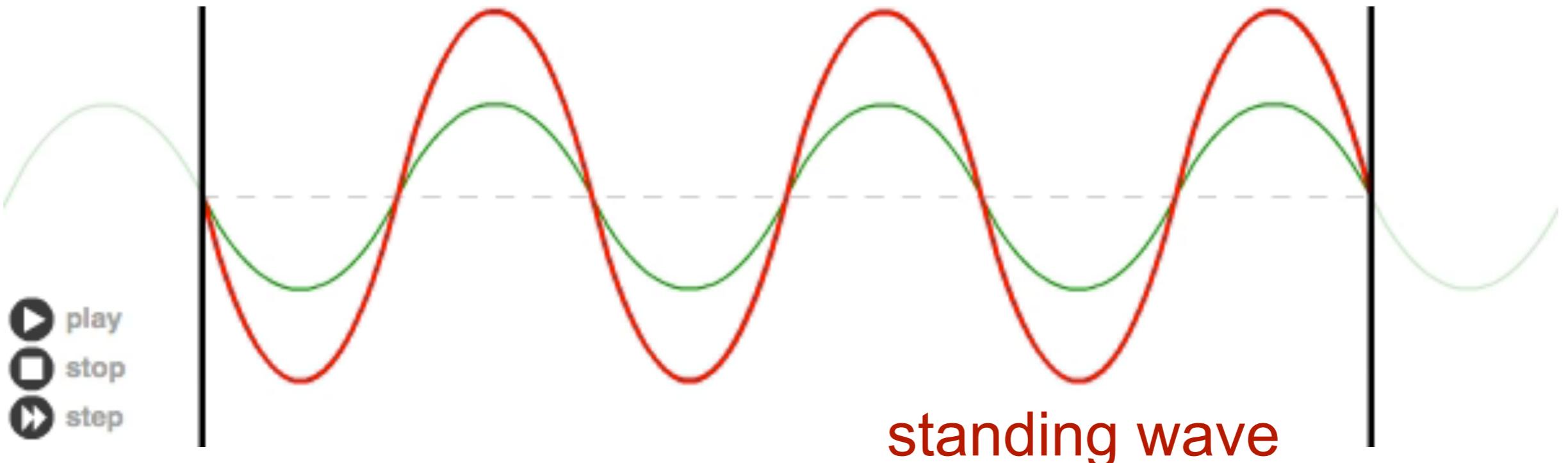
fundamental mode ($n=0$)

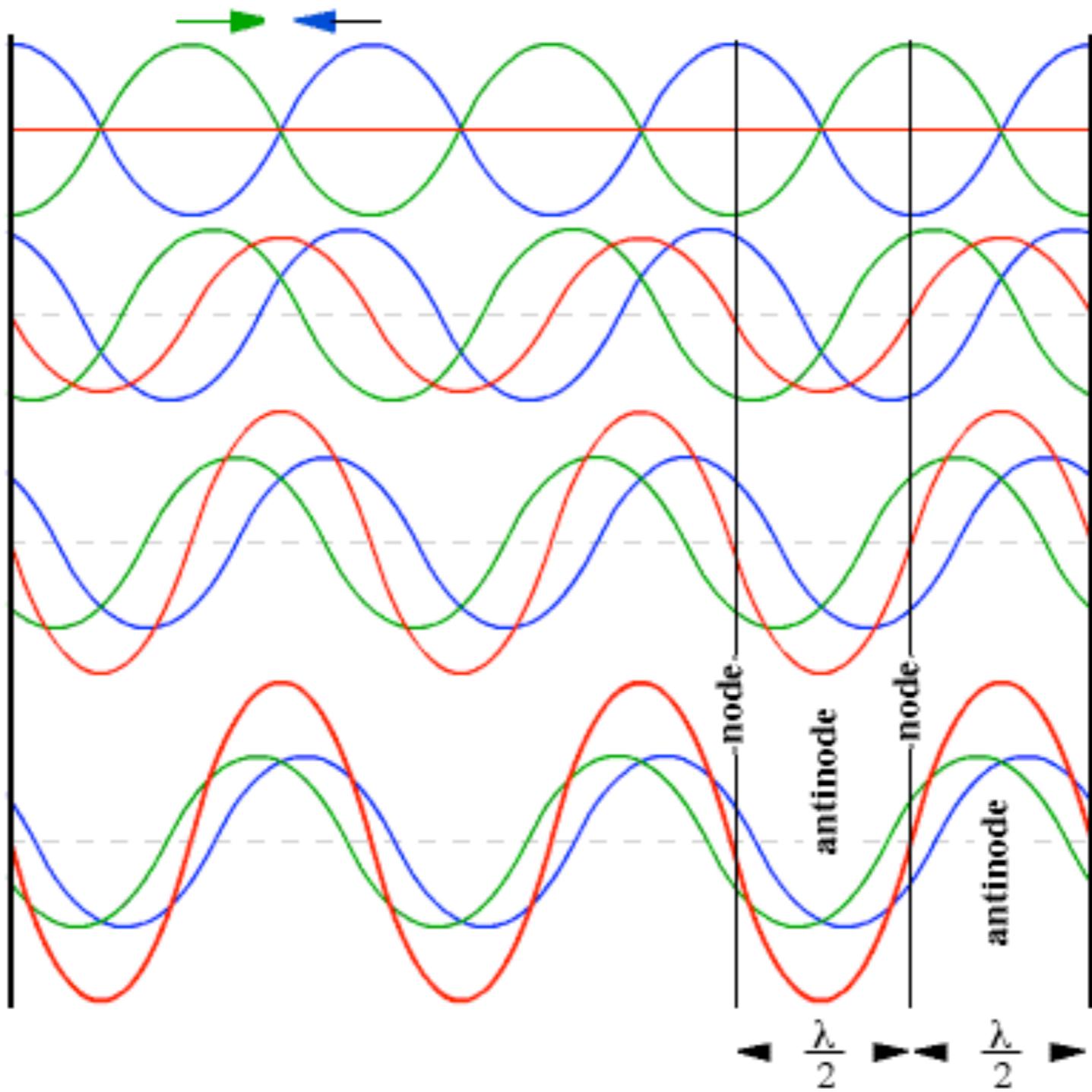
- 1. overtone, node
- 2. overtone, nodes

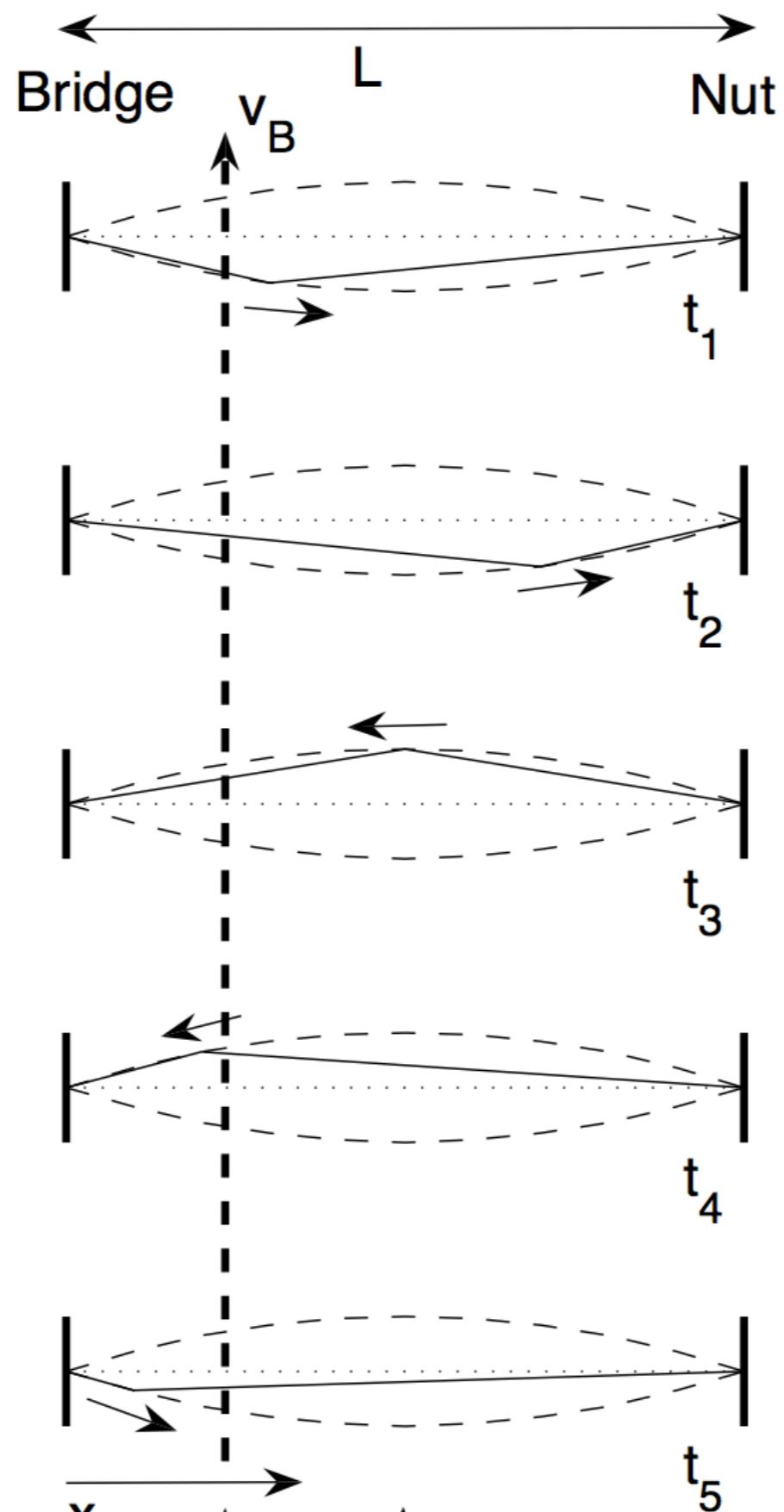


traveling wave →

← traveling wave

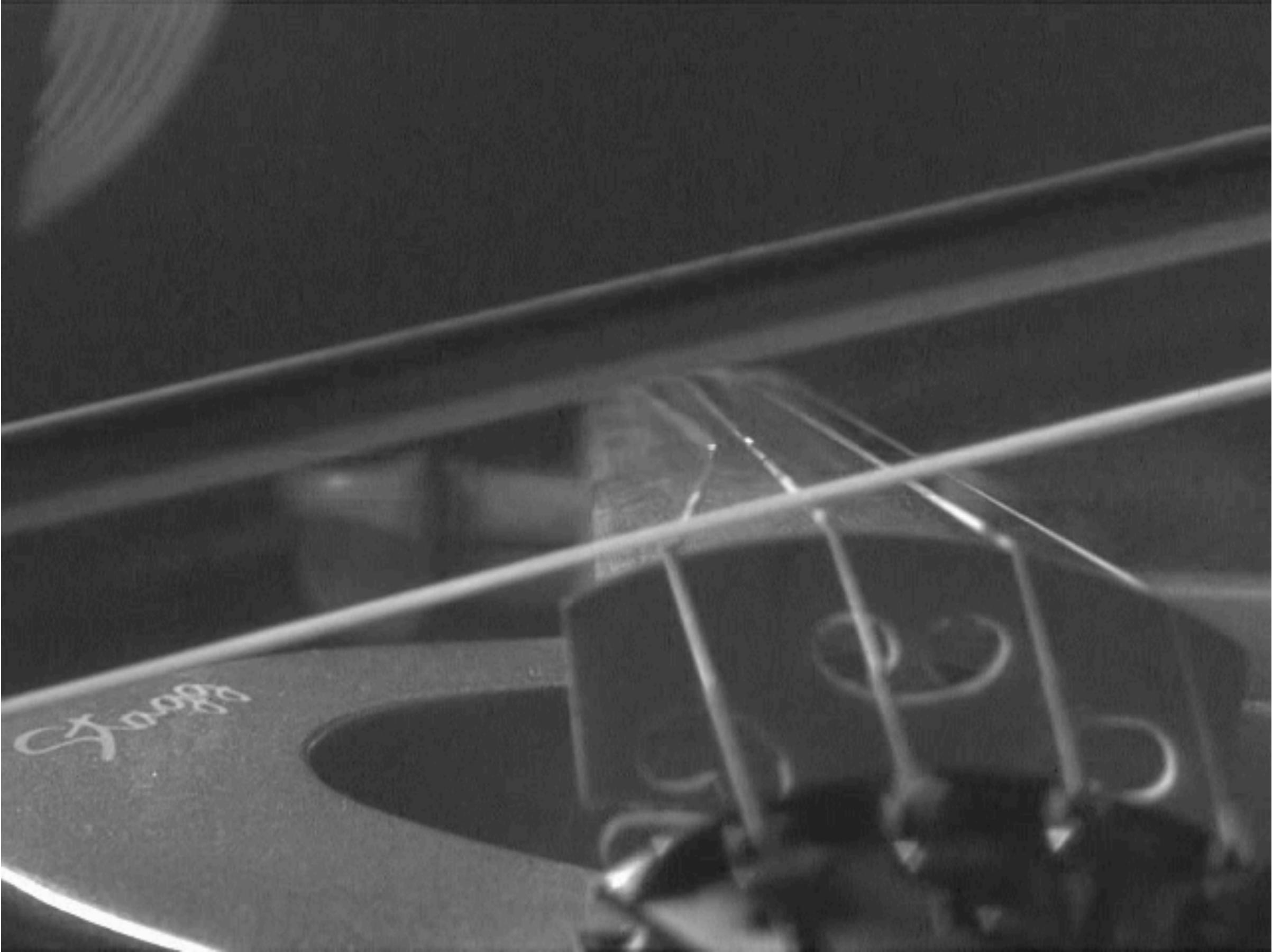






Idealized string:
Helmholtz motion
snapshots of traveling corner





Seismic waves

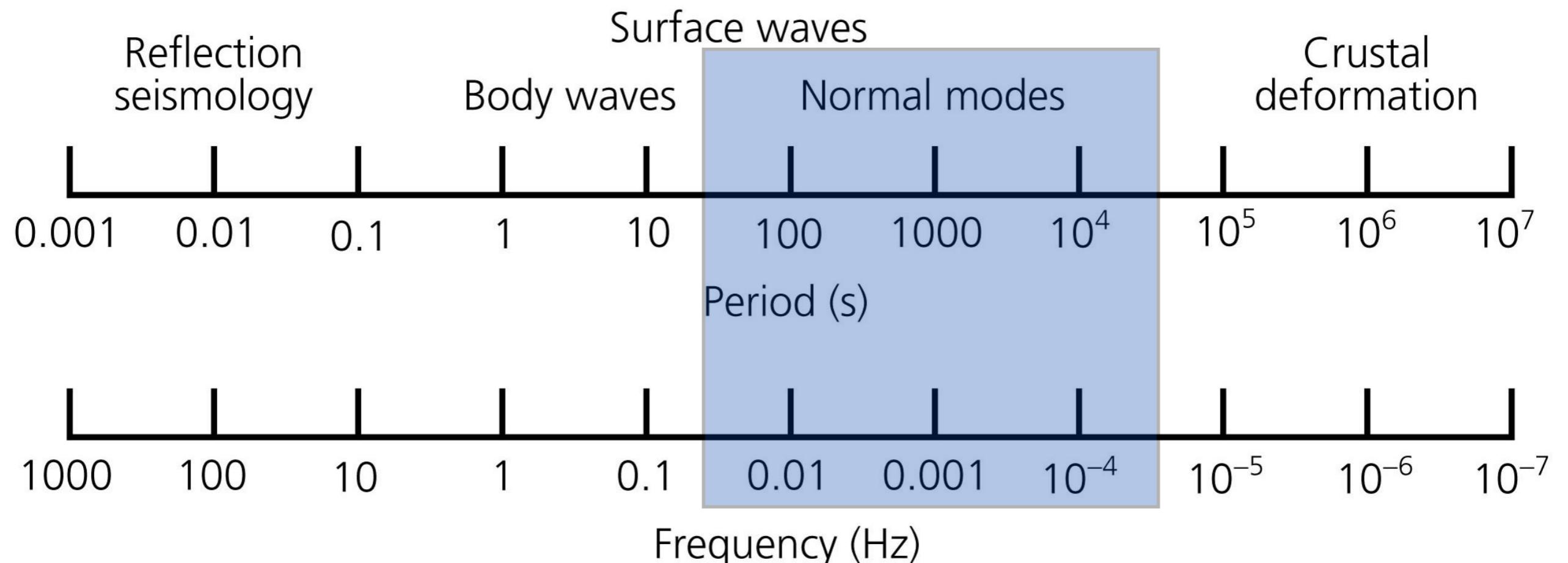


Normal modes of the Earth



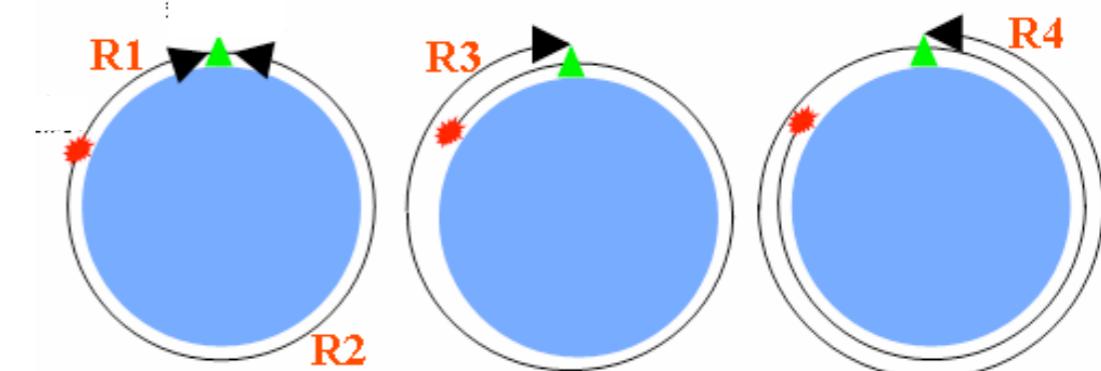
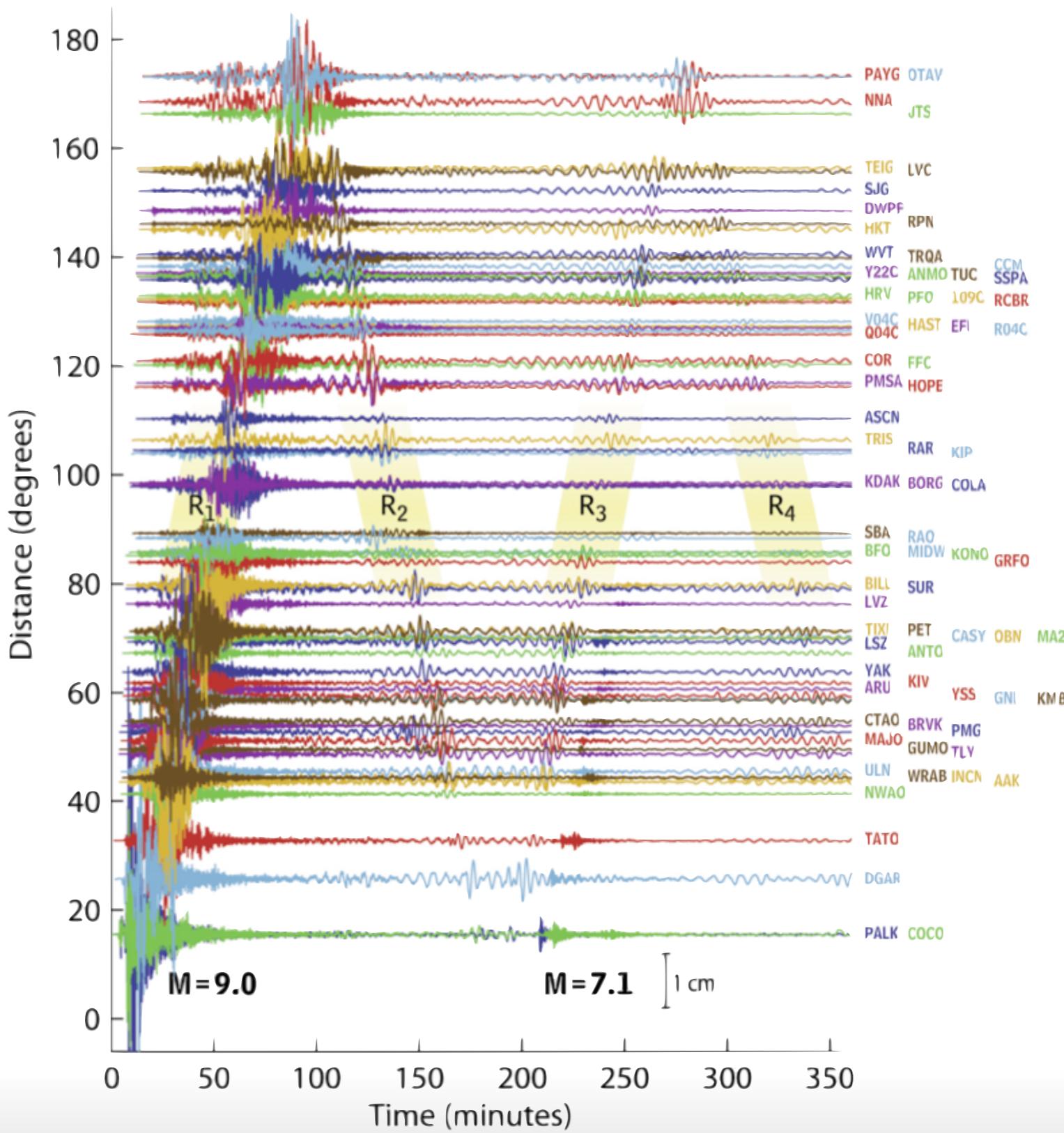
Normal modes

Figure 2.4-7: Seismic spectrum for various studies.



Sumatra - Andaman Islands Earthquake ($M_w=9.0$)

Global Displacement Wavefield from the Global Seismographic Network



Seismic waves



Normal modes

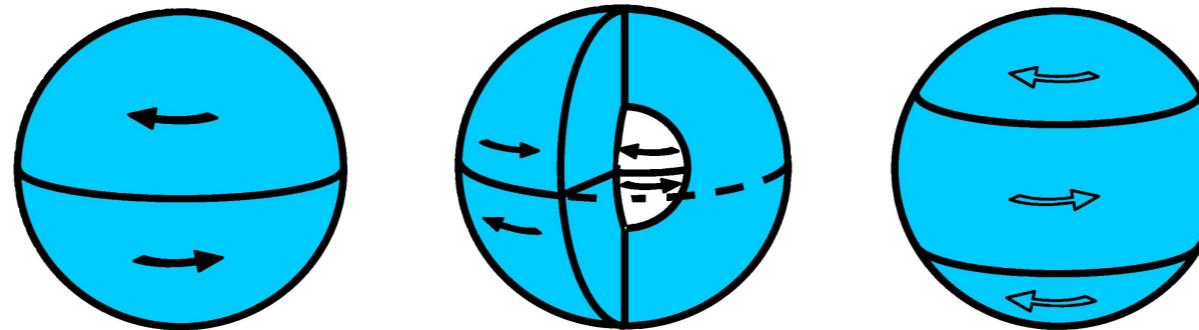
n : overtone number (fundamental $n=0$, 1. overtone $n= 1, \dots$)

l : angular degree

m : azimuthal order ($-l \leq m \leq l$)

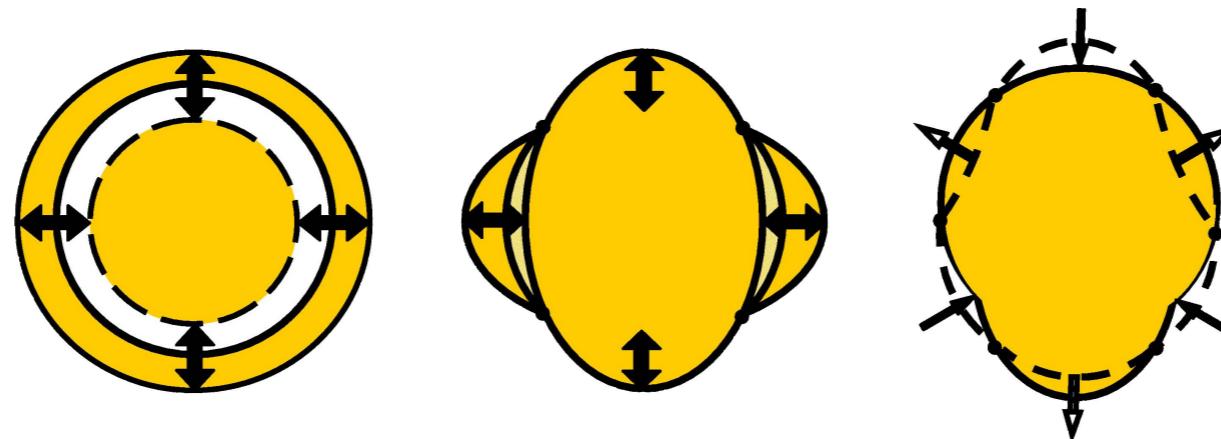
nT_l : multiplet of $2l + 1$ singlets ($-l \leq m \leq l$)

nT_l



Toroidal modes $_0T_2$ (44.2 min), $_1T_2$ (12.6 min)
and $_0T_3$ (28.4 min)

nS_l



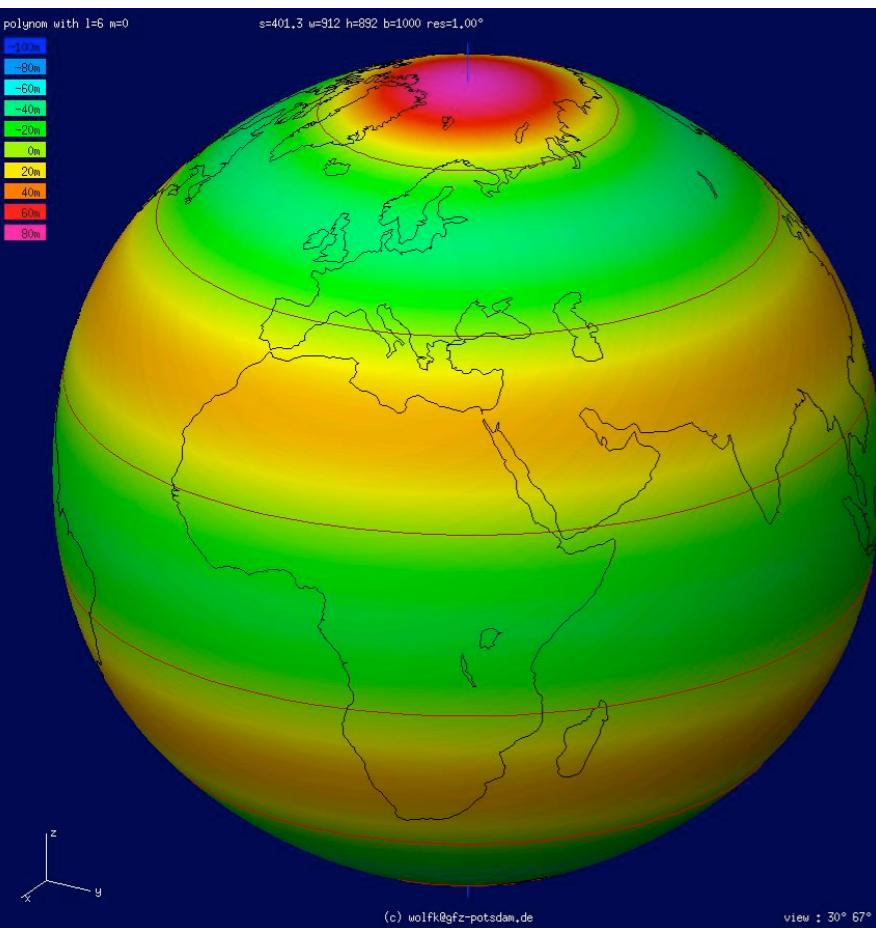
Spheroidal modes $_0S_0$ (20.5 min), $_0S_2$ (53.9 min)
and $_0S_3$ (25.7 min)



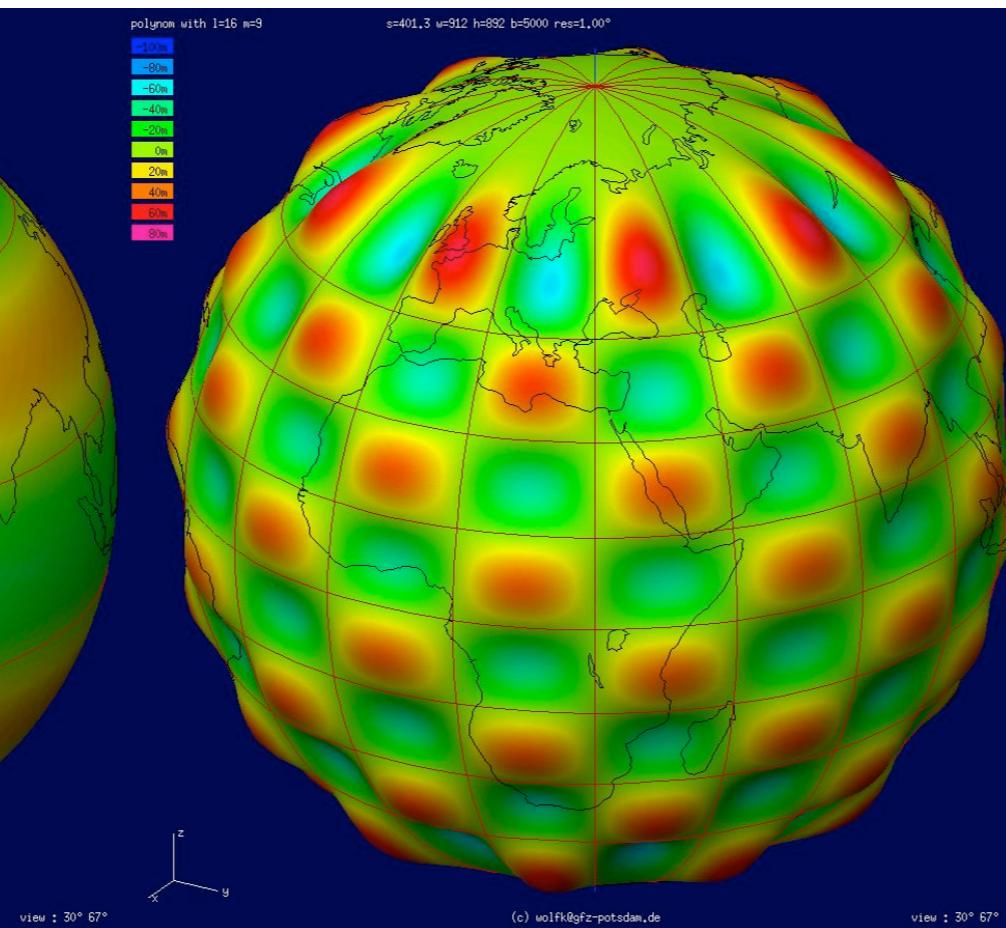
Spherical harmonics

Y_{lm} l : spherical harmonic degree
 m : azimuthal order ($-l \leq m \leq l$)

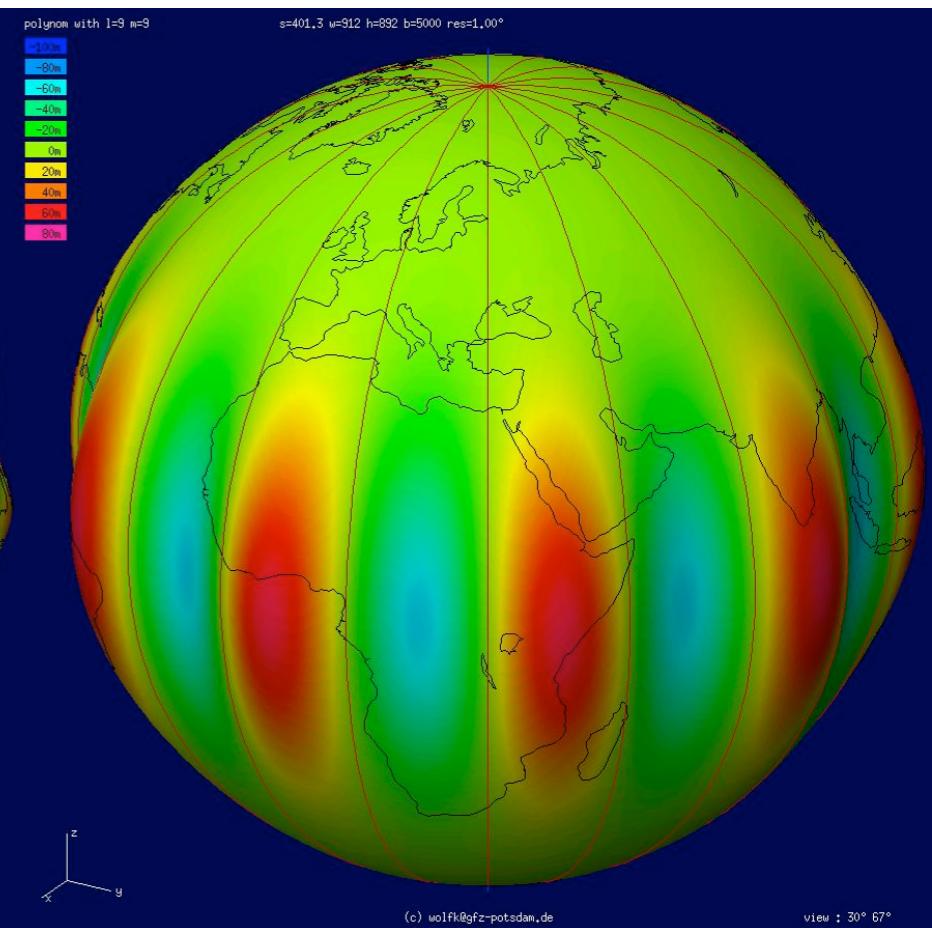
$Y_{6,0}$



$Y_{16,9}$



$Y_{9,9}$



zonal: $l \neq 0, m = 0$

tesseral: $l \neq 0, m \neq 0 \neq l$

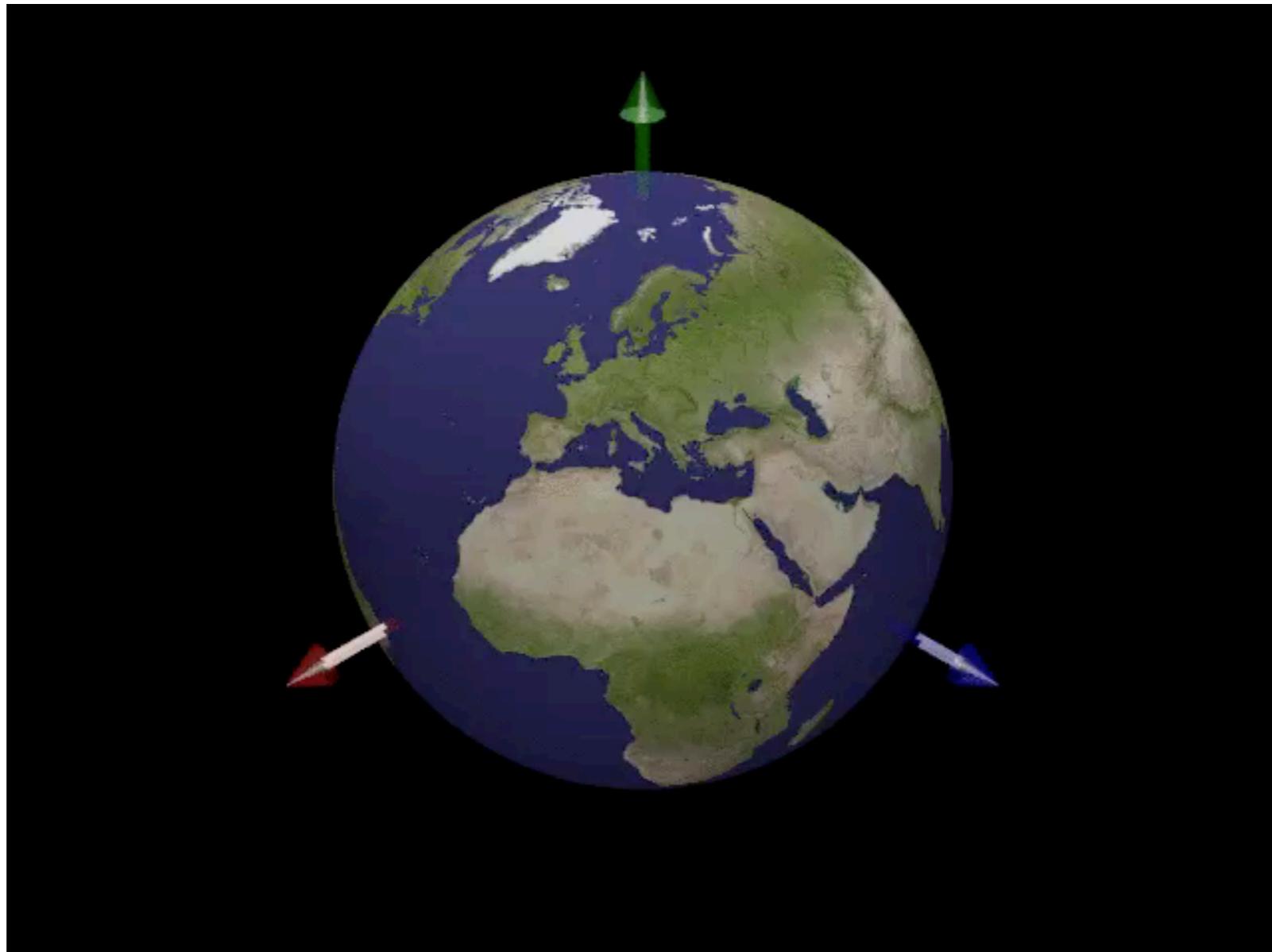
sectorial: $l = m$



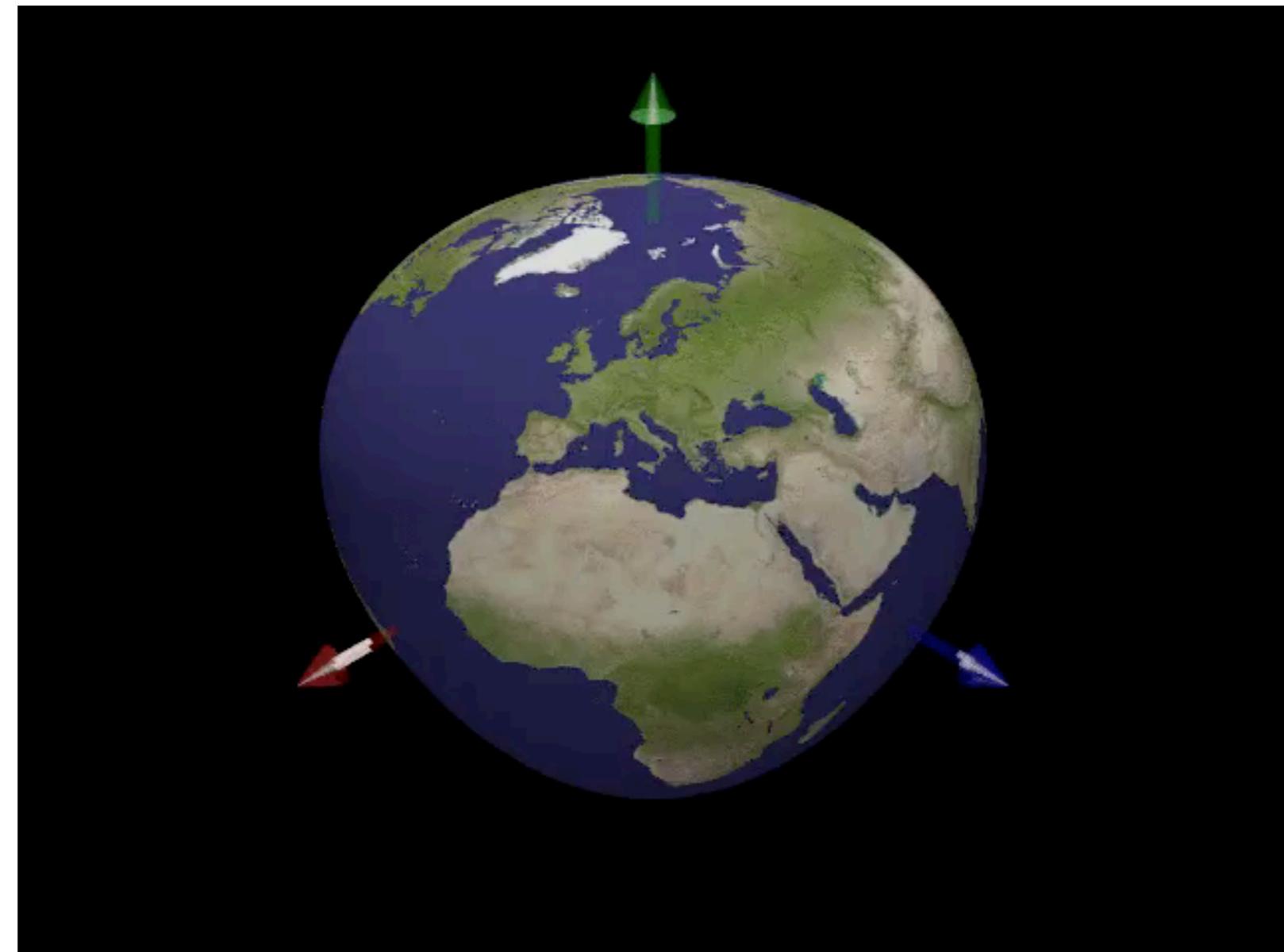
Normal modes

20.9'
 $\delta r=0.05\text{m}$

 S_o
spheroidal mode

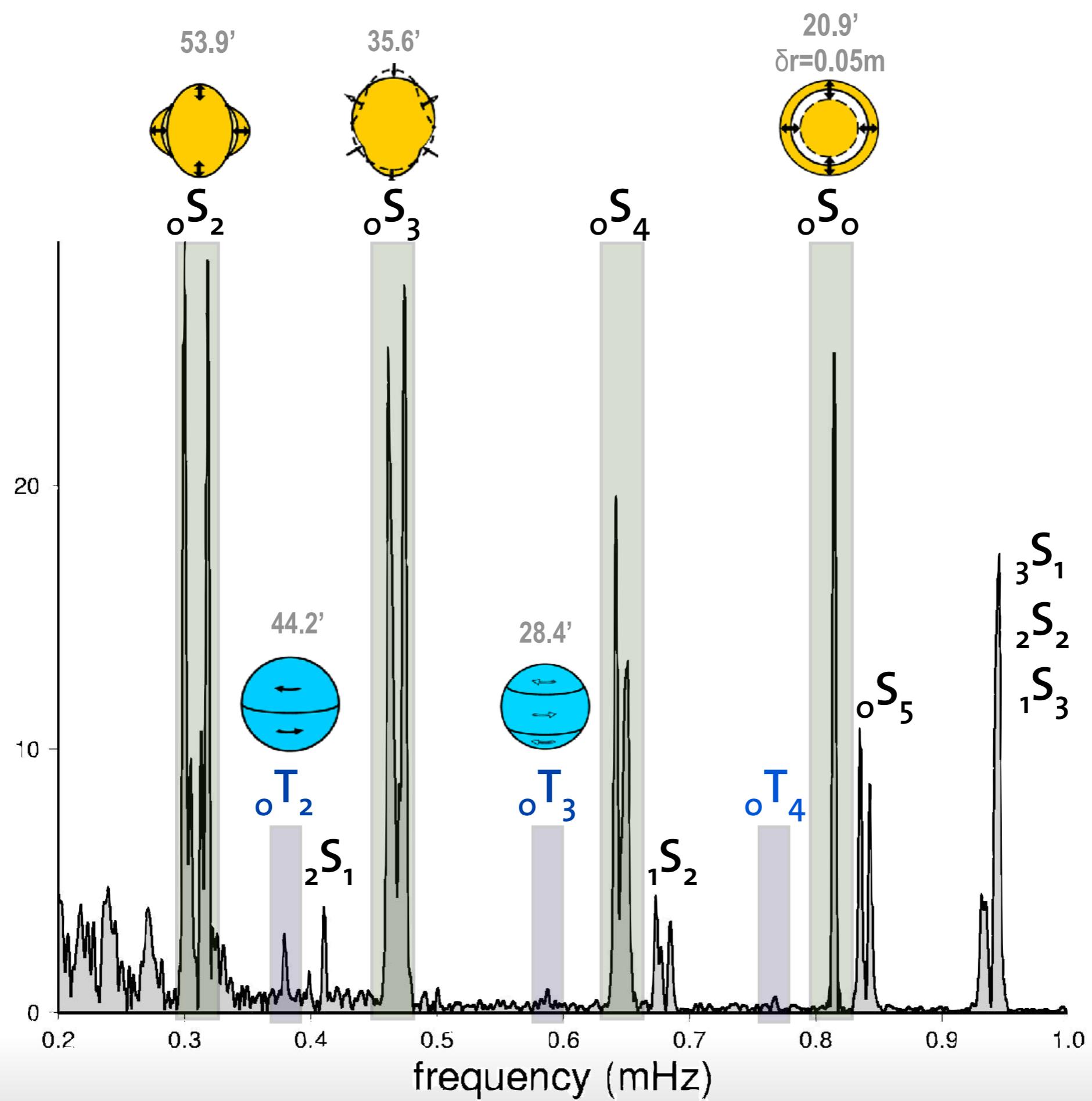


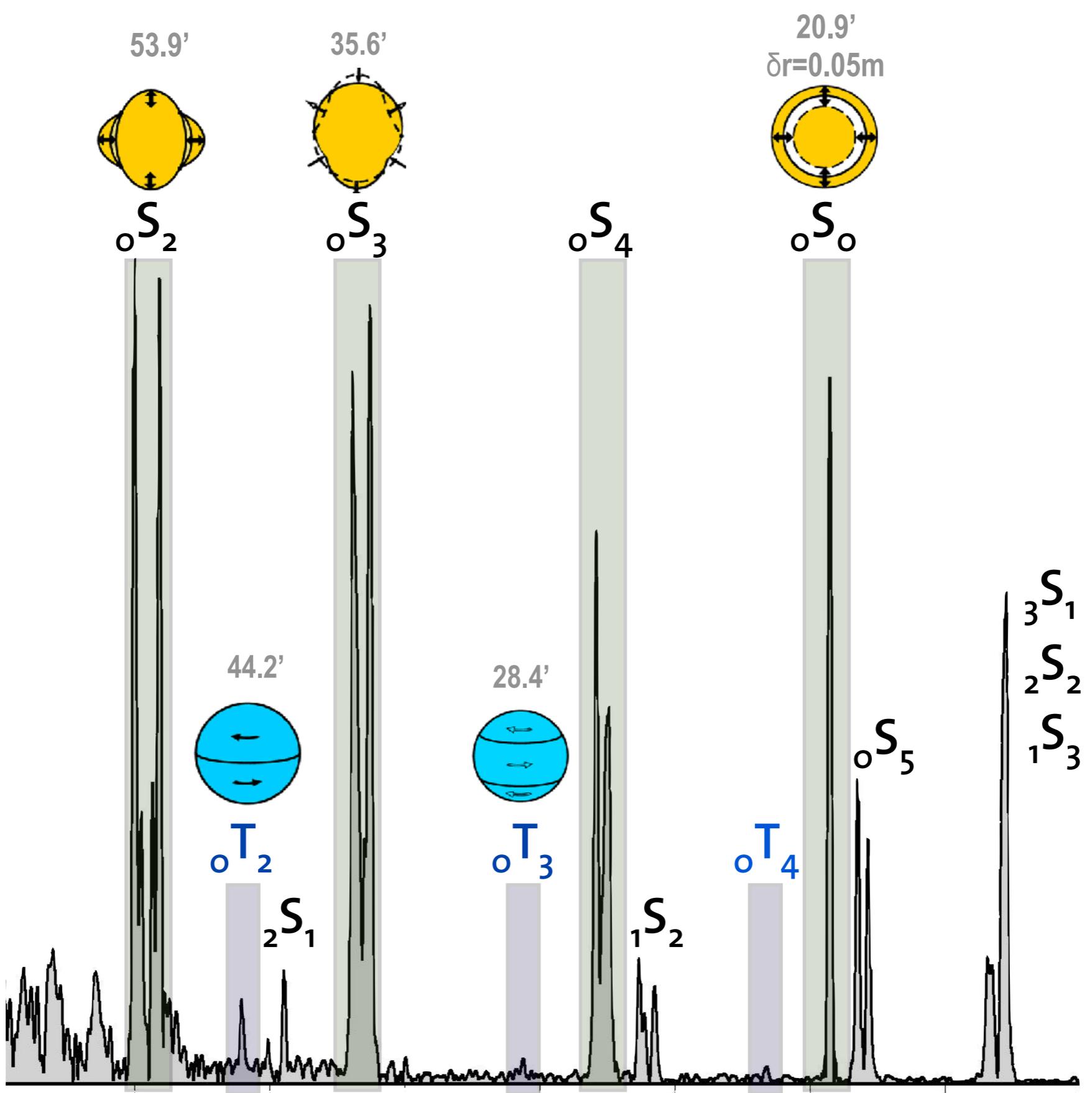
Normal modes



spheroidal mode



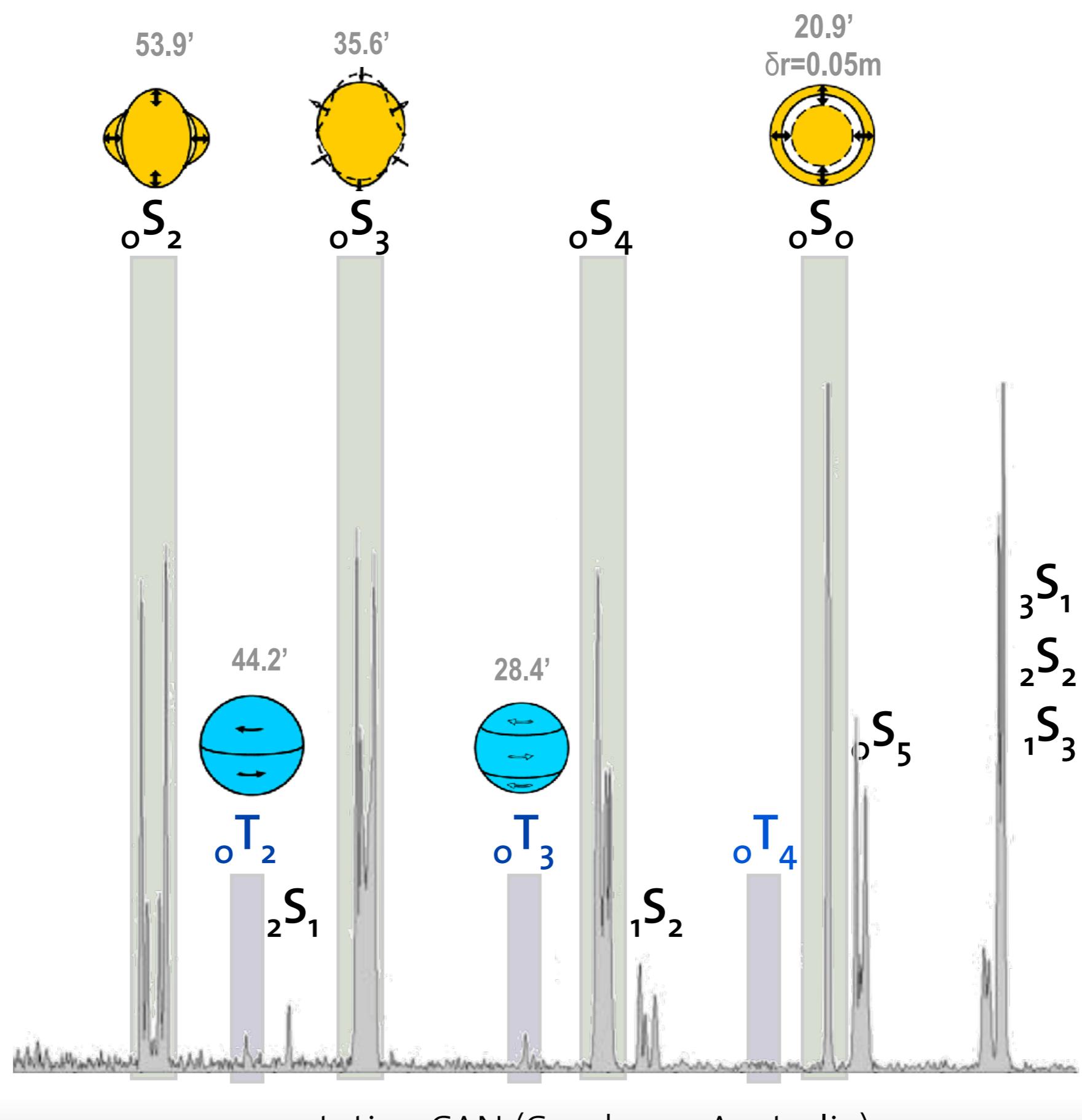




Sumatra Andaman earthquake 12/26/04 M 9.3

Seismic waves





station CAN (Cranberra, Australia)

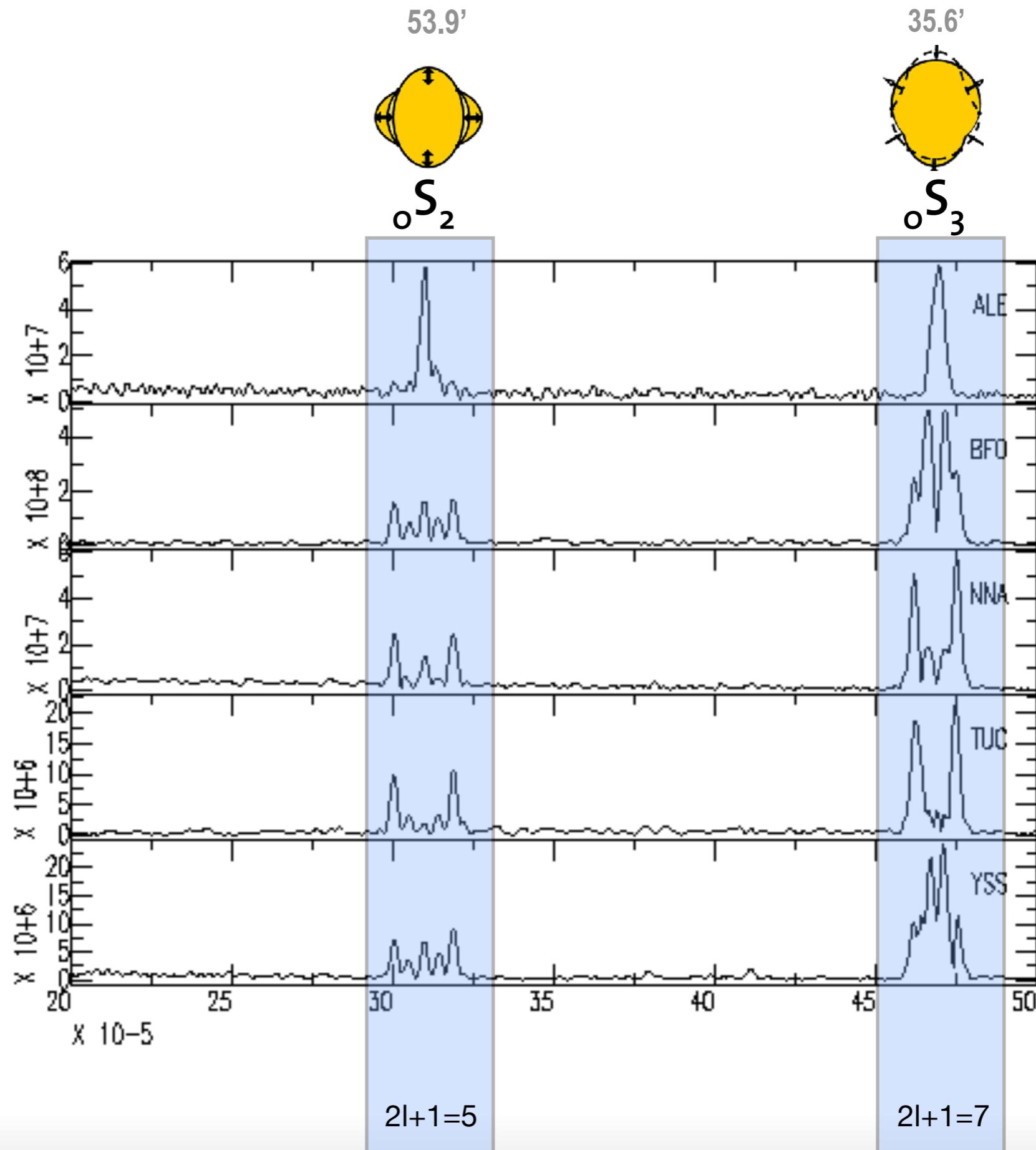
Sumatra Andaman earthquake 12/26/04 M 9.3

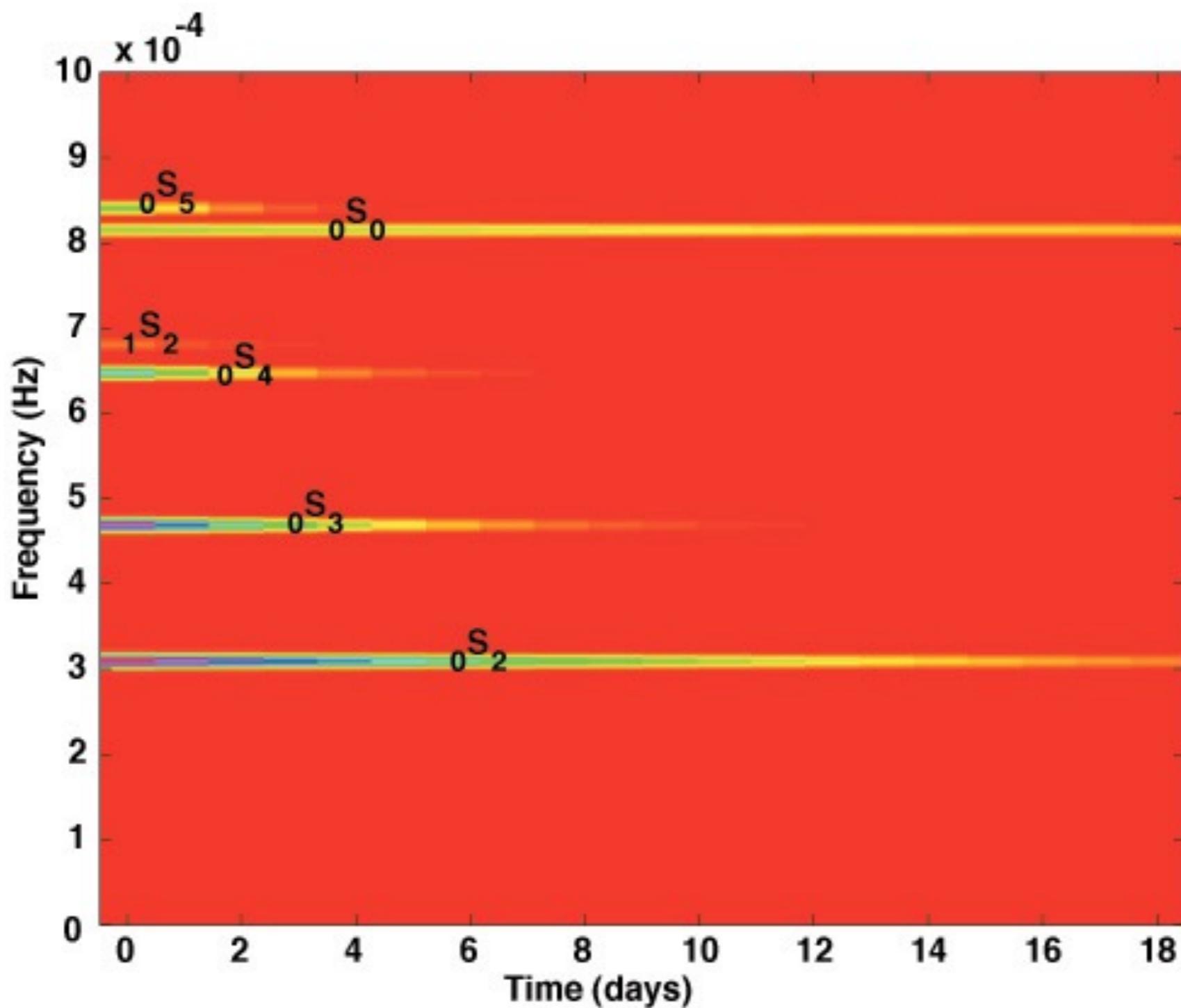
Seismic waves



Normal mode splitting



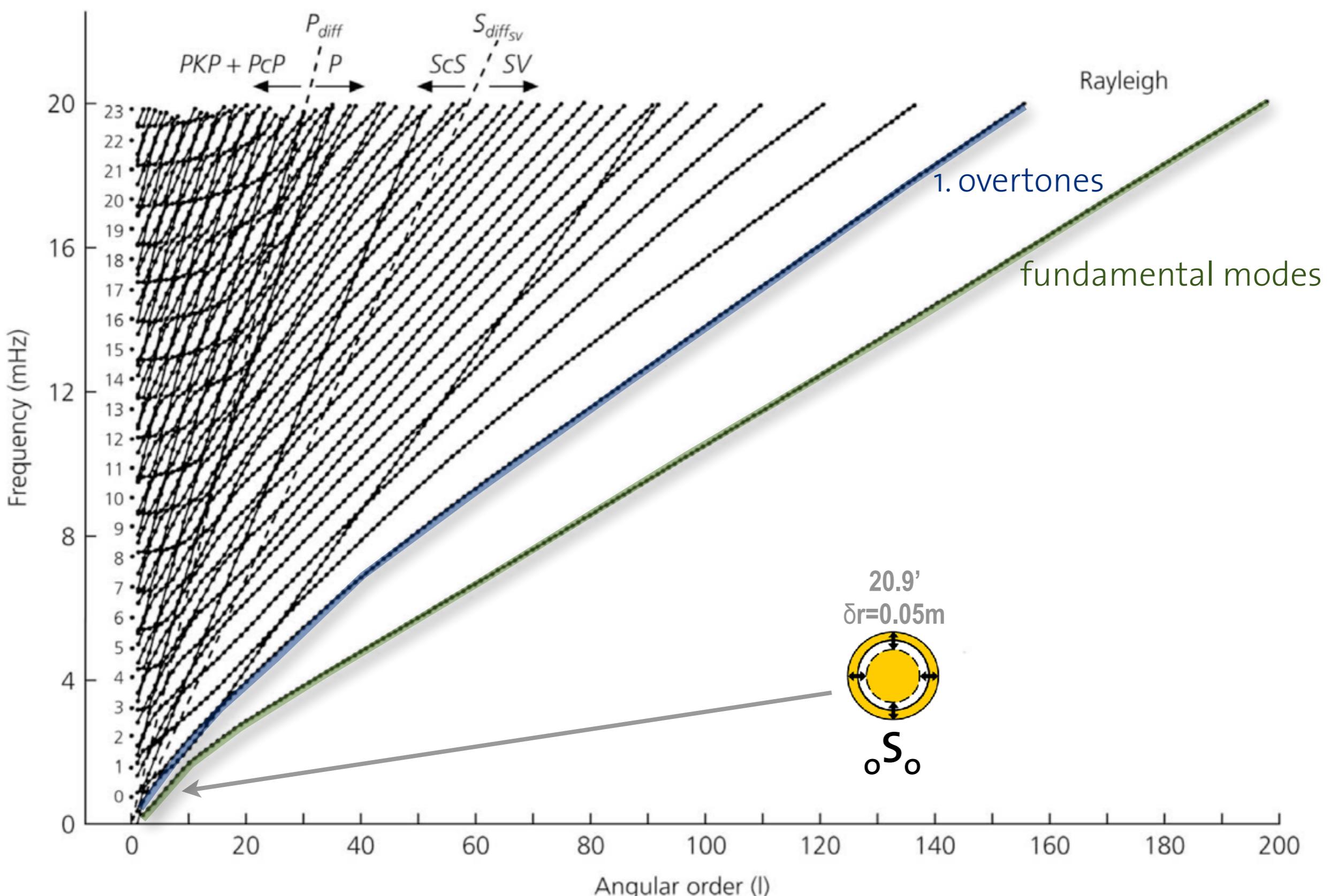




(Courtesy of R. Aster)

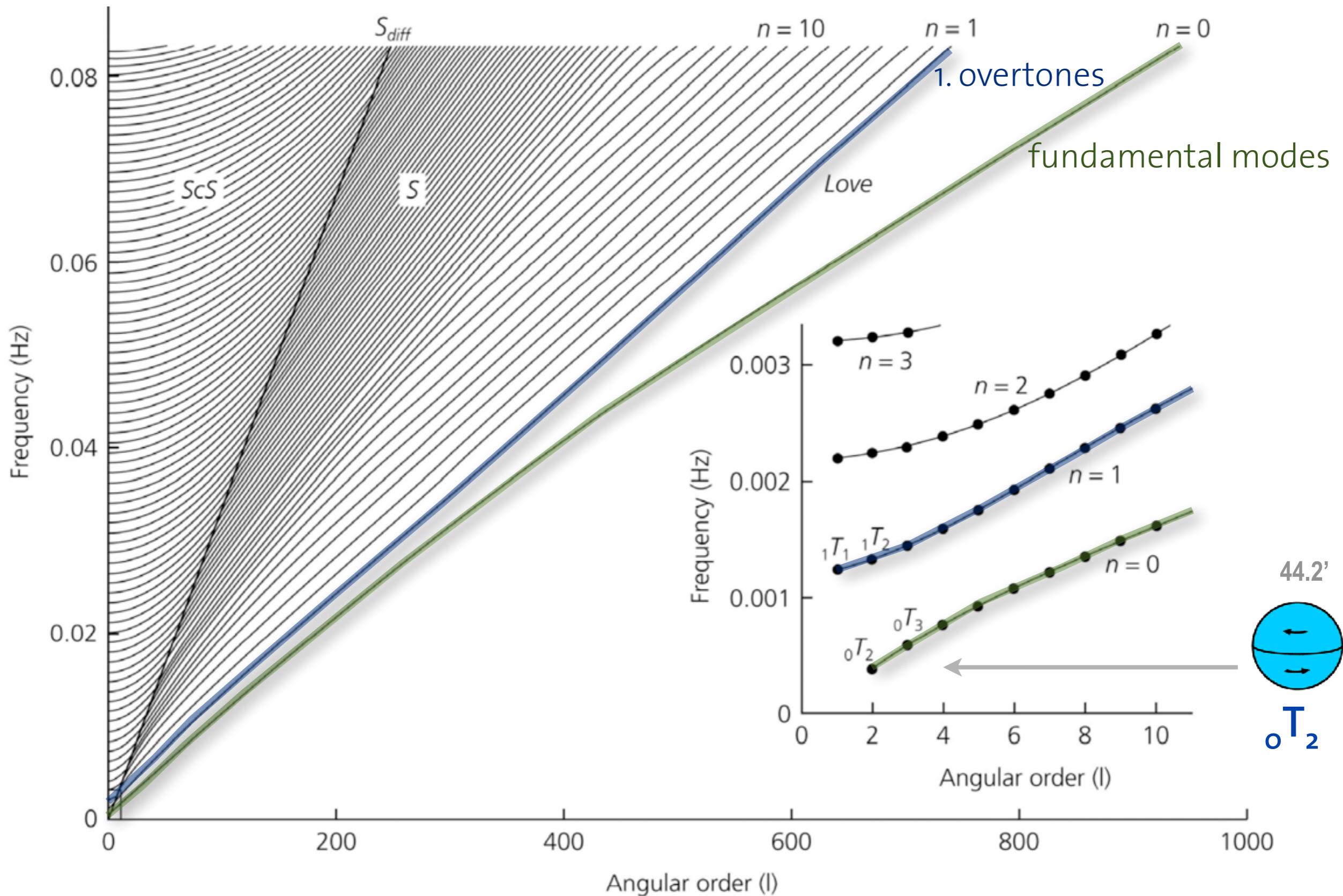
Seismic waves





Spheroidal normal modes





Toroidal normal modes

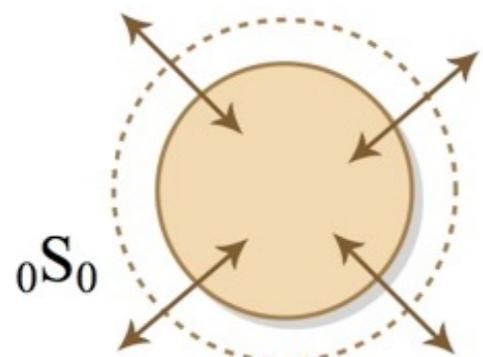
Seismic waves



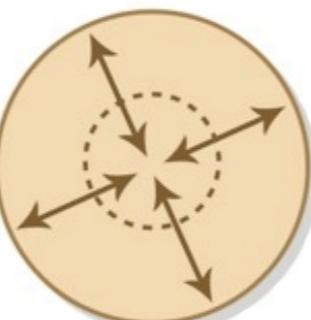
Normal mode sensitivity



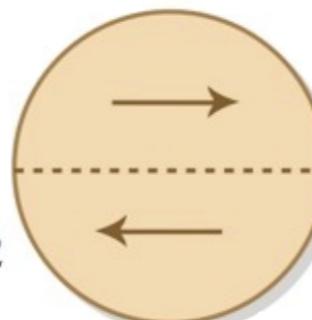
RADIAL MODES



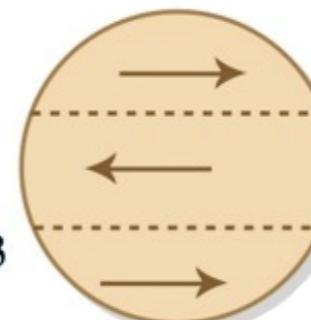
$1S_0$



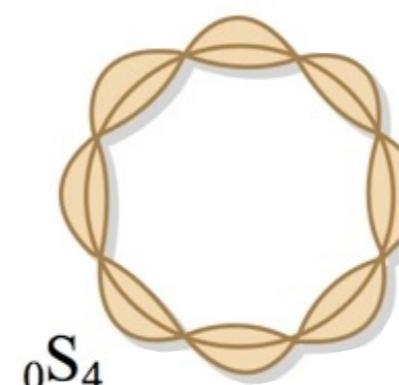
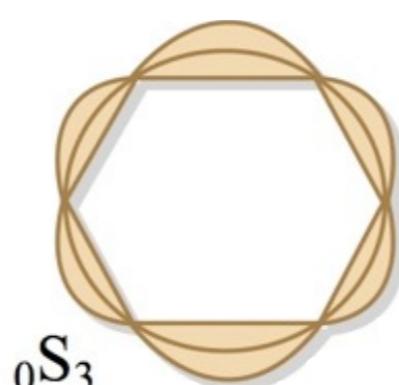
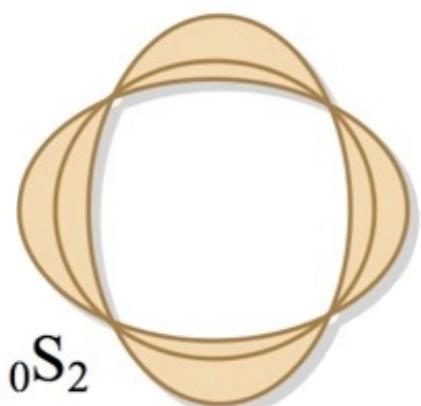
$0T_2$



$0T_3$



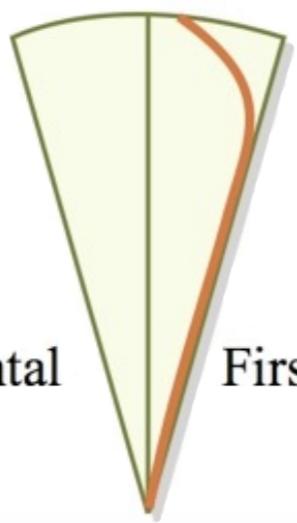
SURFACE PATTERNS



RADIAL PATTERNS

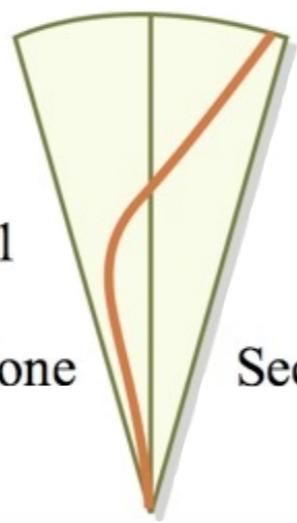
$n = 0$

Fundamental



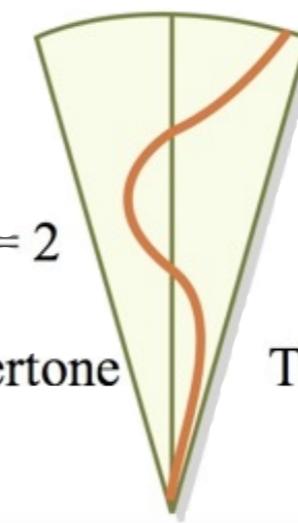
$n = 1$

First Overtone



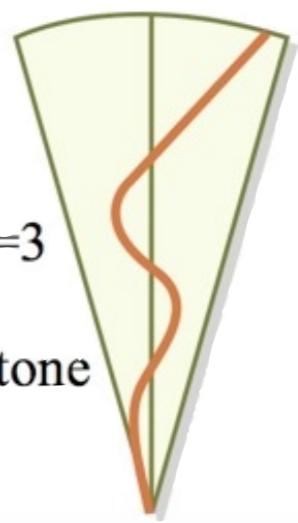
$n = 2$

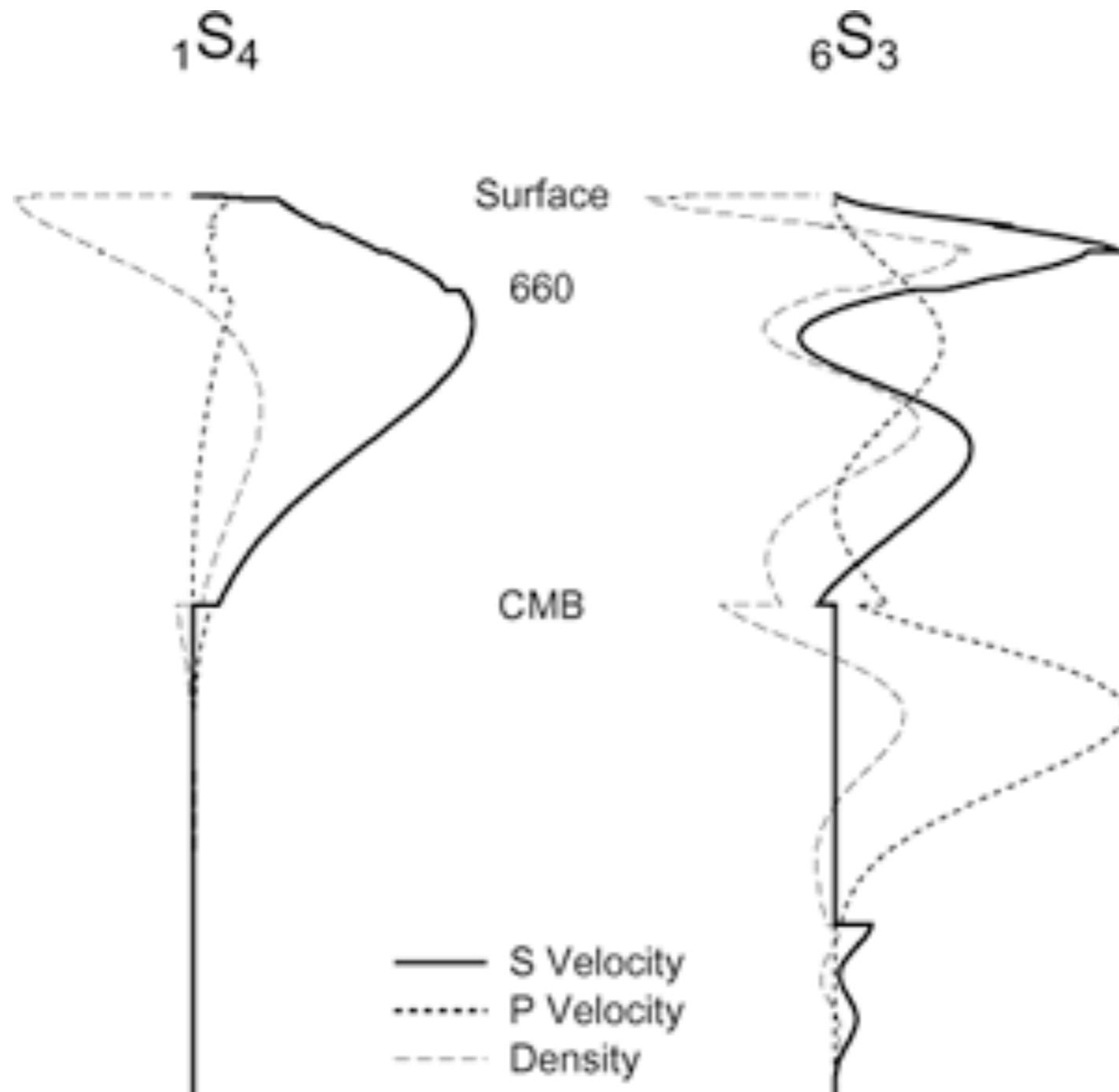
Second Overtone



$n = 3$

Third Overtone

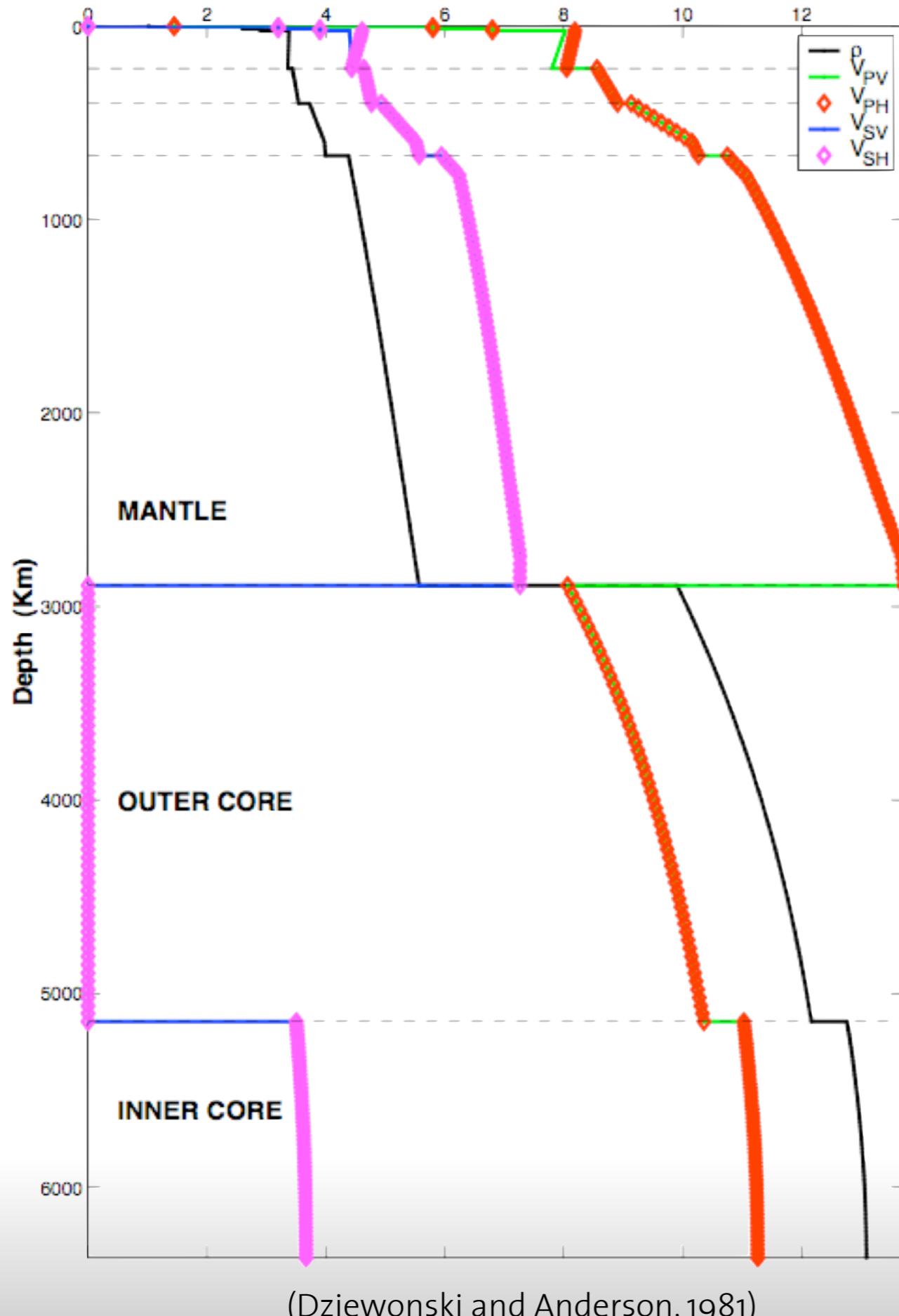




Depth sensitivity kernels of earth's normal modes



PREM (Preliminary Reference Earth Model)



1,000 normal mode periods
500 travel times
100 normal mode Q-values

