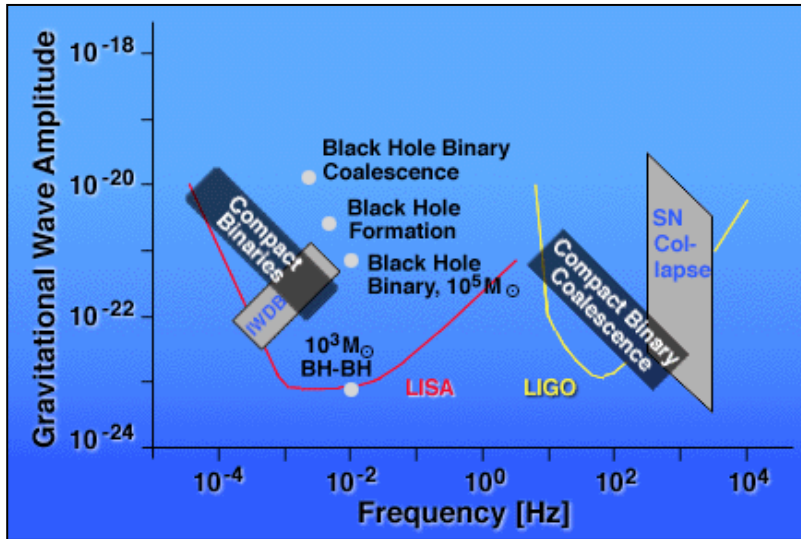

Below, Between and Beyond: Sources and Science

Lee Samuel Finn

Penn State Center for Gravitational
Wave Physics

LIGO-G030203-00-Z

Introduction



- Below ... 10^{-4} Hz $> f$
- Between ... 10 Hz $> f > 0.1$ Hz
- Beyond ... $f > 1$ kHz
- What sources may be found in these bands?
- What science does sensitivity in these bands enable?

Sources: Below

- Characteristic frequencies
 - $f_{\text{QNM}} \sim 10^{-4} \text{ Hz} / (M/10^8 M_{\text{sol}})$
- Black hole mergers
 - Where? (High z) Galaxy mergers
 - Hierarchical formation
 - Galaxies that have merged more likely to merge
 - $M_2/M_1 \sim 1/10$
- Science? Galaxy interactions, evolution in mergers, formation of supermassive BHs

QuickTime™ and a Sorenson Video 3 decompressor are needed to see this picture.

Sources: Between (1)

- Stochastic background
 - Standard inflation: $\Omega \sim 10^{-17} - 10^{-16}$
 - Cosmic strings, other exotic physics larger contributions
 - Uncovered in ~ 1 Hz band
 - Above WD binary cutoff
 - NS binary contribution (may be) resolvable
 - Reachable in LISA follow-on
- Pulsars?
 - Lots of ~ 1 s period pulsars, some quite close by

Sources: Between (2)

- Compact object characteristic frequencies
 - $f_{\text{QNM}} \sim 1 \text{ Hz} / (M/10^4 M_{\text{sol}})$
 - $M > 1000 M_{\text{sol}}$ has $f_{\text{QNM}} < 10 \text{ Hz}$
- Inspiral/Coalescence
 - End-inspiral: $f_{6M}(2 \times 100 M_{\text{sol}}) \sim 10 \text{ Hz}$
- Supermassive star collapse
 - several hundred solar masses
- Tracking inspiral: LISA to ground-based IFO band
 - Multi-decade frequency sweep: map spacetime around black holes, testing relativity (graviton mass measurements)
- Science:
 - hierarchical formation of pre-galactic black holes, stellar populations

Sources: Beyond

- Characteristic frequencies
 - $f_{\text{QNM}} \sim 4 \text{ KHz} / (M / 3 M_{\text{sol}})$
 - $f_{6M}(2 \times M_{\text{sol}}) \sim 1 \text{ KHz}$
- Solar mass black hole formation
 - Mass gap? Are there 3-5 M_{sol} black holes?
- Equation of state?
 - Strange stars and other exotica may have smaller radii than ns and coalesce at higher frequencies
- MS pulsars
 - $h \sim \epsilon I \omega^2 / r$
 - $\epsilon < 10^{-8}$ for millisecond pulsars (cf. 10^{-6} for younger, slower pulsars)

Science

- Below
 - Supermassive black holes and galactic structure
- Between
 - Early universe (stochastic background)
 - Pre-galactic black holes
 - Stellar populations (Vicky Kalogera)
 - Cluster dynamics (Cole Miller)
 - Testing relativity
 - Graviton mass and related question of polarizations
 - Black hole spacetime “mapping”
- Beyond
 - Equation of state (Fred Rasio)
 - MS neutron stars, solar mass black hole formation,