Lecture 2

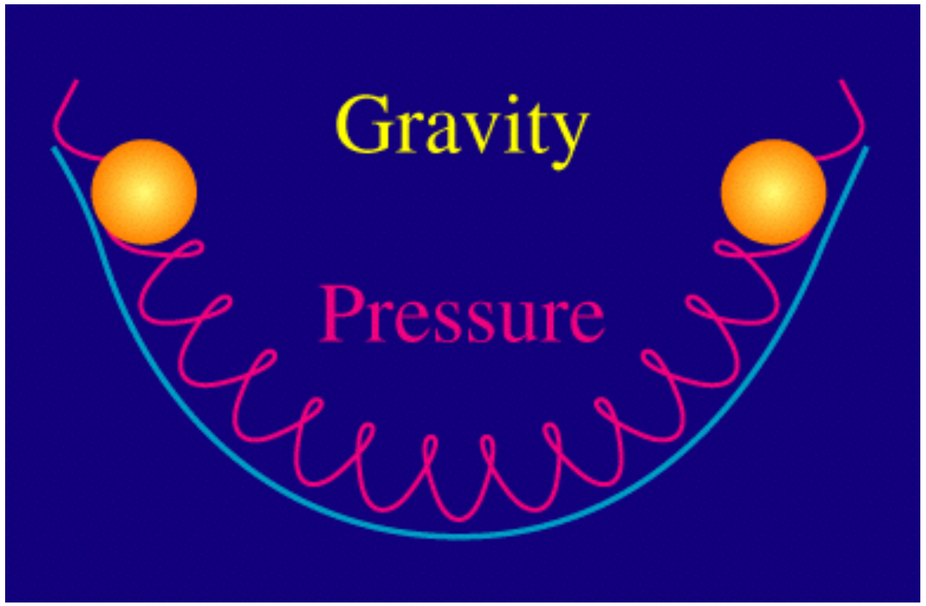
AST 449

Overview of the acoustic peaks

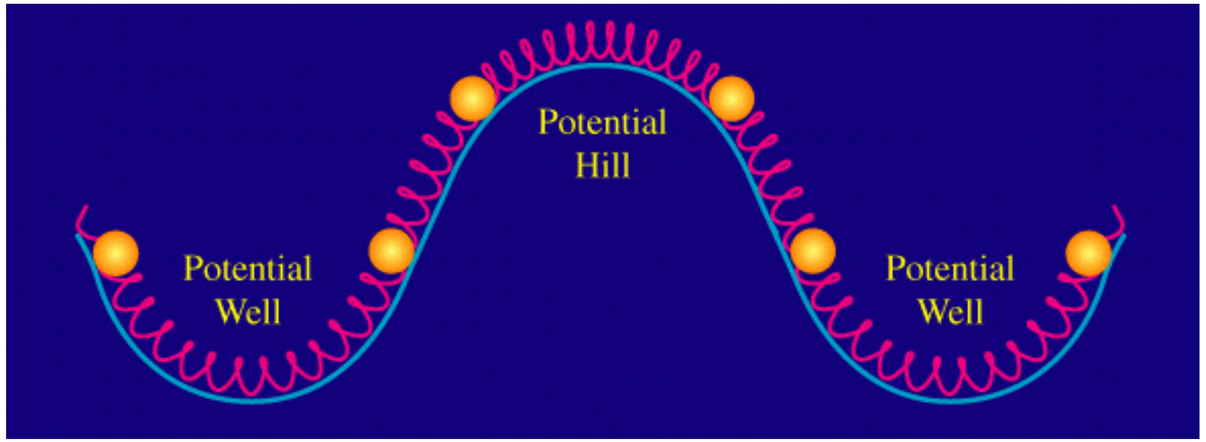
- Animations and comments from Wayne's tutorial website (http://background.uchicago.edu/~whu/intermediate/intermediate.html)

Acoustic oscillations

- Gravitational compression

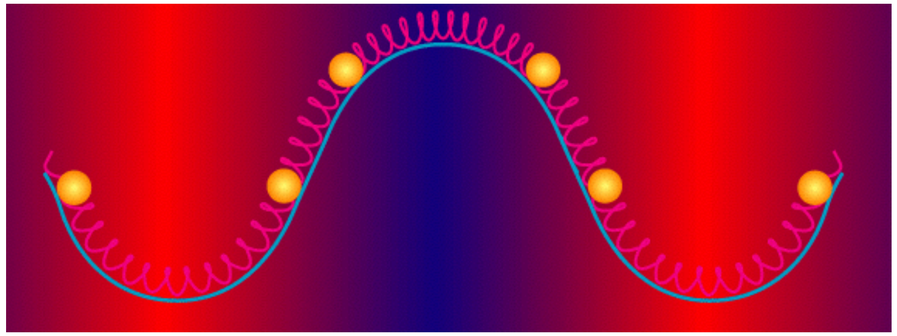


- Potential Wells and Hills

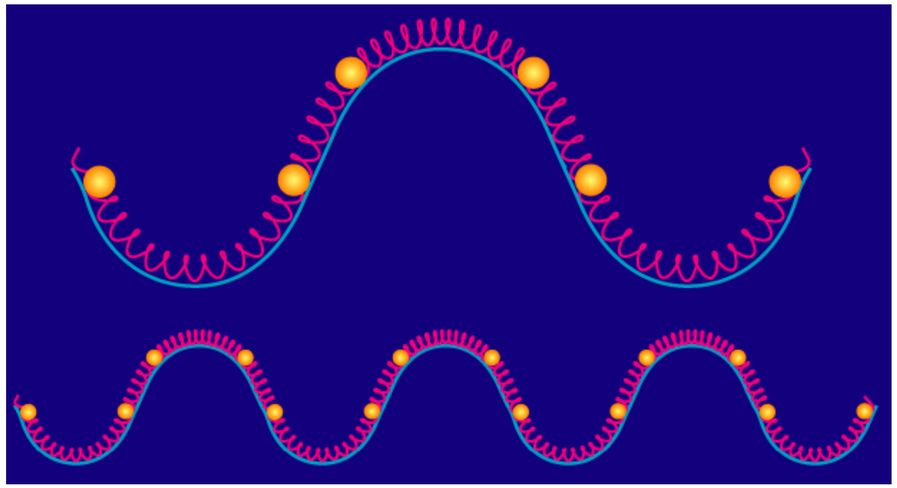


Acoustic oscillations

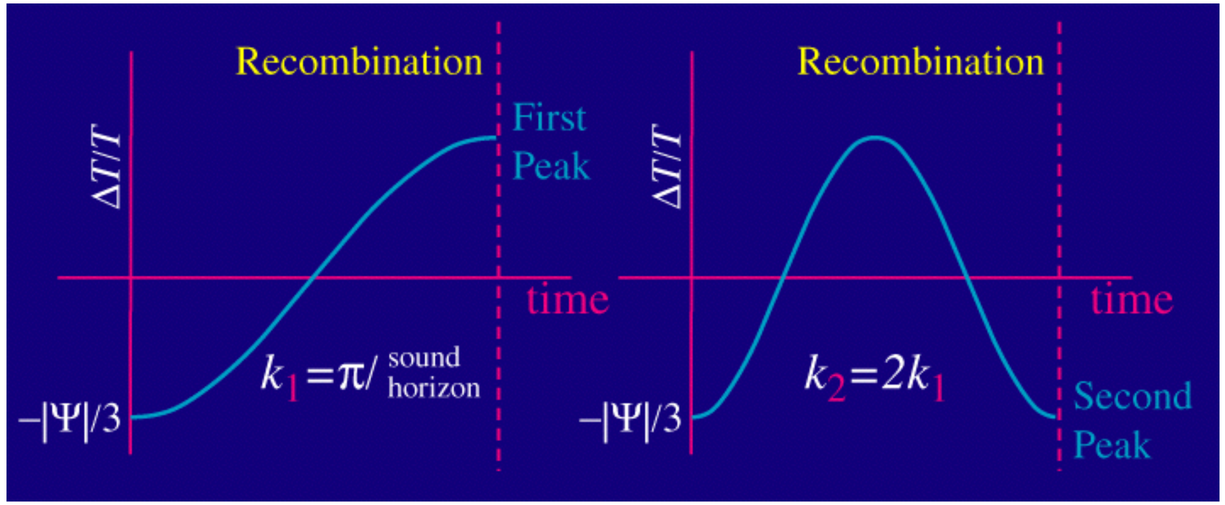
- Seeing Sound



- Harmonic Modes

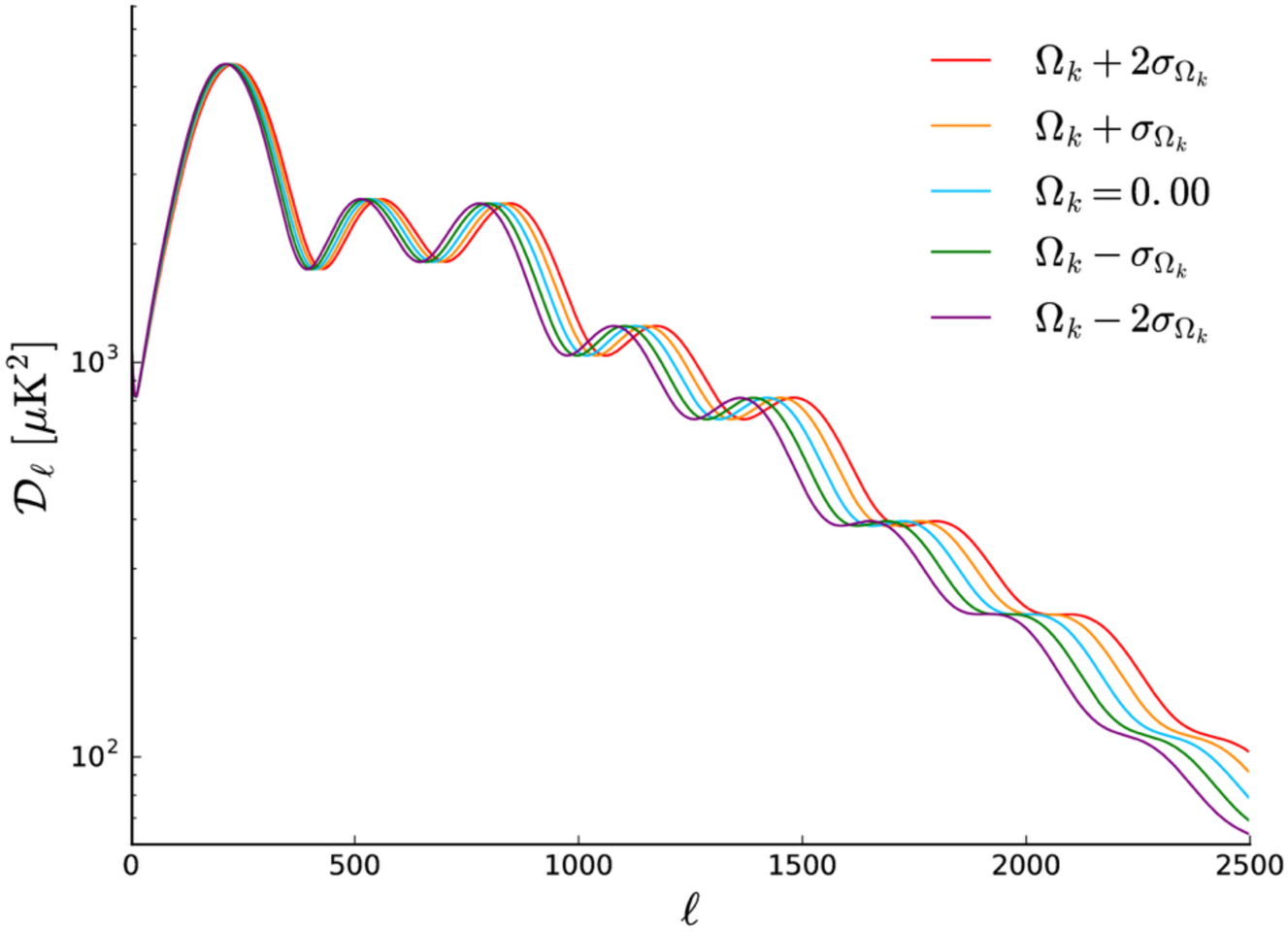


- Harmonic Extrema
  - oscillation frozen in at recombination
  - extrema



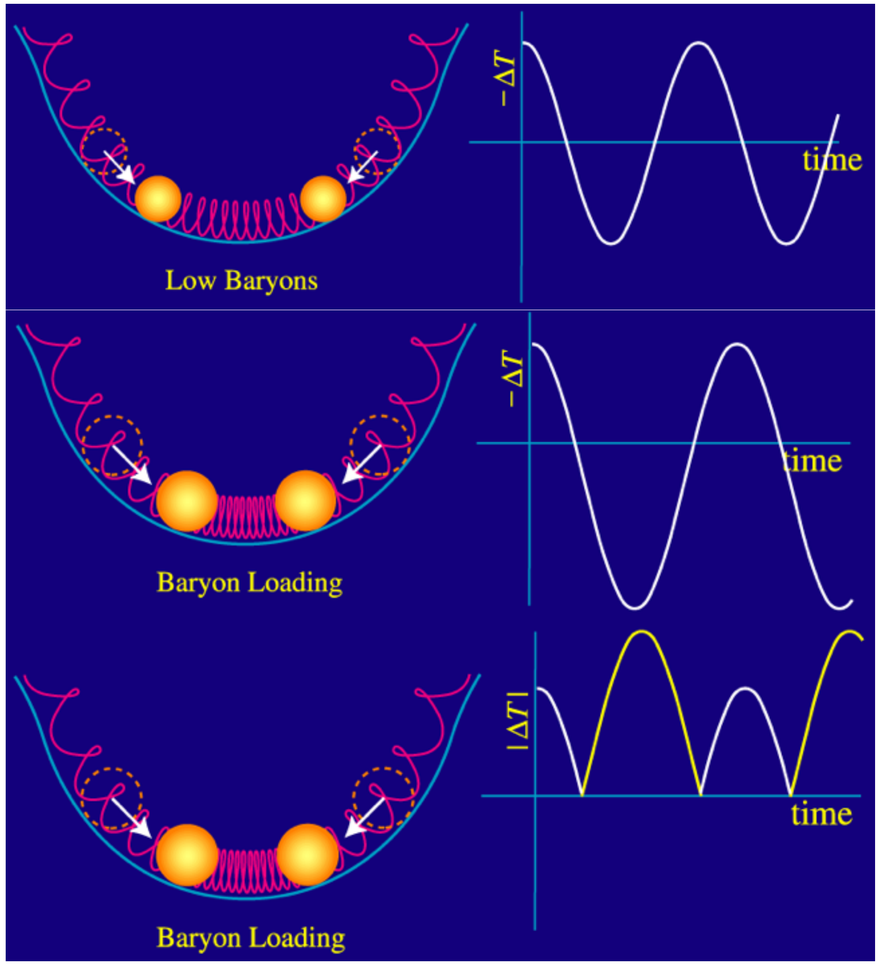
Acoustic Peaks

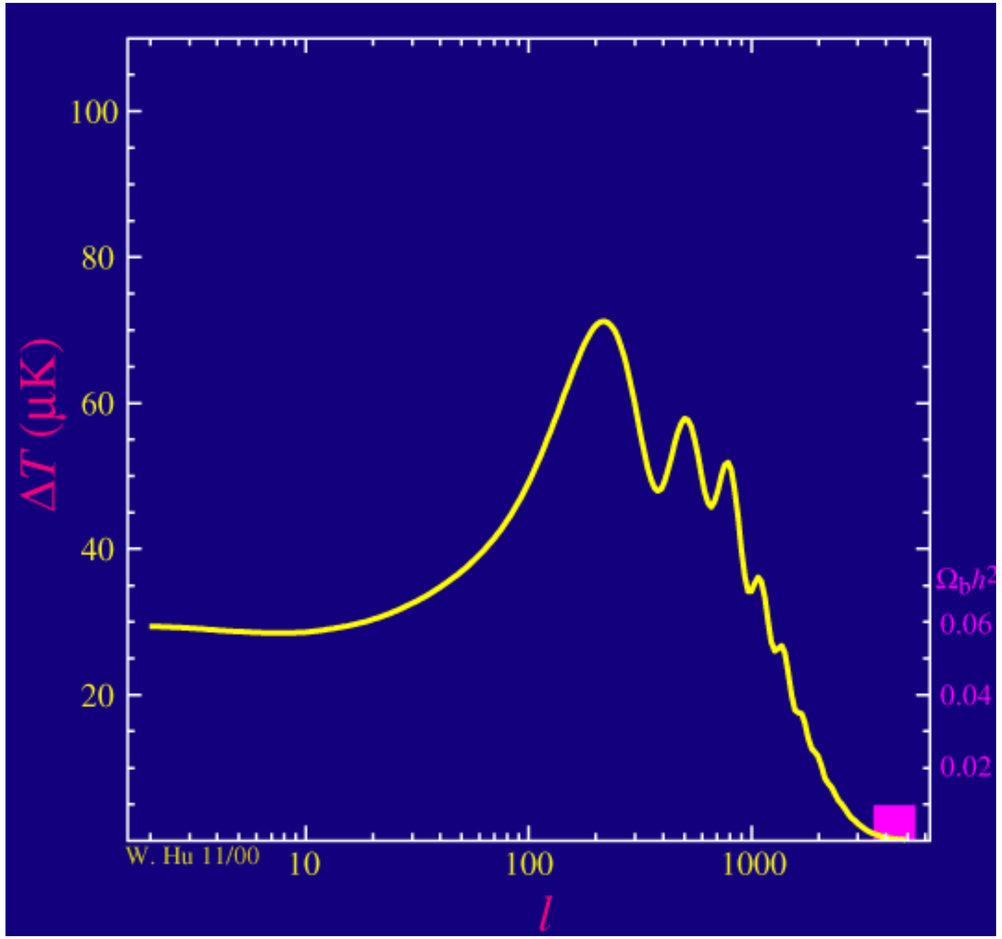
- Spatial flat



Acoustic Peaks

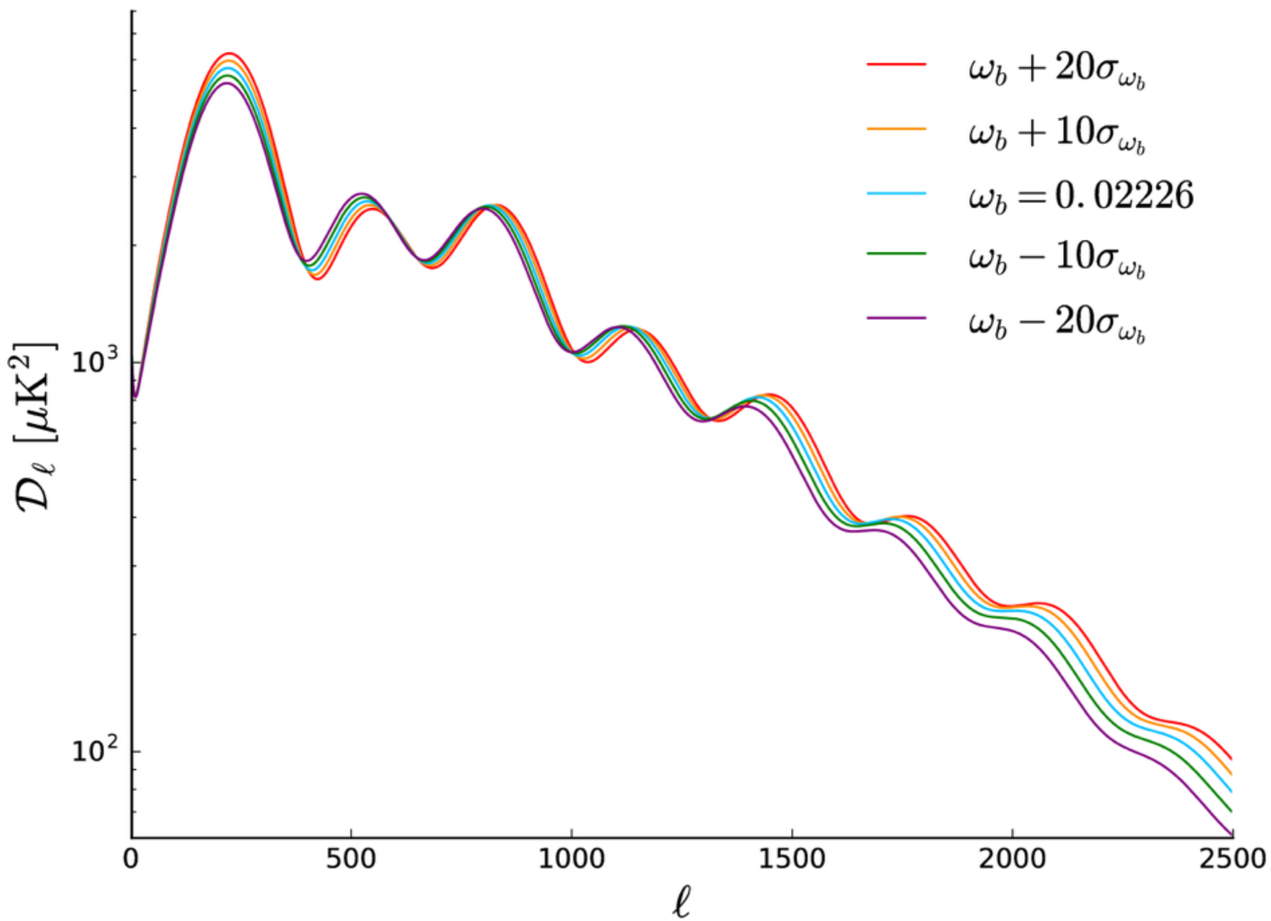
- Baryon loading





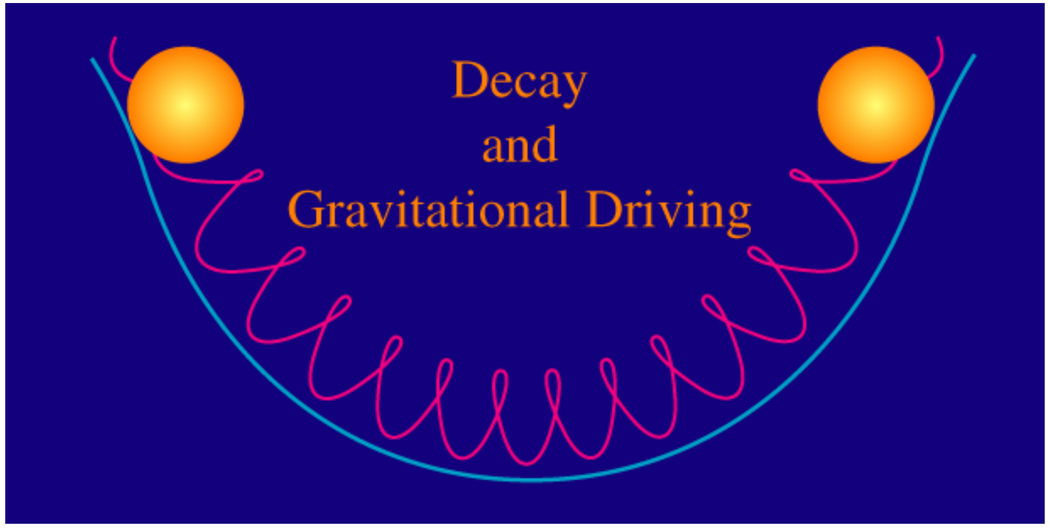
Acoustic Peaks

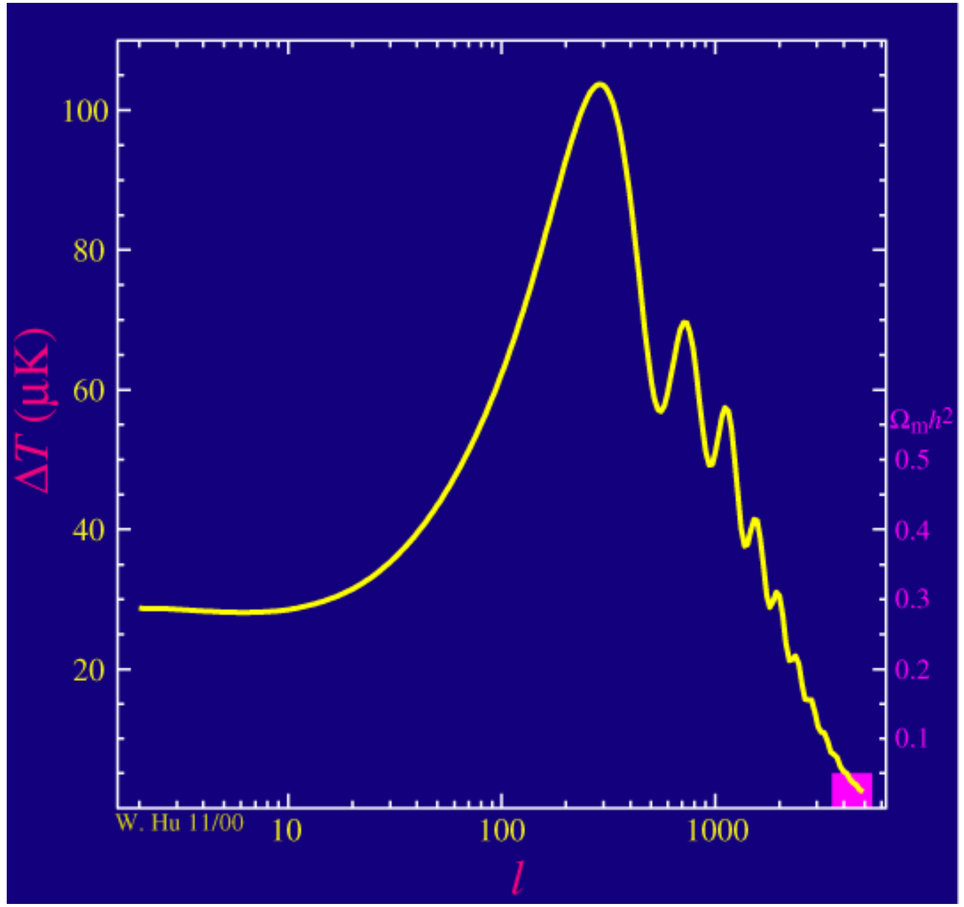
- Baryon loading



Acoustic Peaks

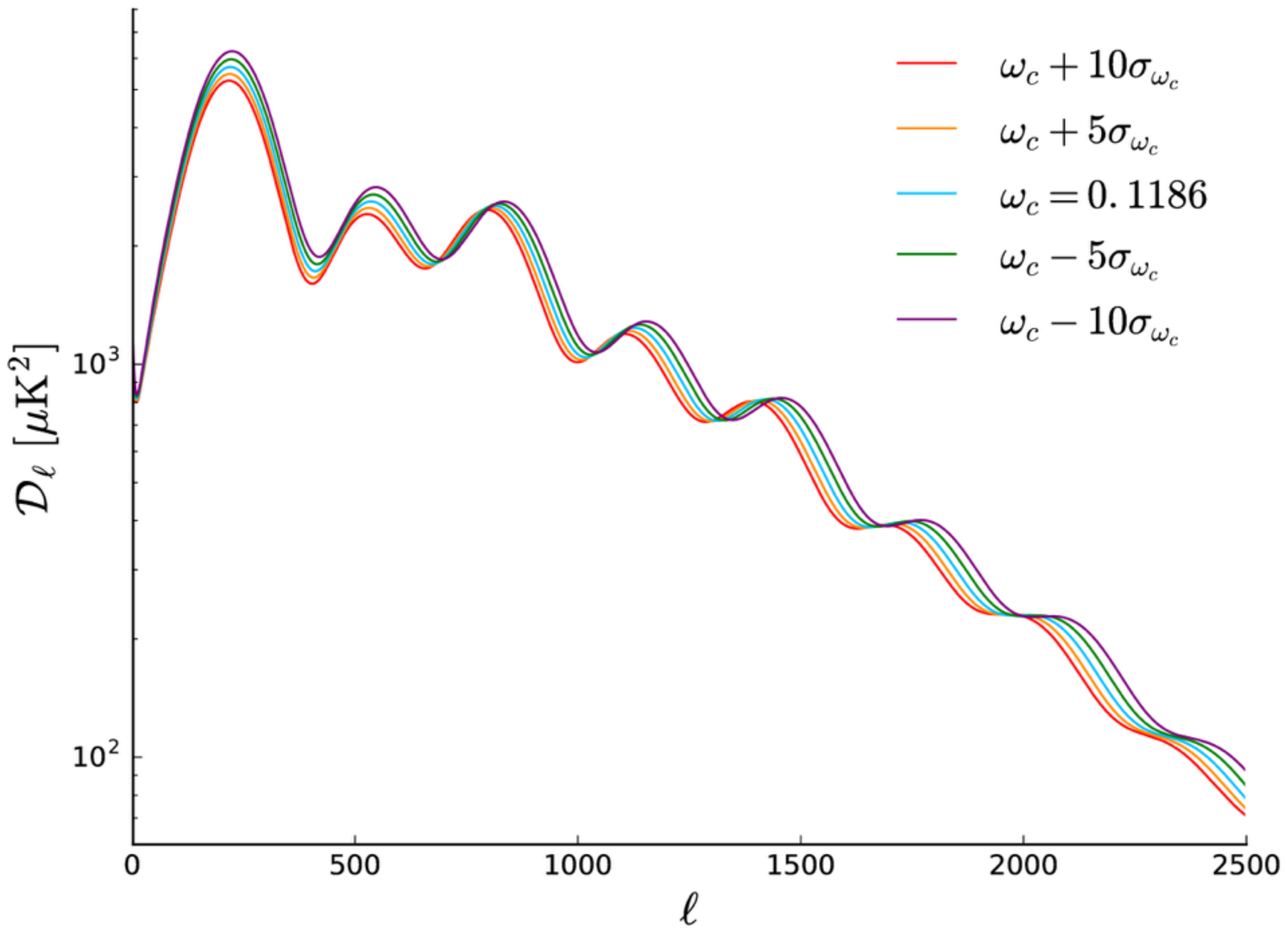
- Radiation driving





Acoustic Peaks

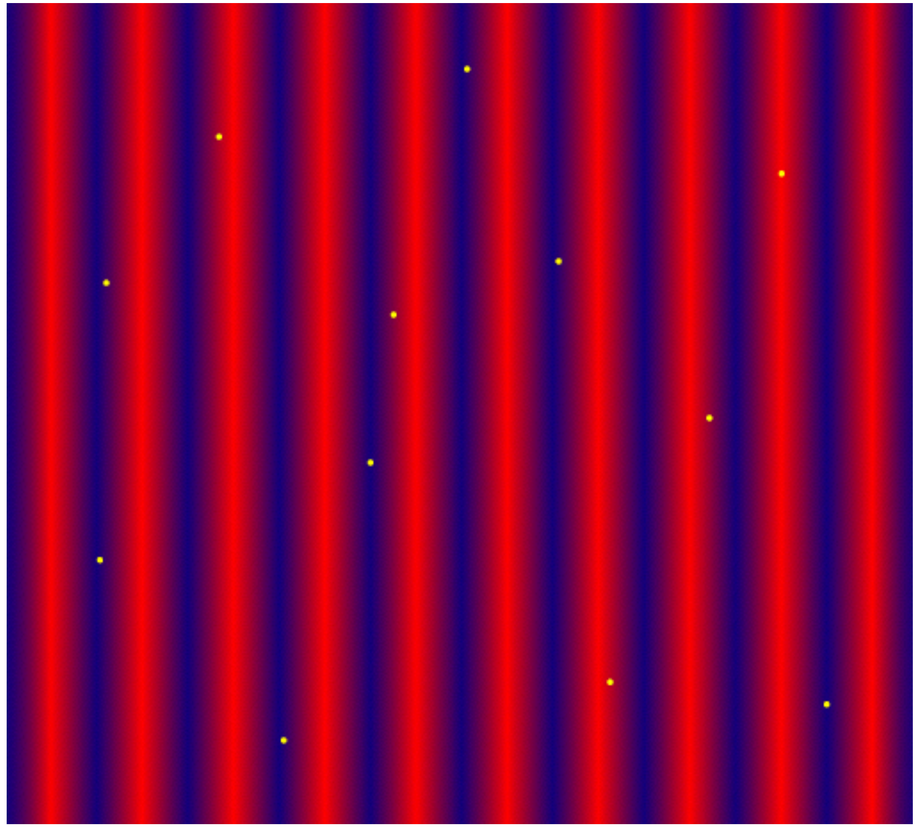
- Radiation driving

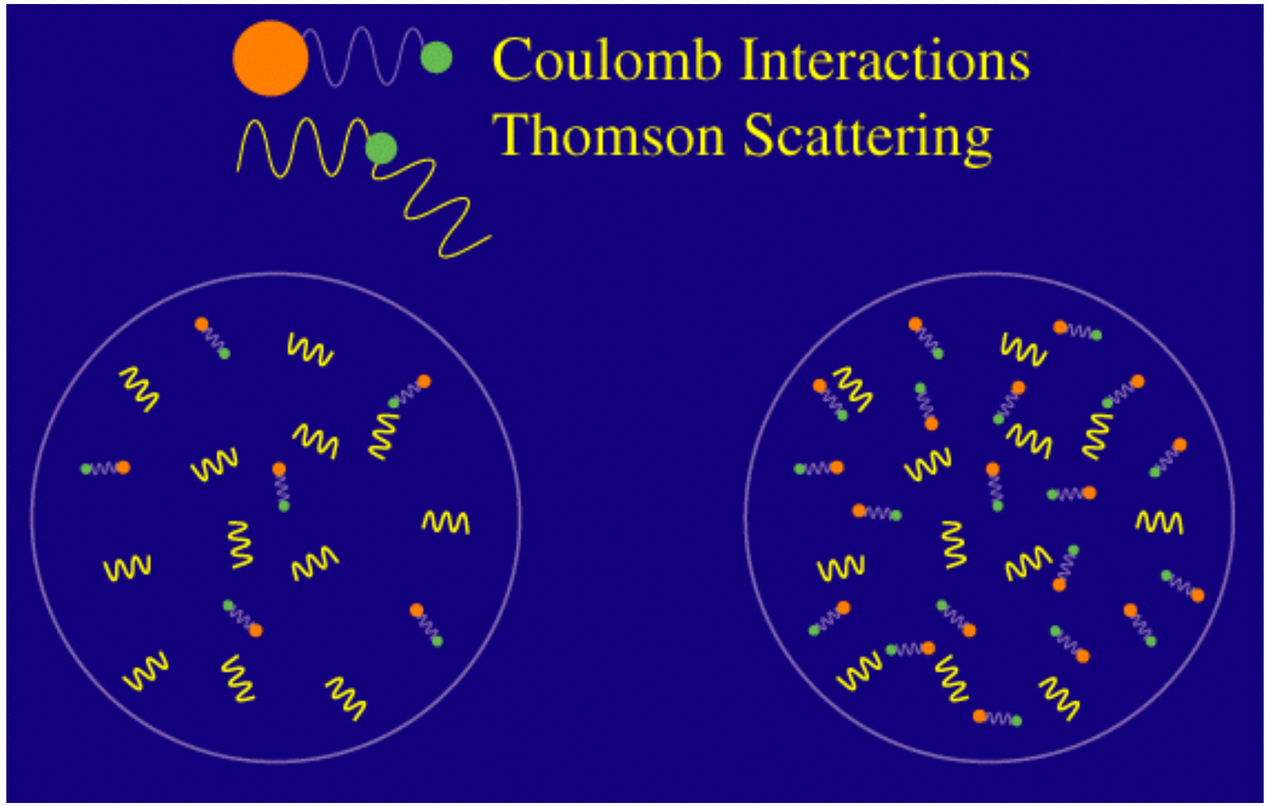


Damping tail

- Diffusion damping

$$\theta_d = \frac{r_d}{d_A} \propto \frac{1}{d_A} \int_0^{a^*} \frac{da}{a^3 \sigma_T n_e H(a)}$$





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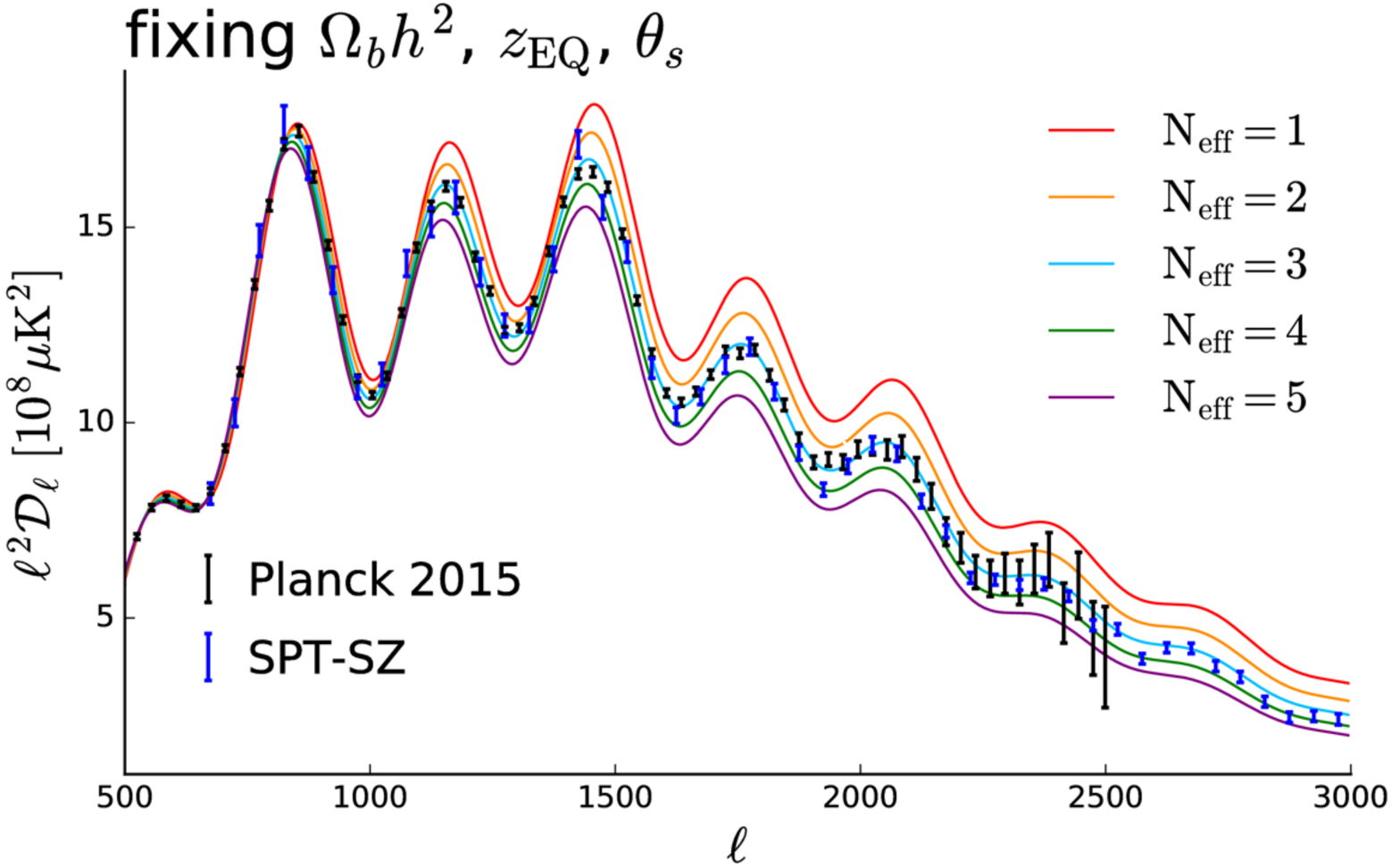

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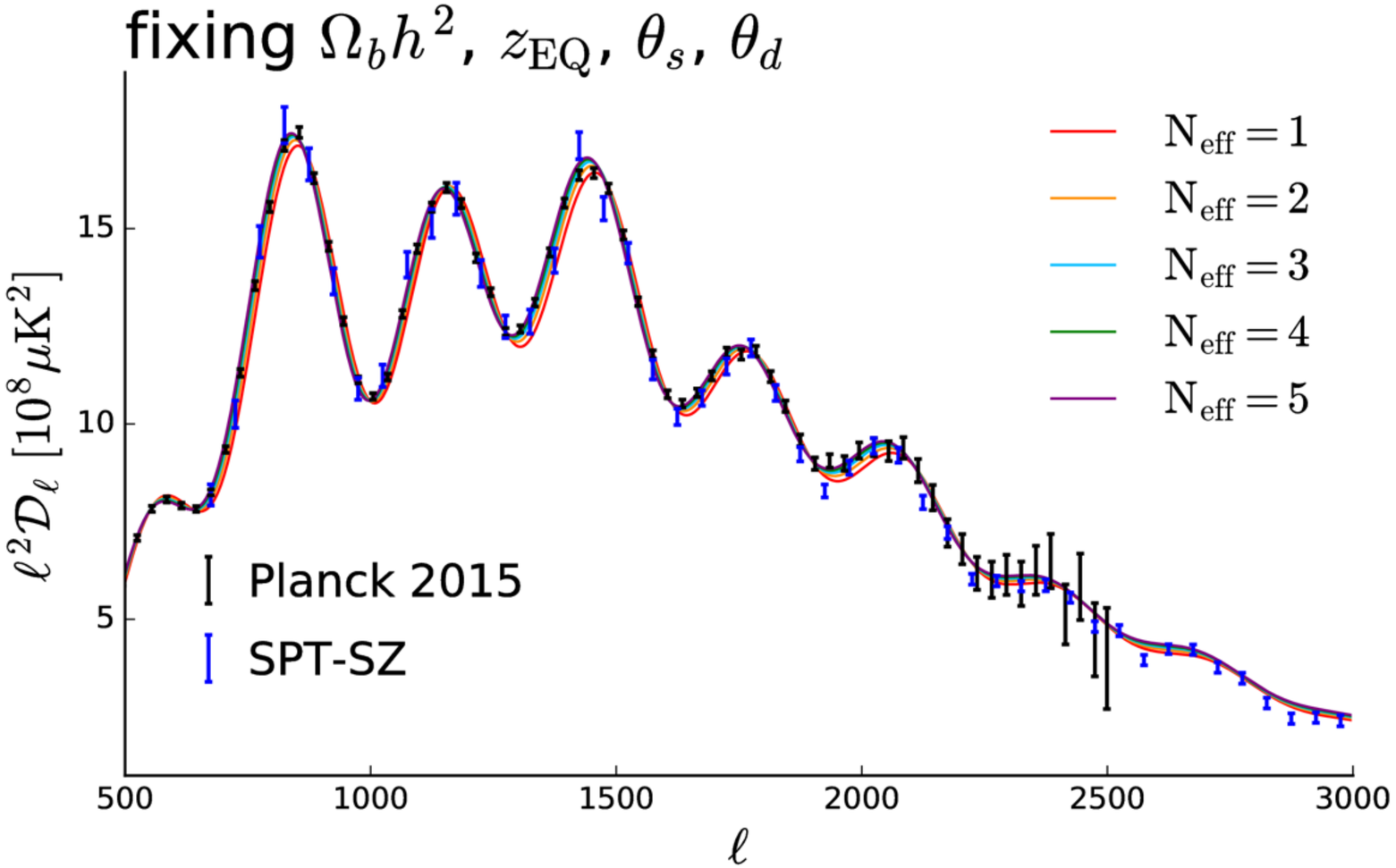

Python environment setup on midway

- In `home` folder - `.bashrc`

```
module load intel/14.0 # load intel compiler (ifort, icc)
module load mkl
module load intelmpi/4.1+intel-14.0
module load qt/4.8 # enable qt environment for python plotting
module load git
module load python/2.7-2014q3 # load python
module load firefox # load firefox for ipython notebook
module load fftw3/3.3

# python startup file, scripts to be load at startup
export PYTHONSTARTUP=~/.pythonstartup

# python library search path
# I have my own python scripts/library in
# $HOME/Projects/git/hpylib. You can set up your own.
export PYTHONPATH=$HOME/Projects/git/hpylib:$PYTHONPATH
```

Python environment setup on midway

- In `home` folder - `.pythonstartup`

```
import matplotlib
matplotlib.use('Qt4Agg')
import matplotlib.pyplot as plt
import pylab
pylab.ion()
import numpy as np
```

Install `cfitsio` on midway

```
wget http://heasarc.gsfc.nasa.gov/FTP/software/fitsio/c/cfitsio3380.tar.gz

tar -zxf cfitsio3380.tar.gz
cd cfitsio

# here we use intel fortran and C compiler
./configure FC=ifort CC=icc
make

# don't forget make install to create static library
make install

# now let's create an environment variable in ~/.bashrc for future convenience
export CFITSIO=(path_to_your_cfitsio_dir)/cfitsio
```

Install CAMB/pycamb on midway

- Get CAMB package from github
  https://github.com/cmbant/CAMB.git

```
# compile camb, with default compiler ifort
cd camb
make

# install pycamb
cd pycamb/
python setup.py install --user
```

Install cosmomc+clik on midway

- Get cosmomc from github
  `git@github.com:cmbant/CosmoMC.git`

- Get Planck likelihood module
  `wget http://irsa.ipac.caltech.edu/data/Planck/release_2/software/COM_Likelihood_Code-v2.0.R2.00.tar.bz2`

Install cosmomc+clik on midway

- Install planck likelihood

```
# install planck likelihood module for cosmomc
tar xvfj COM_Likelihood_Code-v2.0.R2.00.tar.bz2
cd plc-2.0

./waf configure --lapack_mkl=${MKLROOT} --cfitsio_prefix=${CFITSIO}
./waf install

# now lets add some environment variable in ~/.bashrc
# the following line is the example of mine
export CLIK_PATH=/home/zhenhou/data/planck_data/2015/likelihood/plc-2.0
```