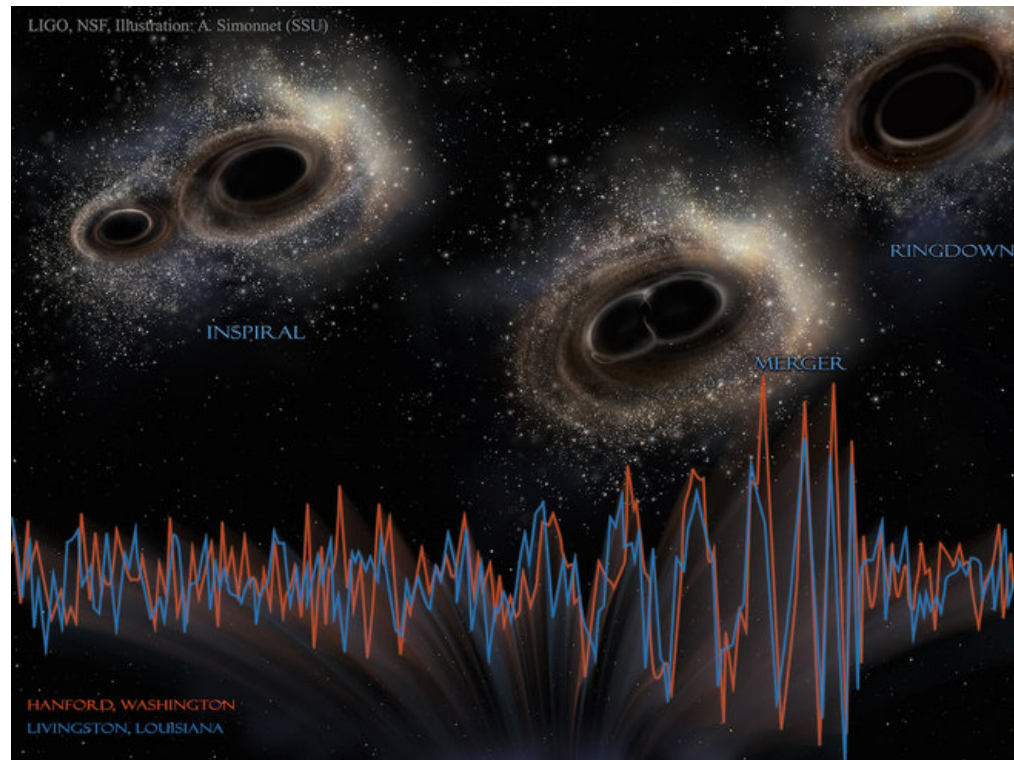


Physics 1240: Sound and Music

Today (8/7/19): Special Topics: Music in Modern Physics

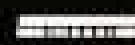
Next time: Review for Final



Review

- Audio File Formats:
 - Uncompressed: **.wav, .aiff**
 - Compressed (lossless): **.wma, .flac**
 - Compressed (lossy): **.mp3**
 - Other: **MIDI**
- Electrophones:
 - Sampler
 - Drum pads
 - Synthesizer (Moog)
 - Electric guitar
 - Theremin

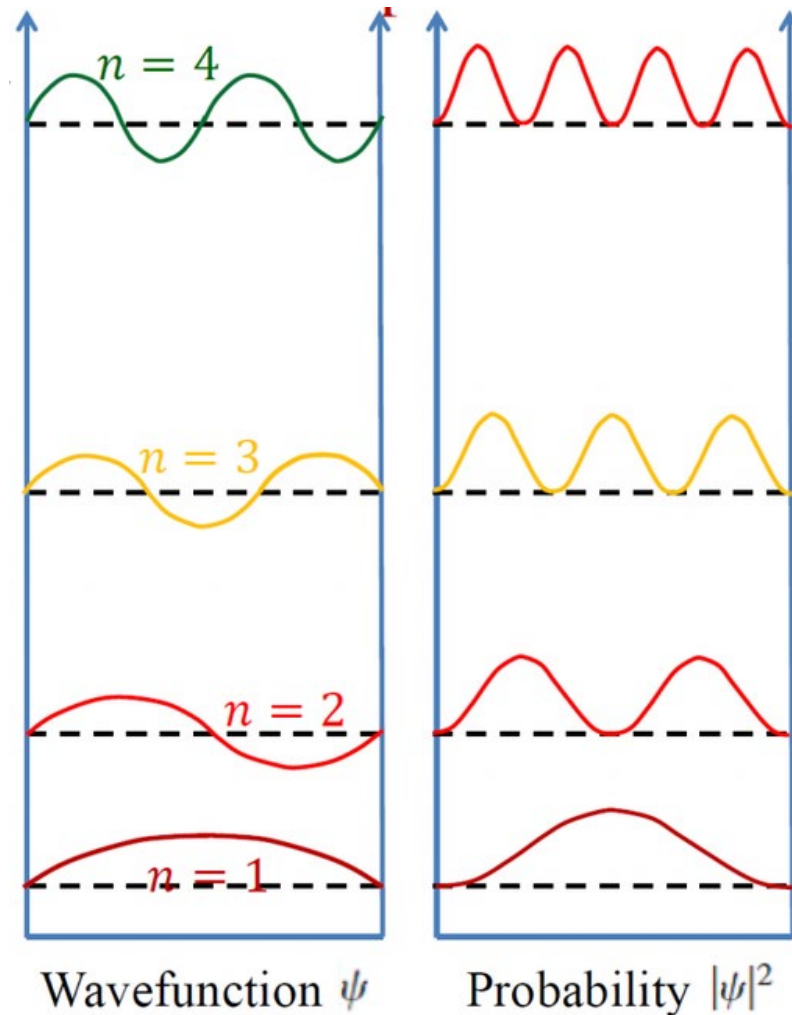
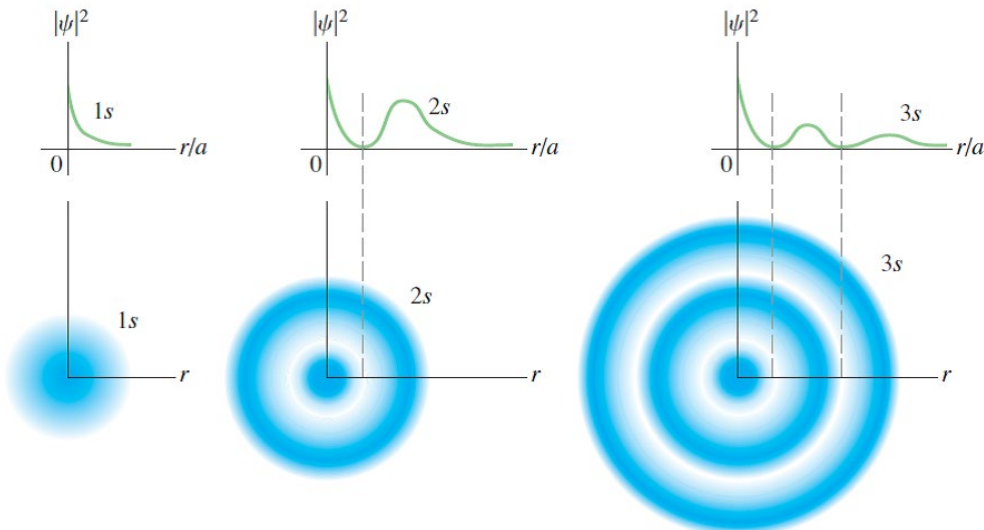




AUTOTUNE

Quantum Mechanics

- Wave function: $\Psi(x,t)$
Mathematical description of the quantum state of a particle
- $|\Psi|^2$ gives the probability a particle is at a certain location

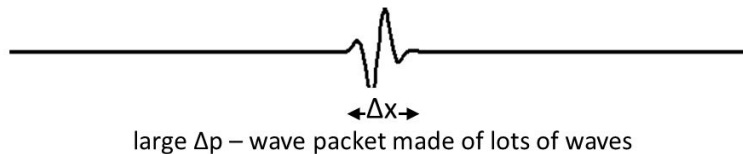
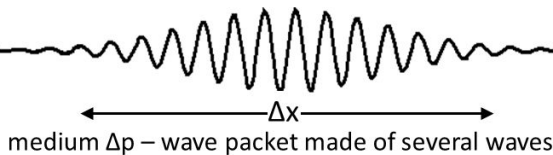
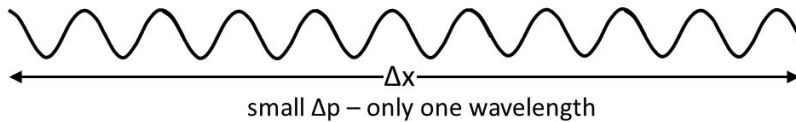


Quantum Mechanics

- Uncertainty Principle:

- How long do you need to determine whether two notes are in tune?

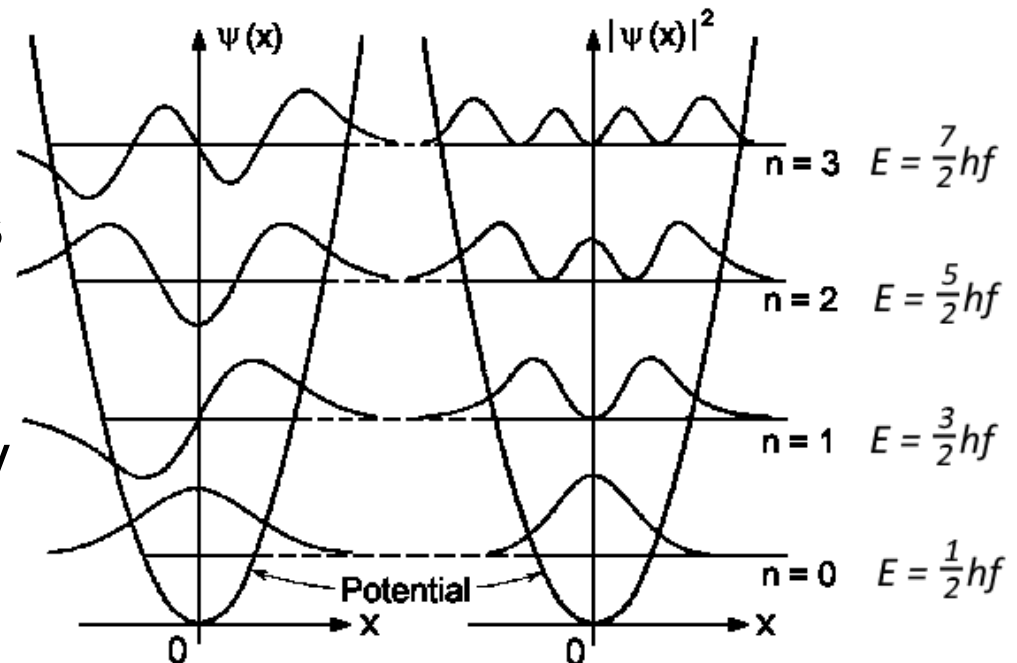
- $\Delta x \Delta p \geq \hbar/2$



- “One cannot simultaneously sharpen a signal in both the frequency and time domains ($\Delta f \Delta t \sim 1$)”

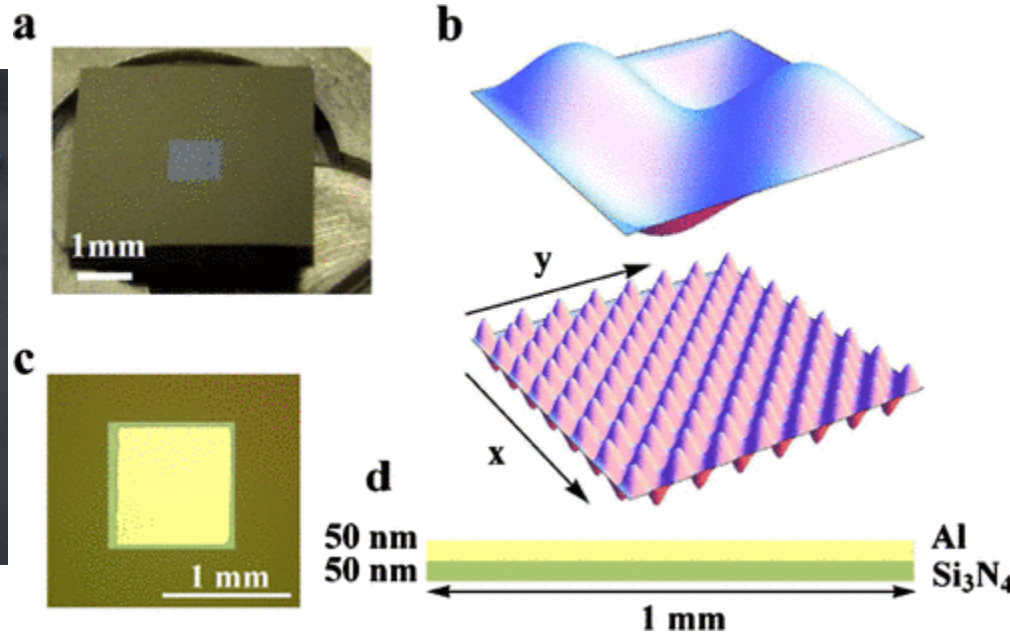
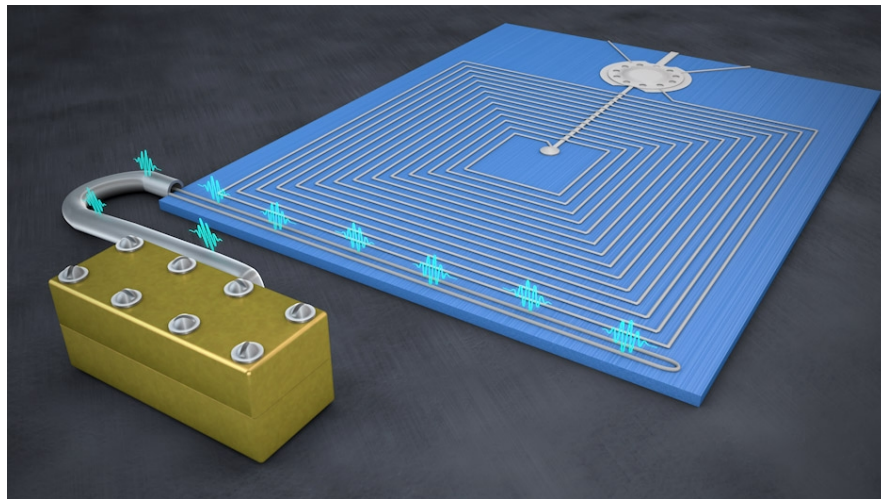
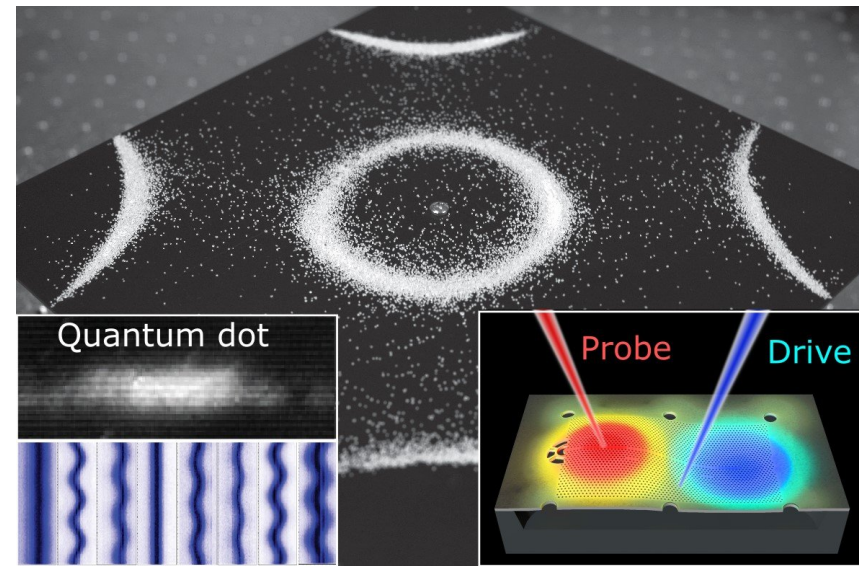
Quantum Mechanics

- “Essentially, all of physics is the study of harmonic oscillators and their applications”
 - Macroscopic behavior
 - RLC circuits
 - Star motion
 - Hydrogen-like atoms
 - Phonons
 - Quantum field theory



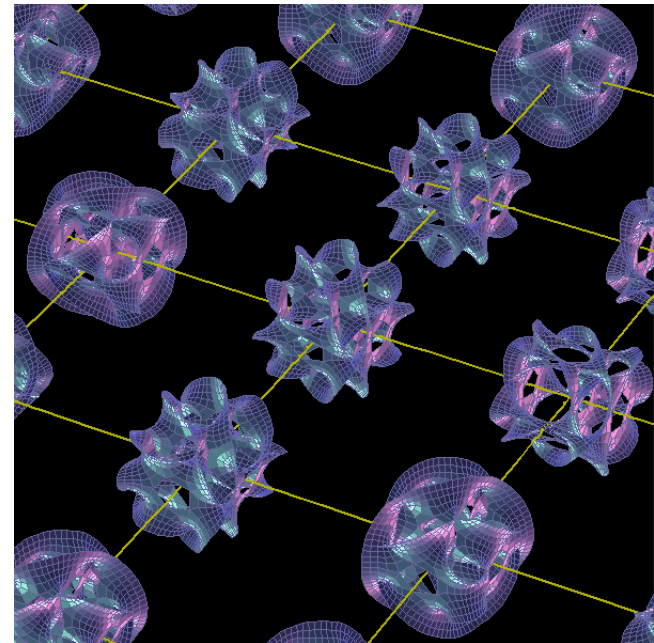
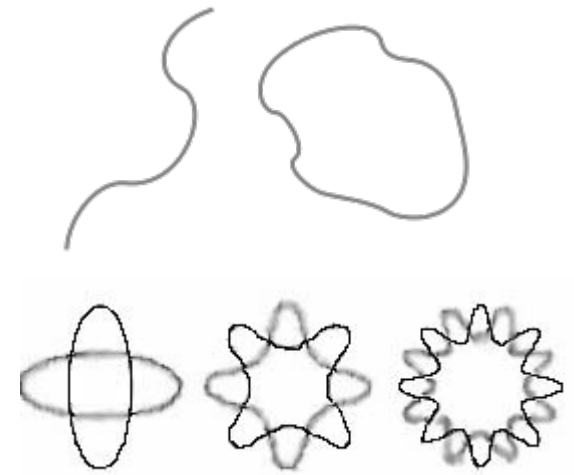
Recent Research

- Visualizing vibrational modes with quantum dots
- Tiny quantum drums (Cindy Regal, Konrad Lehnert)



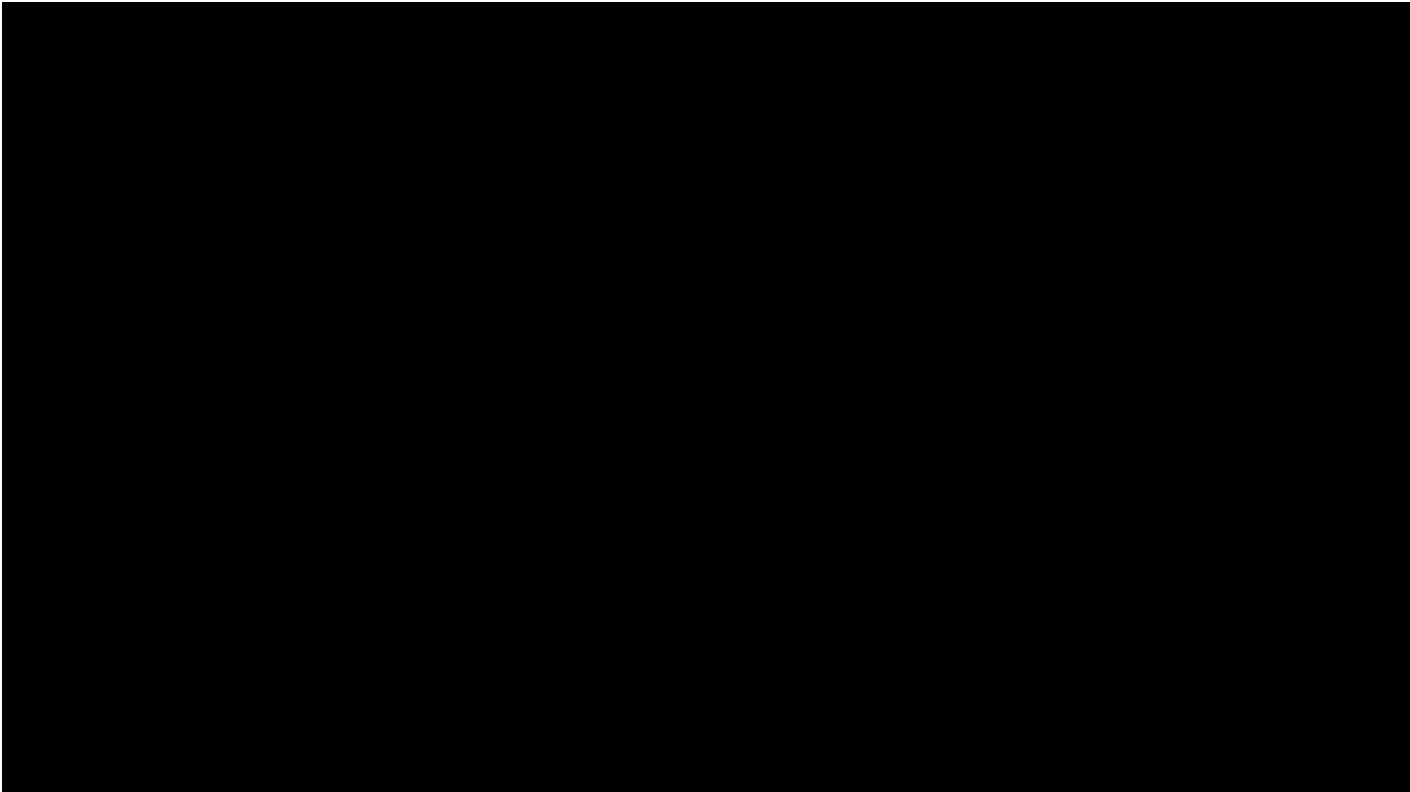
String Theory

- Point particles replaced by 1D strings
 - open or closed
 - different vibrational modes correspond to different particle properties
- Attempts to merge quantum theories with gravitational theories (“theory of everything”?)
- Requires extra dimensions (10+1)

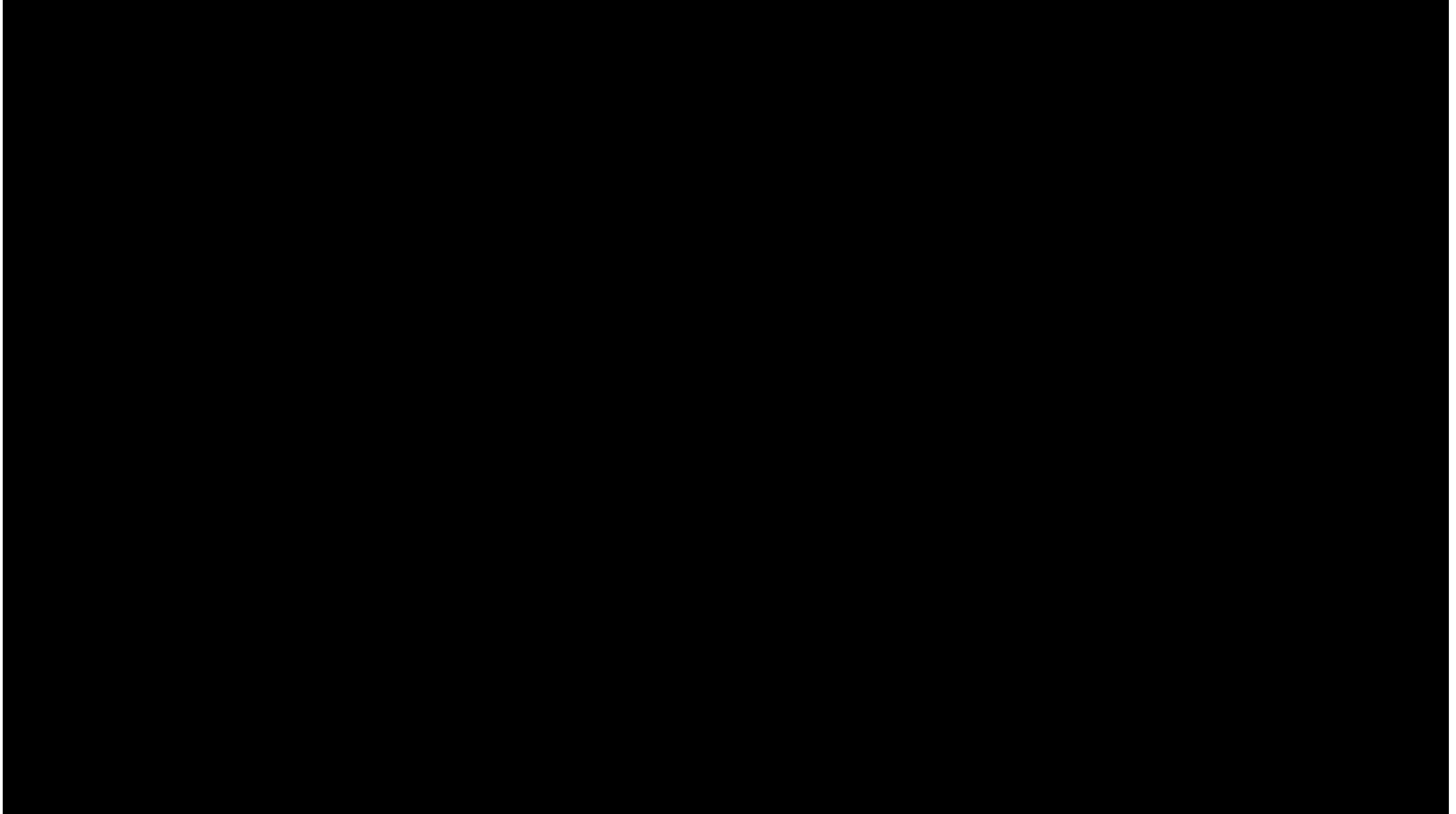


Astrophysics

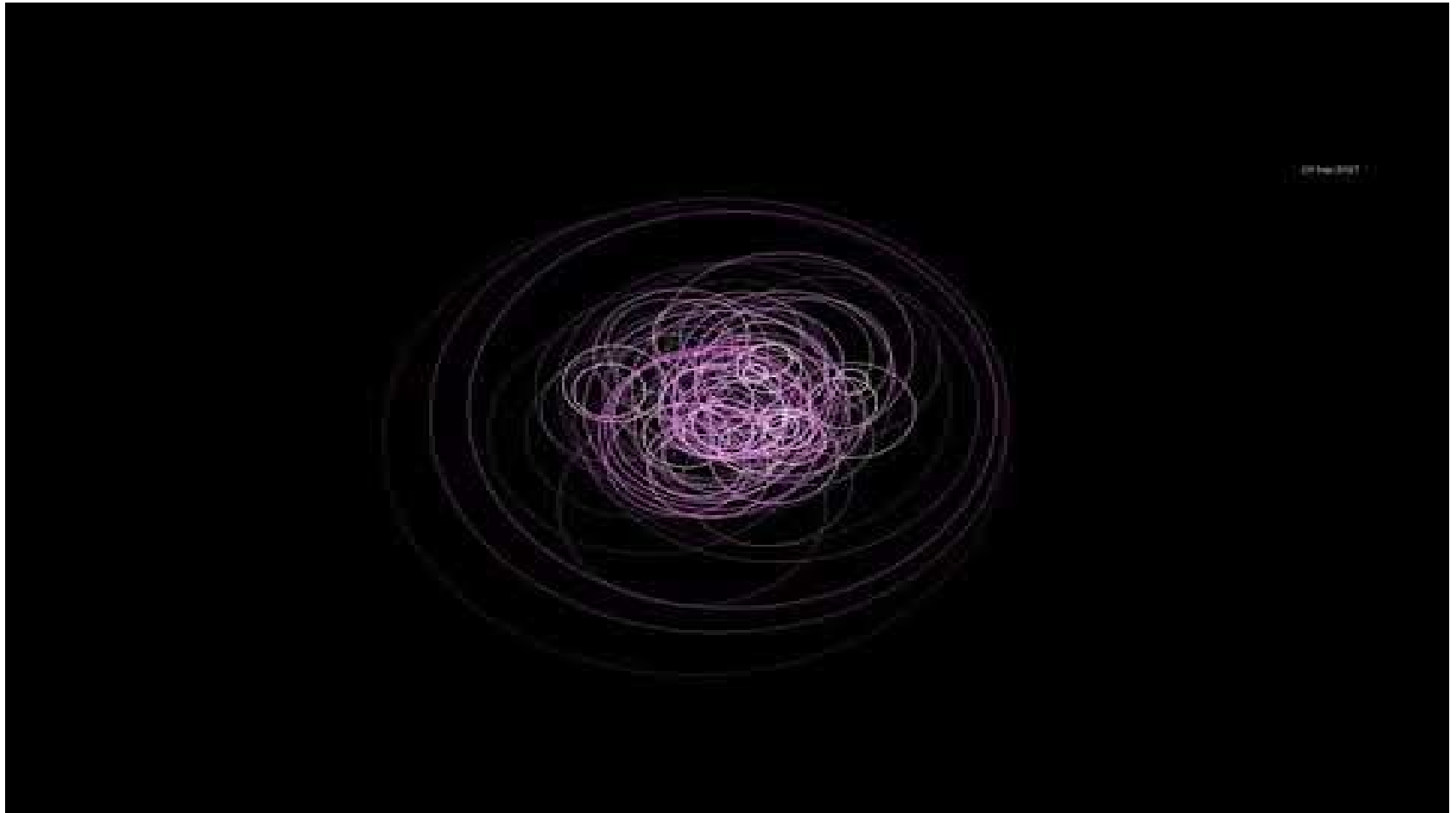
- No sound in space!
- Sonification: converting data into audio signals



Plasma waves from Saturn



Gamma ray burst from blazar

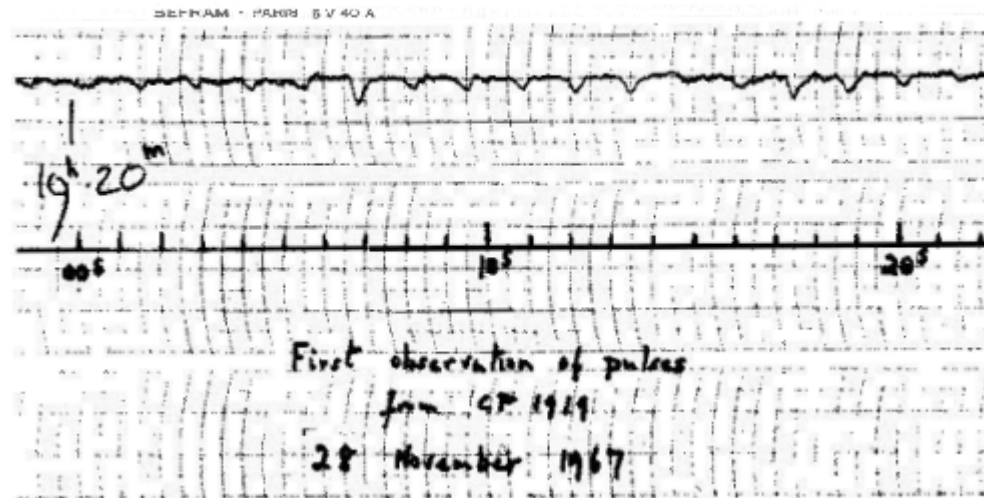
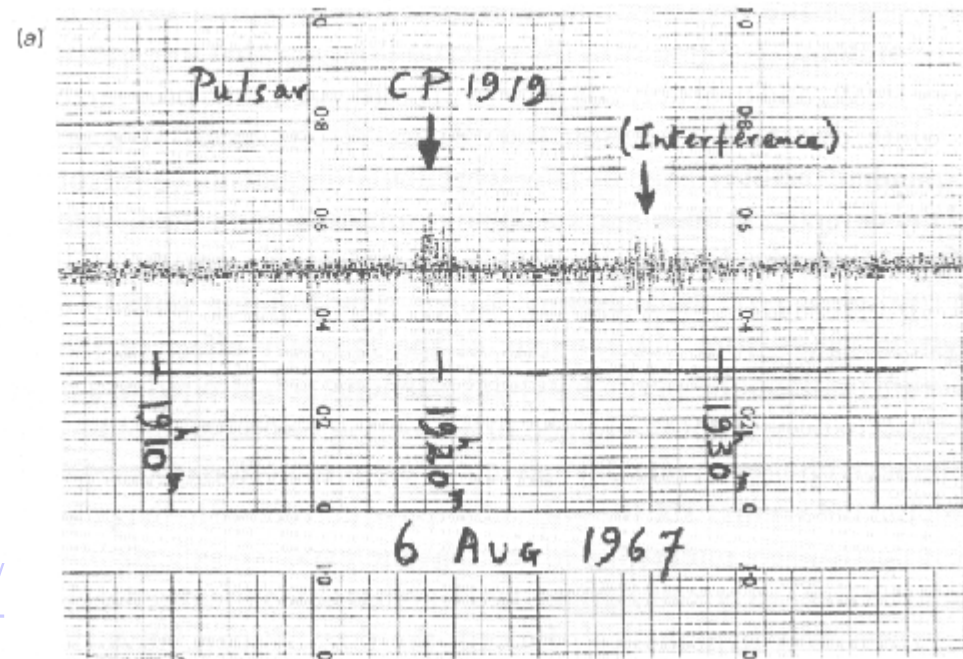
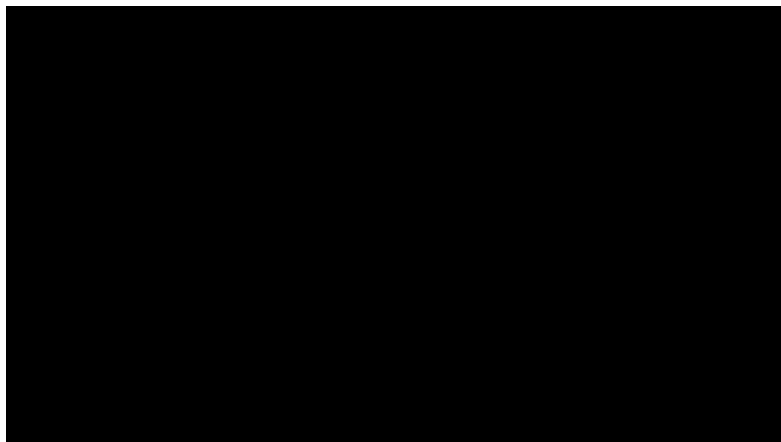


Pulsars

- First radio pulsar (LGM-1) discovered 1967 by Jocelyn Bell
 - Period: 1.3373 sec
 - Pulse width: 0.04 sec

- Sonifying pulsars:

<http://www.jb.man.ac.uk/pulsar/Education/Sounds/>



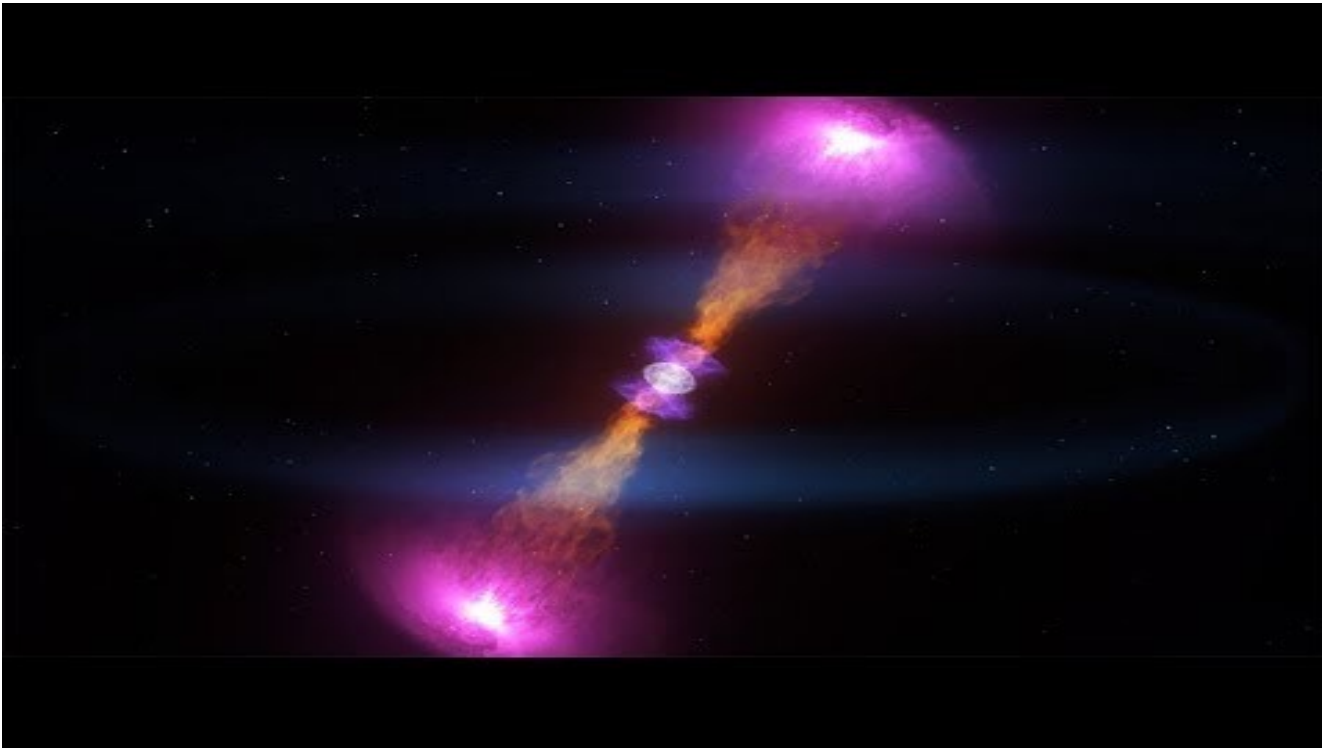
But what is a pulsar?

- Rapidly rotating neutron star
- Result of stellar explosion (“supernova”) for stars with masses between 10 and 30 solar masses
- Neutron degeneracy pressure (Pauli exclusion principle)



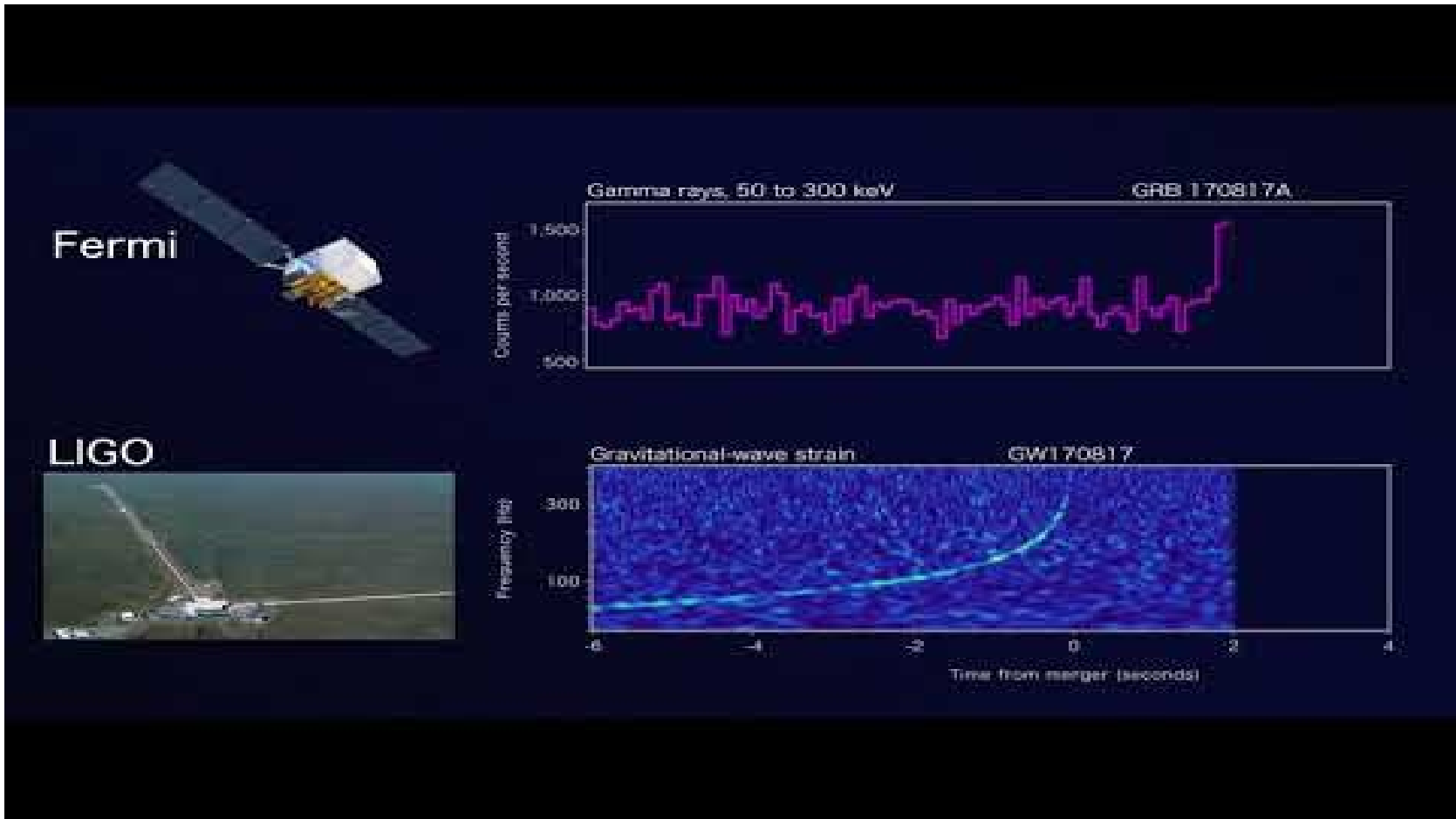
What if two neutron stars collide?

- Head-on collision unlikely
- Two stars orbiting each other (binary system) will eventually merge

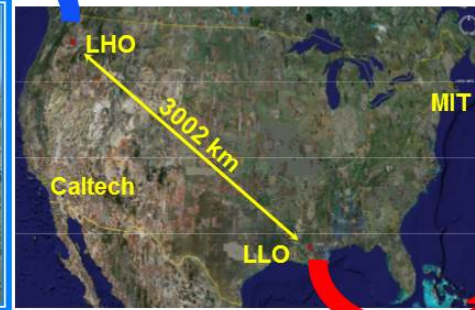
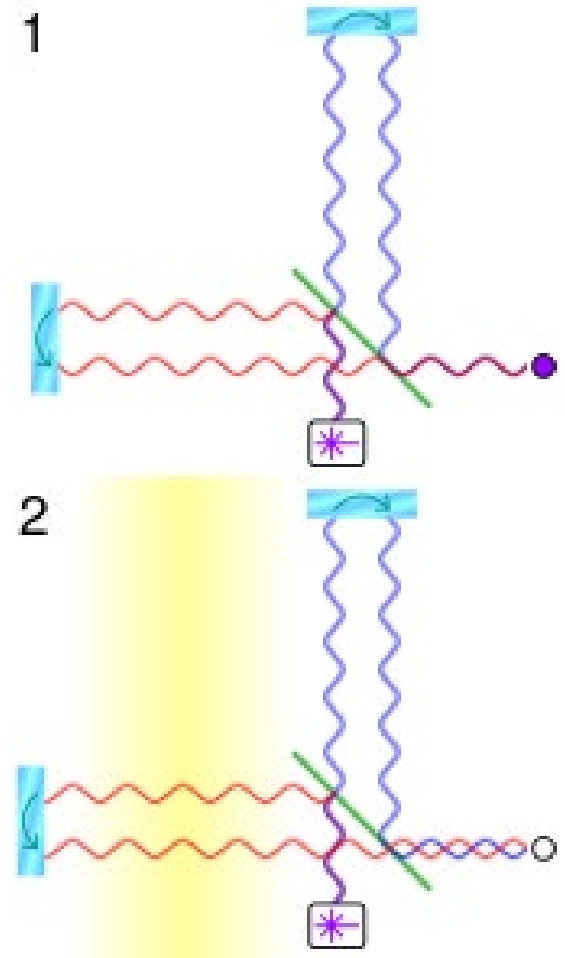
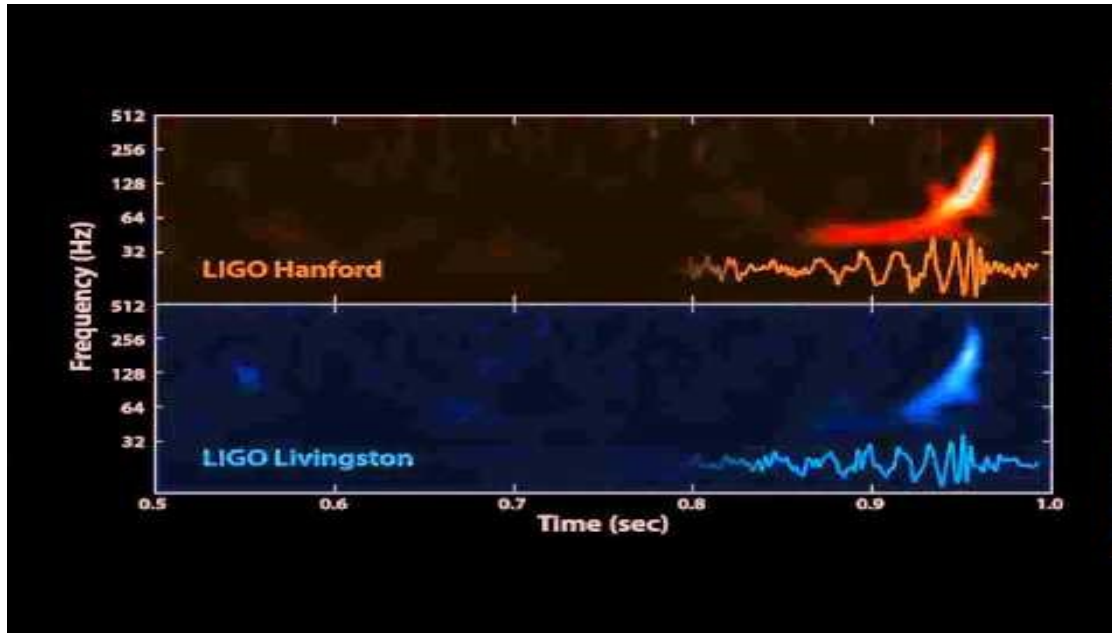


What if two neutron stars collide?

Neutron star merger (GW170817, Aug 17, 2017)



- LIGO: gravitational interferometer
- Black hole mergers (“chirp”)



Tomorrow: FCQs, review session

Question:

What would you like to do for the review session tomorrow?

- Review lecture
- Review tutorial
- Clicker question review
- In-class practice final
- Open question session
- Something else?