Overview of Cyles and Long-term Variability in the Heliosphere

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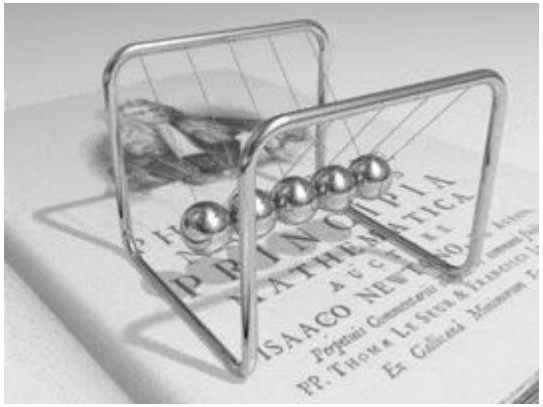
Goals:

- Categorize general types of long term variability in physics
- Preview some of the topics covered in the summer school
- Discuss how to categorize some of these topics

Categories of Long Term Variability

- Orbits and Revolutions
- Oscillations
- Long Term Losses
- No Transient Events
  - Claps
  - Bangs
  - Explosions

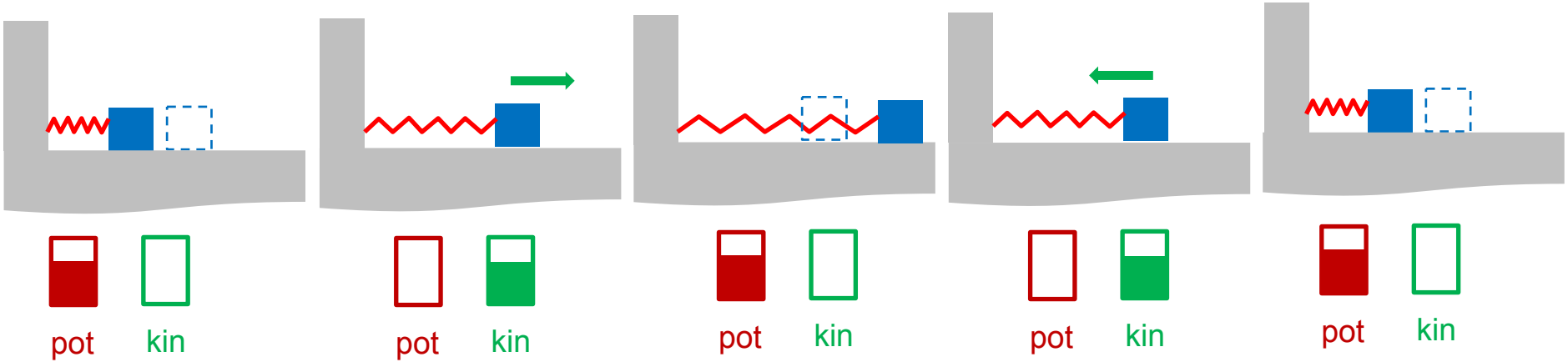


Cycles

Oscillations

- Simple oscillator
- Oscillations @ multiple frequencies
- Forced

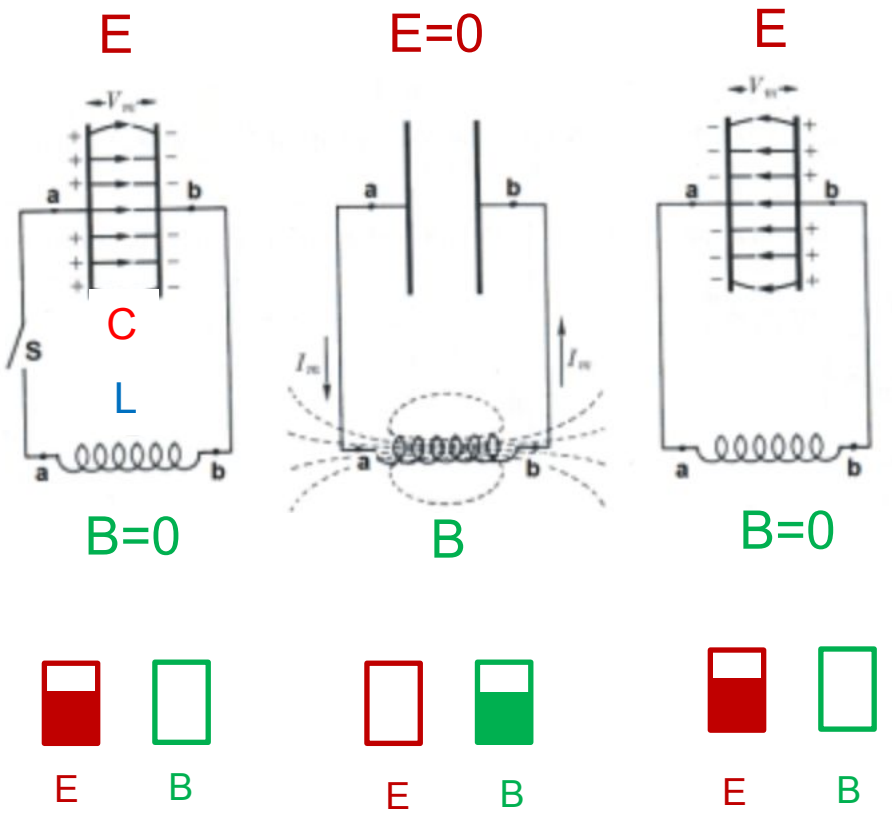
Simple oscillation: spring and mass



Exchange potential (spring) and kinetic (mass) energy

Simple oscillation: Capacitor and Inductor

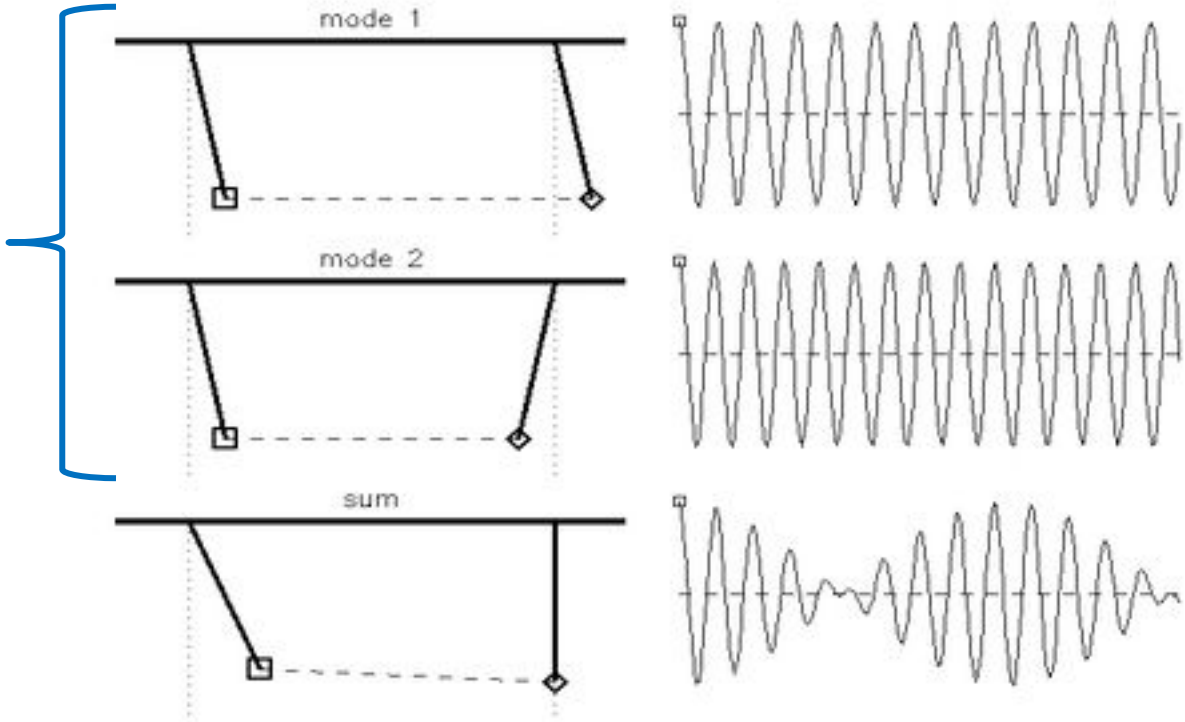
Exchange electric (capacitor) and magnetic (inductor) energy



Multiple (i.e. 2) simple oscillations

2 degrees of freedom

- 2 normal modes
- each mode = simple oscillator
- different frequencies

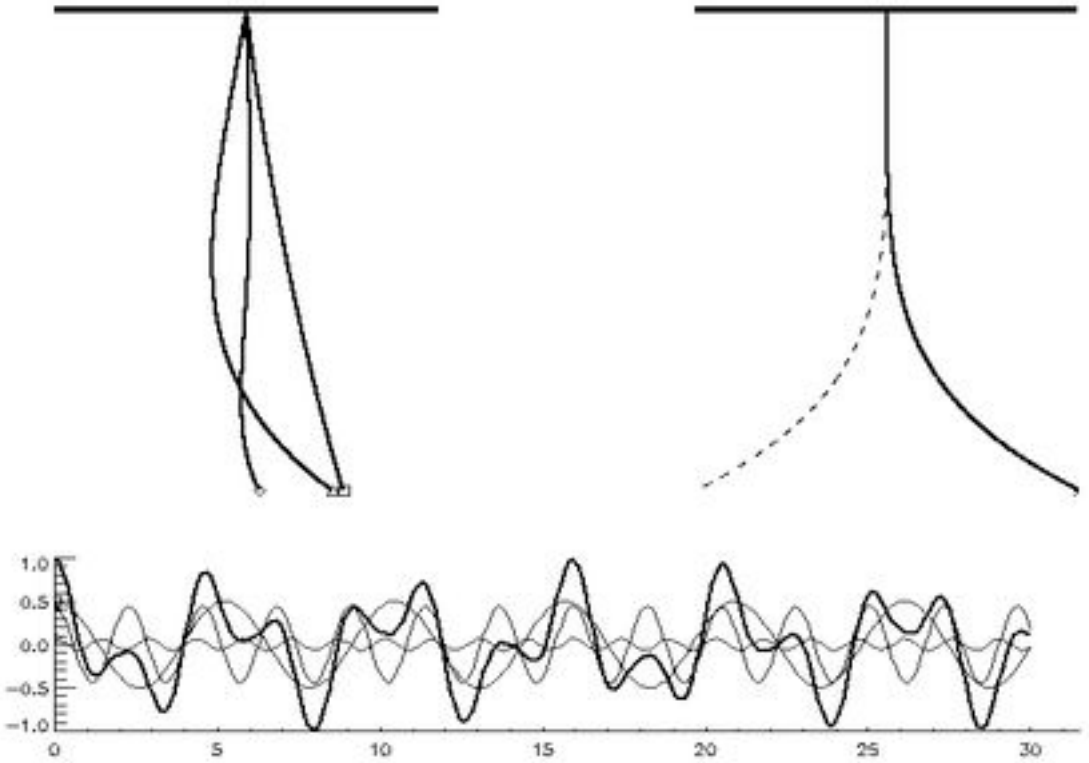


Superposition of 2 modes NOT simple oscillation

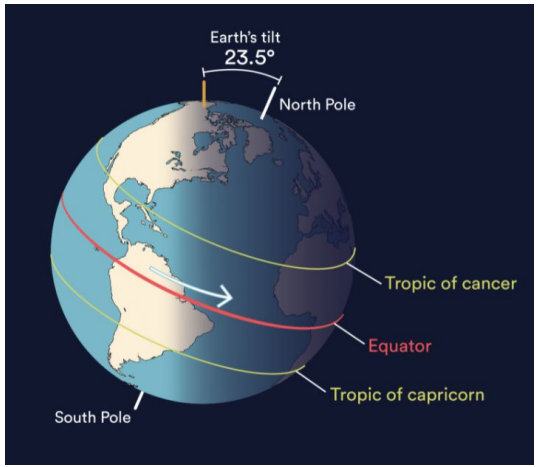
- **“beating”**

More modes = more complex behavior

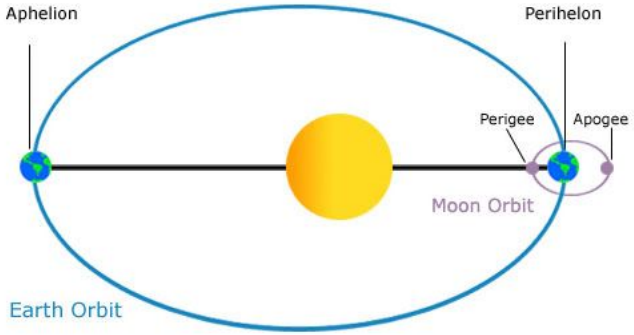
Q: How many degrees of freedom does a string have?



Steady angular motion □ periodicity



Rotation (revolution):
Earth □ period = 24 hr
day/night cylce

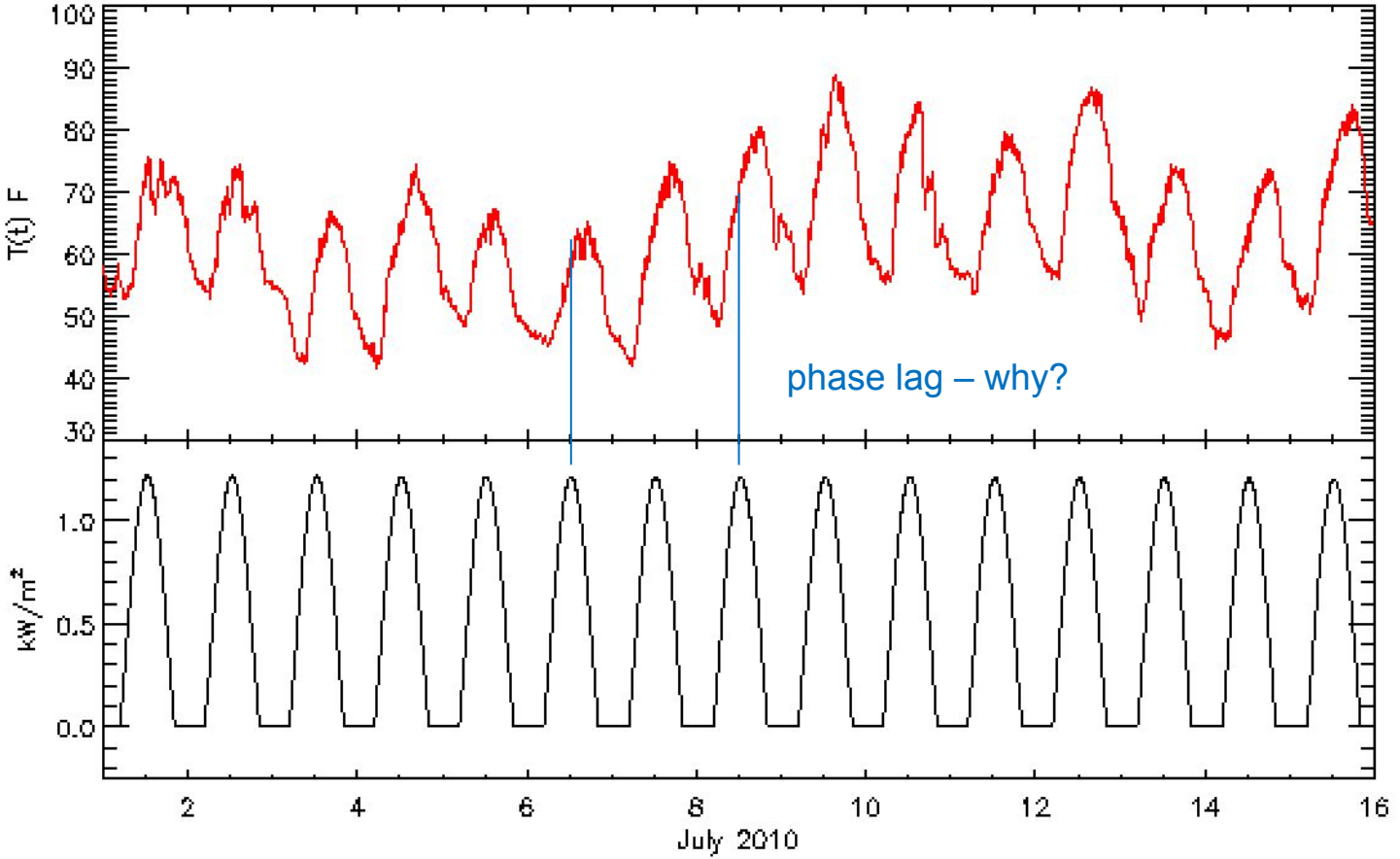


Orbit:
Earth/Sun □ period = 365 d
Seasons (combined with tilt of rotation axis)
Earth/moon □ period = 29 d
Phases of moon

Driven oscillation: the temperature

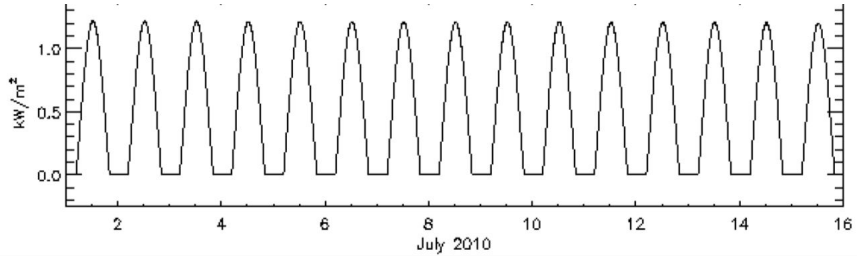
Response: Temperature in Bozeman, MT

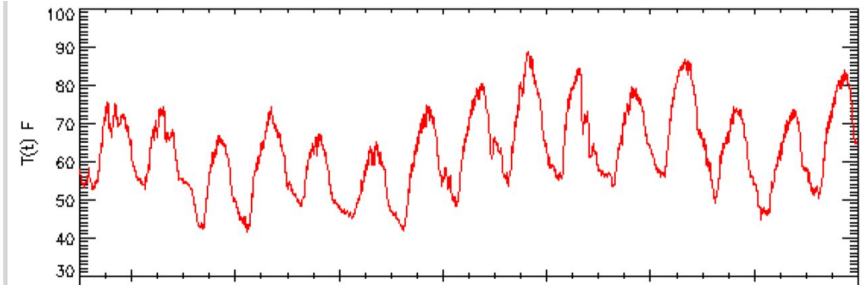
Driving: sunlight on ground in Bozeman, MT (a.k.a. insolation) – result of Earth's rotation

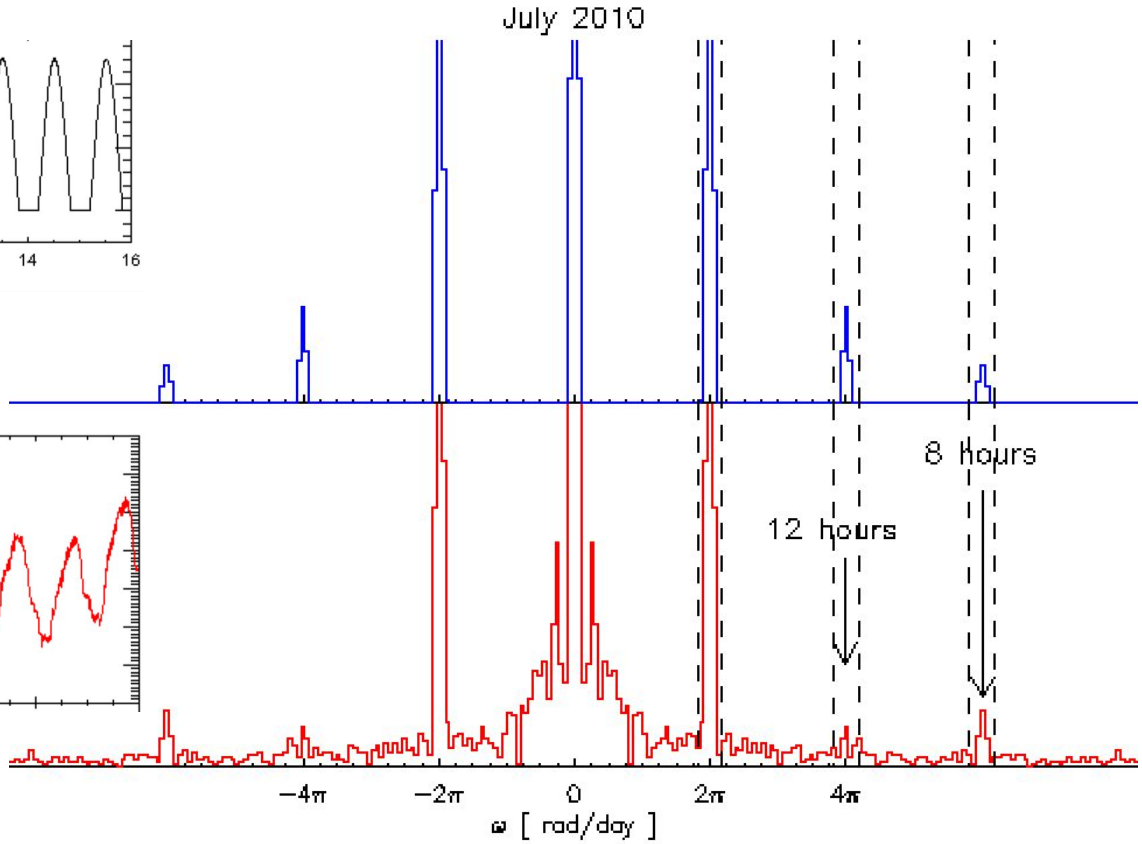


Driven oscillation: the temperature

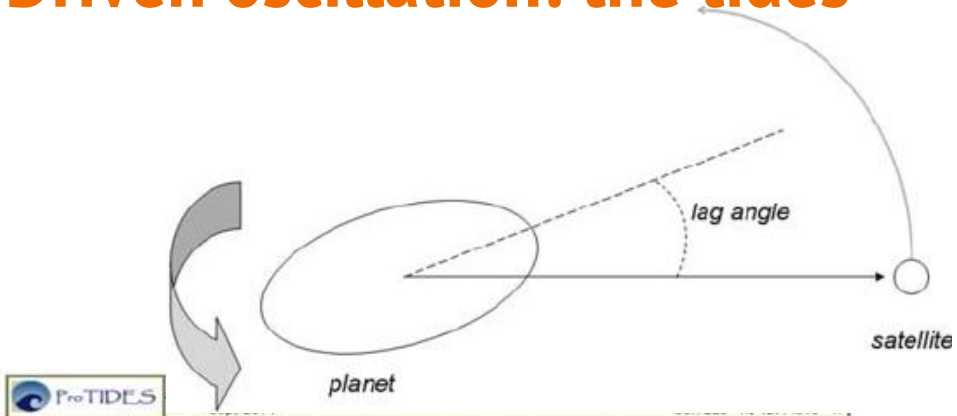
Q: why is there driving @ 8-hour period in July?

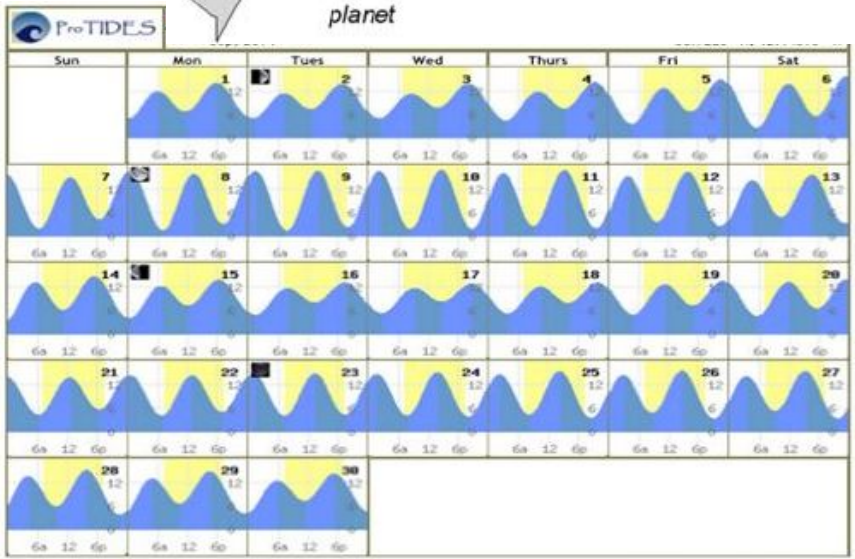






Driven oscillation: the tides



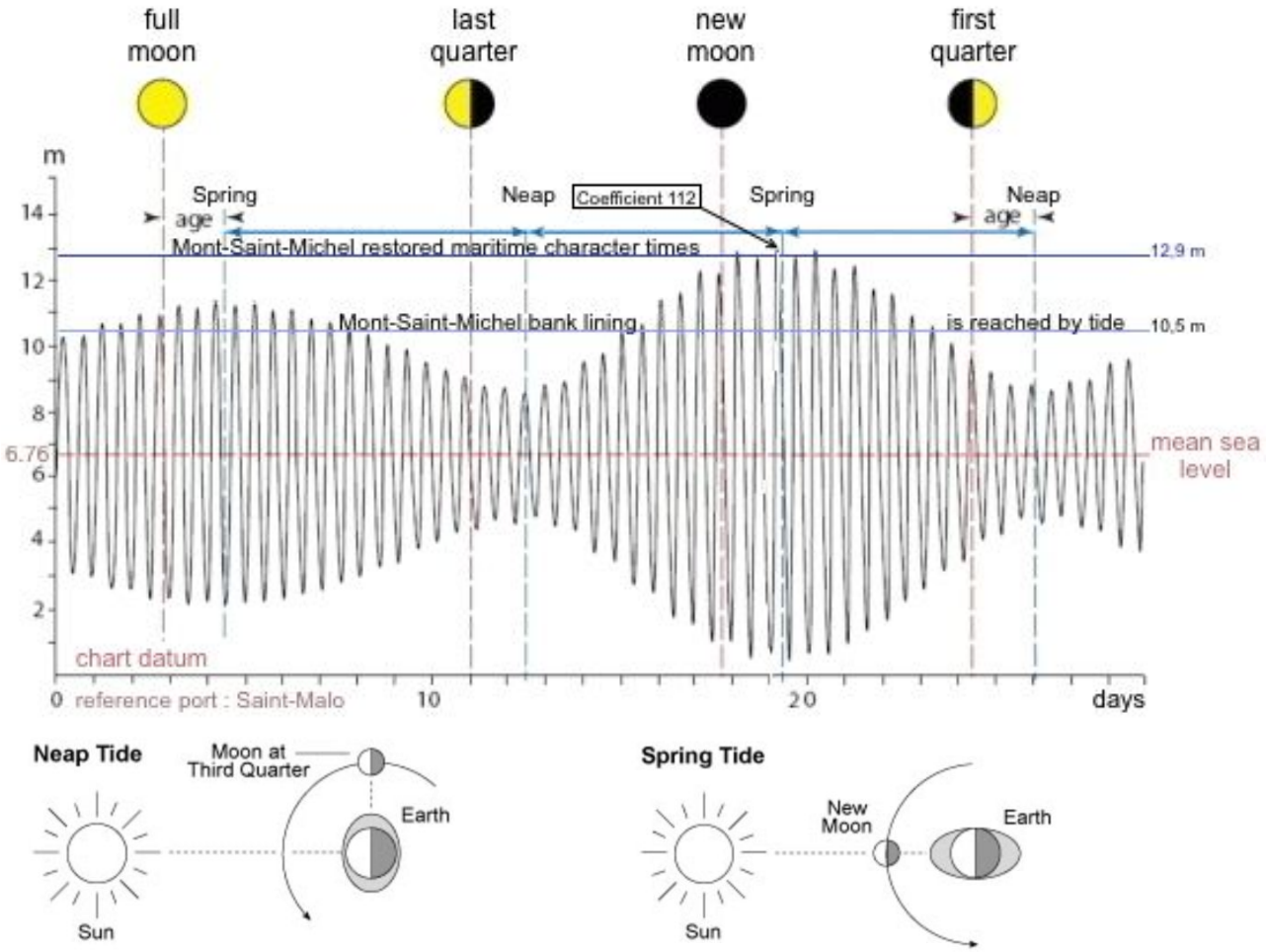


Rotation through gravitational field **gradient**

- 2 bulges/rotation
- period = 0.5 X rotation period (i.e. 2 high tides per day)

As in any driven damped oscillator: response **lags** forcing

Q: why not a simple sin curve?


full moon
last quarter
new moon
first quarter
m
14
12
10
8
6.76
6
4
2
Spring age
Neap
Coefficient 112
Spring
Neap age
Mont-Saint-Michel restored maritime character times
12,9 m
Mont-Saint-Michel bank lining
is reached by tide
10,5 m
mean sea level
chart datum
0 reference port : Saint-Malo
10
20
days
Neap Tide
Moon at Third Quarter
Earth
Sun
Spring Tide
New Moon
Earth
Sun