

The LIGO logo consists of several concentric, slightly irregular circles in a light gray color, positioned in the top-left corner of the page. To the right of these circles, the word "LIGO" is written in a bold, black, sans-serif font.

**LIGO**

---

**LIGO**

**Kip S. Thorne**

The Feynman Professor of Theoretical Physics

Presentation for PMA Visiting Committee,  
Caltech, 15 March 2000

# Gravitational Waves

- Ripples of spacetime curvature

- » Predicted by general relativity
- » Emitted strongly by objects made wholly or in part from spacetime curvature:
  - black holes, neutron stars, the big bang, ...



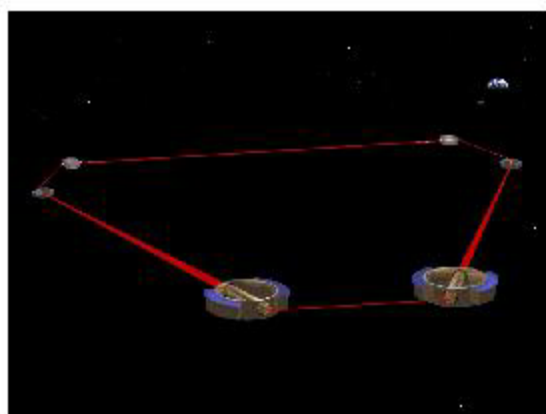
- LIGO: 10 - 2000 Hz

- » Black holes: 2 to 200 Msun
- » neutron star births, spins, vibrations & collisions
- » the big bang?...



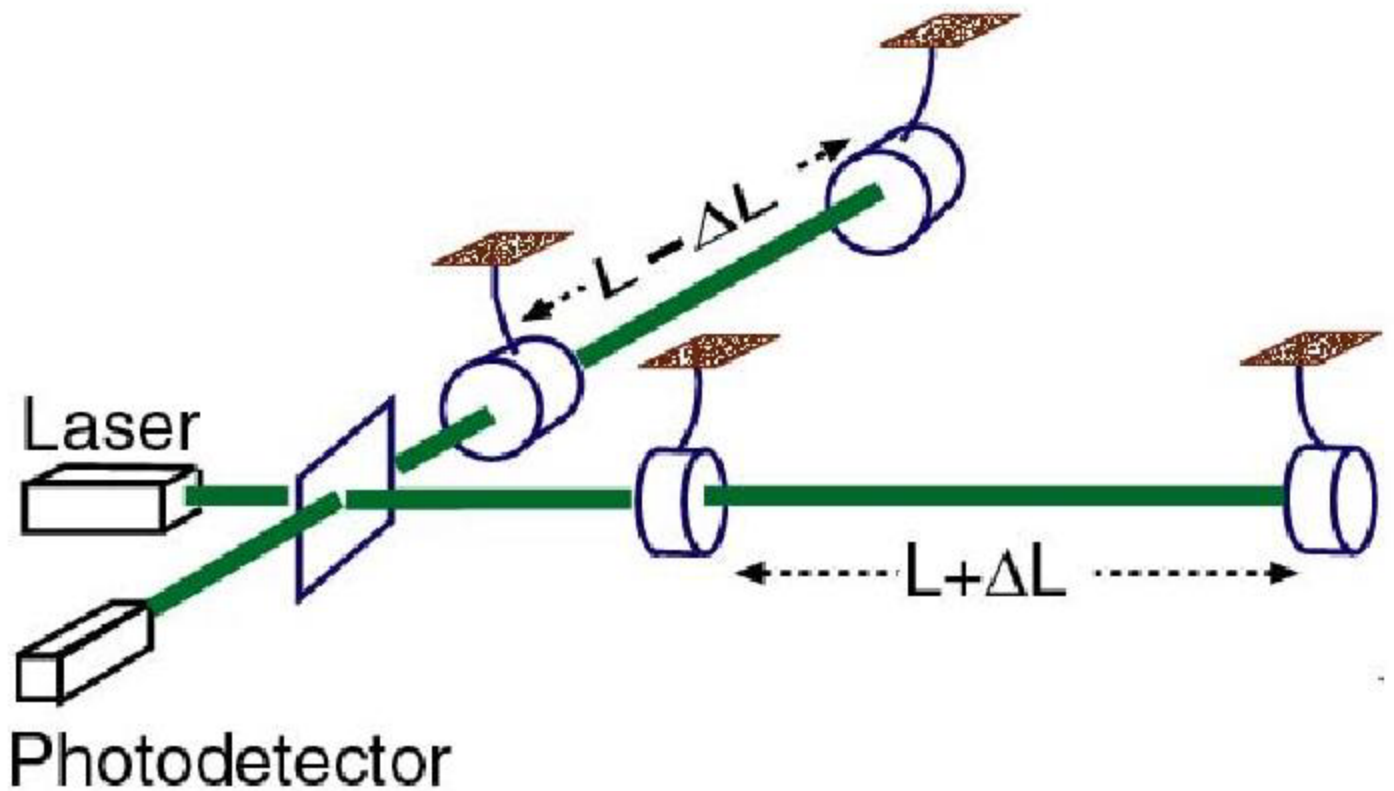
- LISA: 0.0001 0.01 Hz

- » Black Holes: 10 thousand to 100 million Msun
- » binary stars
- » the big bang? ...



**LIGO**

# Gravitational-Wave Detector (Interferometer)



$$\Delta L = h L \approx 4 \times 10^{-16} \text{ cm}$$

$\approx 10^{-21}$       4 km

# LIGO : Laser Interferometer Gravitational-Wave Observatory

- Two Facilities [constructed 1994-99]
  - » Hanford, Washington



- » Livingston, Louisiana

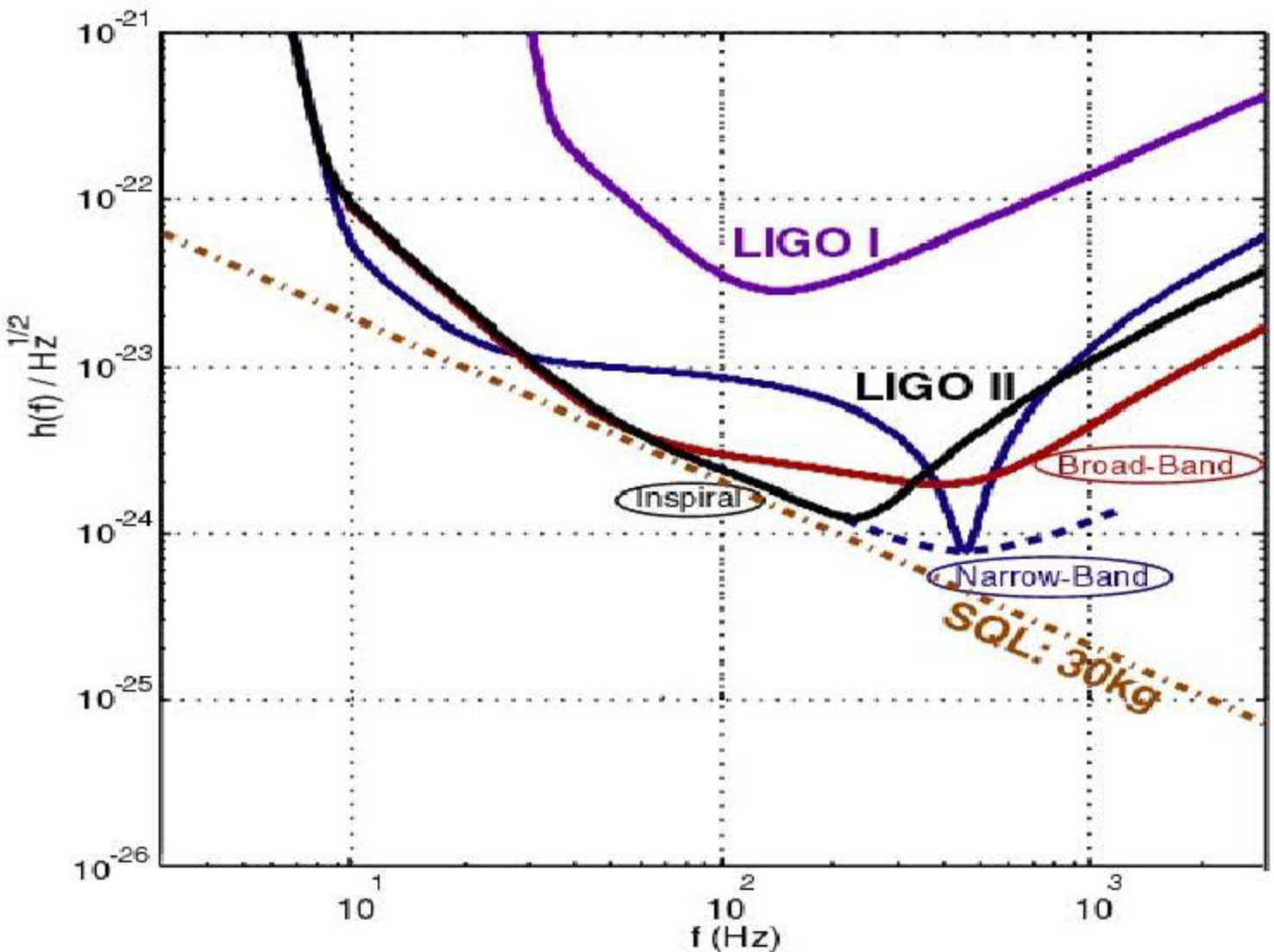


# LIGO

LIGO-I (2002-2004)

LIGO-II (ca 2006-2008)

- LIGO-I: Interferometers now being mounted
  - » sensitivity at level of plausible detection for BH/BH
- LIGO-II: R&D underway
  - » conceptual-design sensitivity ~20 times better (10,000 higher event rate)
  - » would be surprising if don't see many sources



# LIGO Organization & Caltech Roles

- LIGO Laboratory

- » Responsible for Facilities; and for Design, Construction, & Operation of Interferometers
- » **Caltech** & MIT; Headquartered at Caltech
- » Director: Professor **Barry Barish**  
Deputy Director: **Gary Sanders**

- LIGO Scientific Community (LSC)

- » Formulates science goals
- » Carries out Interferometer R&D
- » ~250 scientists and engineers in ~20 institutions
  - ACIGA (Australia), Caltech, Cornell, U. Florida, GEO600 (Britain&France), IAP-Nizhny Novgorod (Russia), JILA (U Colorado), LSU, Louisiana Tech, MIT, U. Michigan, Moscow State U. (Russia), NAOJ-TAMA (Japan), U. Oregon, Penn State U., Stanford, Syracuse, U. Texas-Brownsville, U. Wisconsin-Milwaukee
- » **Includes groups at Caltech led by Professors Drever, Libbrecht, Prince, Thorne; and LIGO Laboratory**

# LIGO Laboratory Demographics as of Jan 1

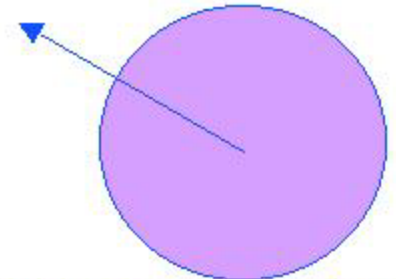
---

- Total Personnel: 144 [132 FTE]
  - » Grad students: 12
  - » Postdocs: 16
  - » Scientists: 21
  - » Engineers: 36
  - » Other staff: 59
- At Caltech: 85
  - » Grad students: 6 (plus ~8 in LSC groups)
  - » Summer Undergraduate Research [REU/SURF]: ~15 each summer
- At MIT: 17
  - » Grad students: 6
- At Hanford: 18
- At Livingston: 12

# Examples of Science: BH-BH INSPIRAL & MERGER

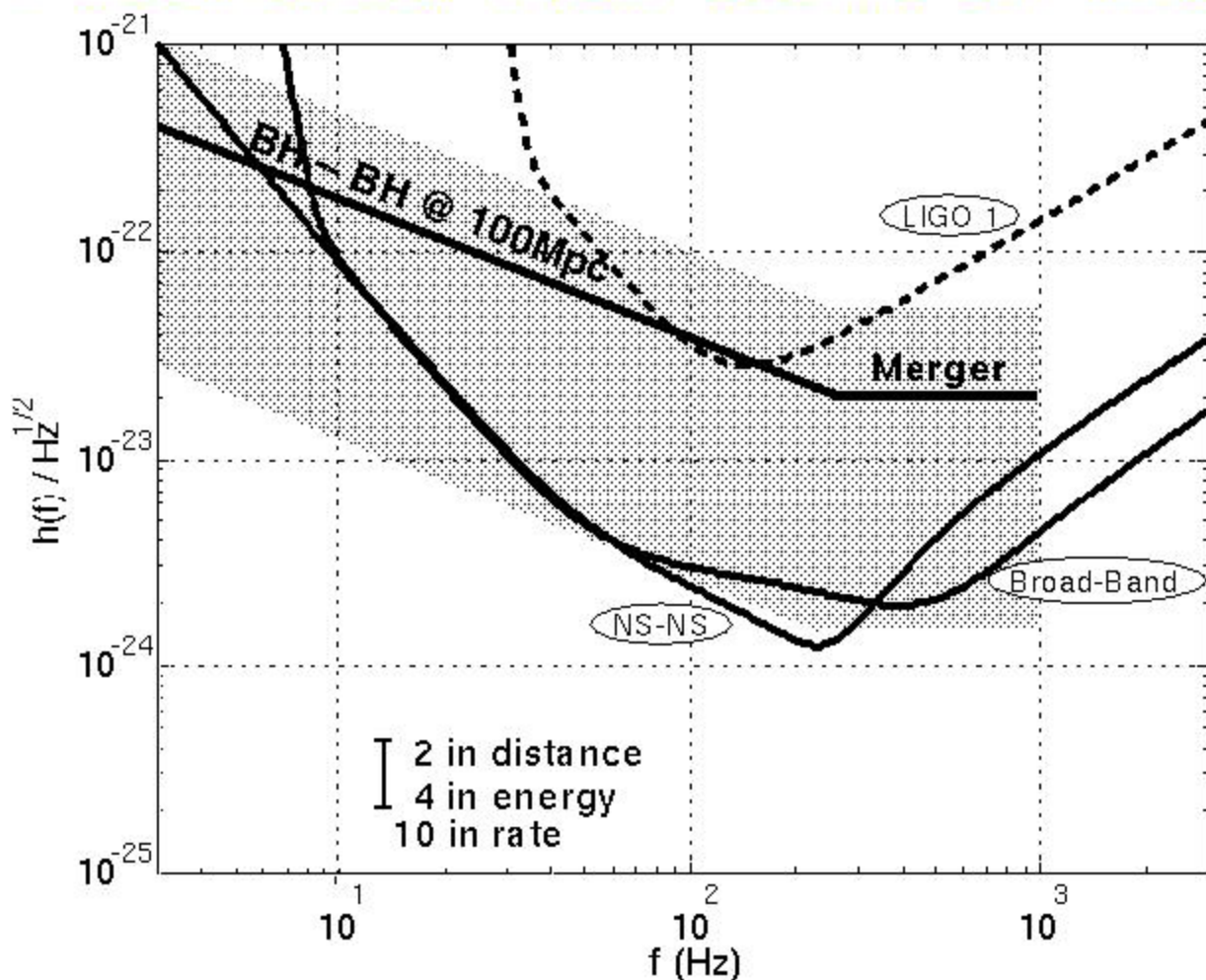
- Globular Clusters: machines for making binary black holes

» [Portegeis-Zwart & McMillan]



- Rates Highly Uncertain. Optimistic estimates:

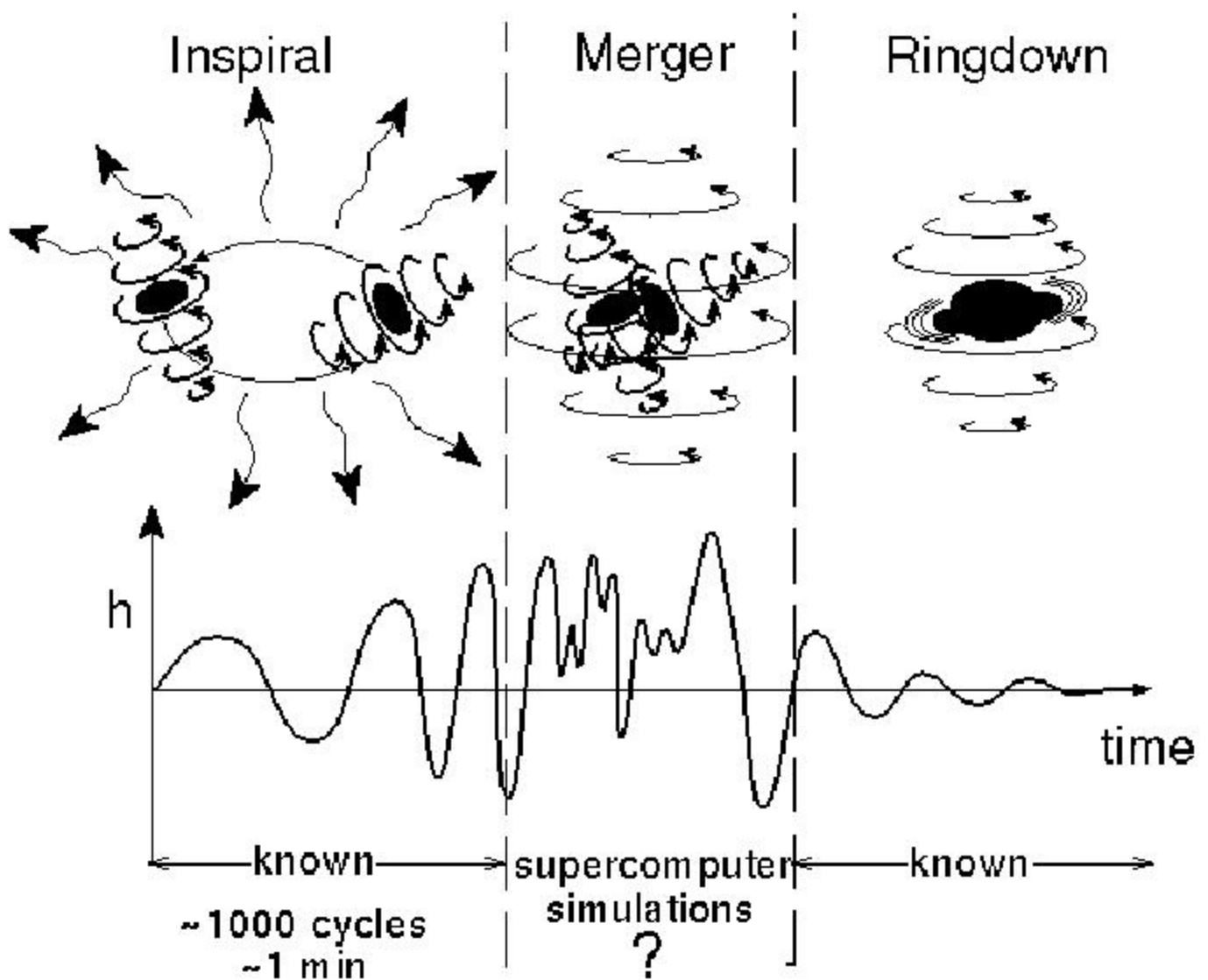
» LIGO-I: 100 Mpc, ~1/year. LIGO-II: z=0.5, ~1/hour





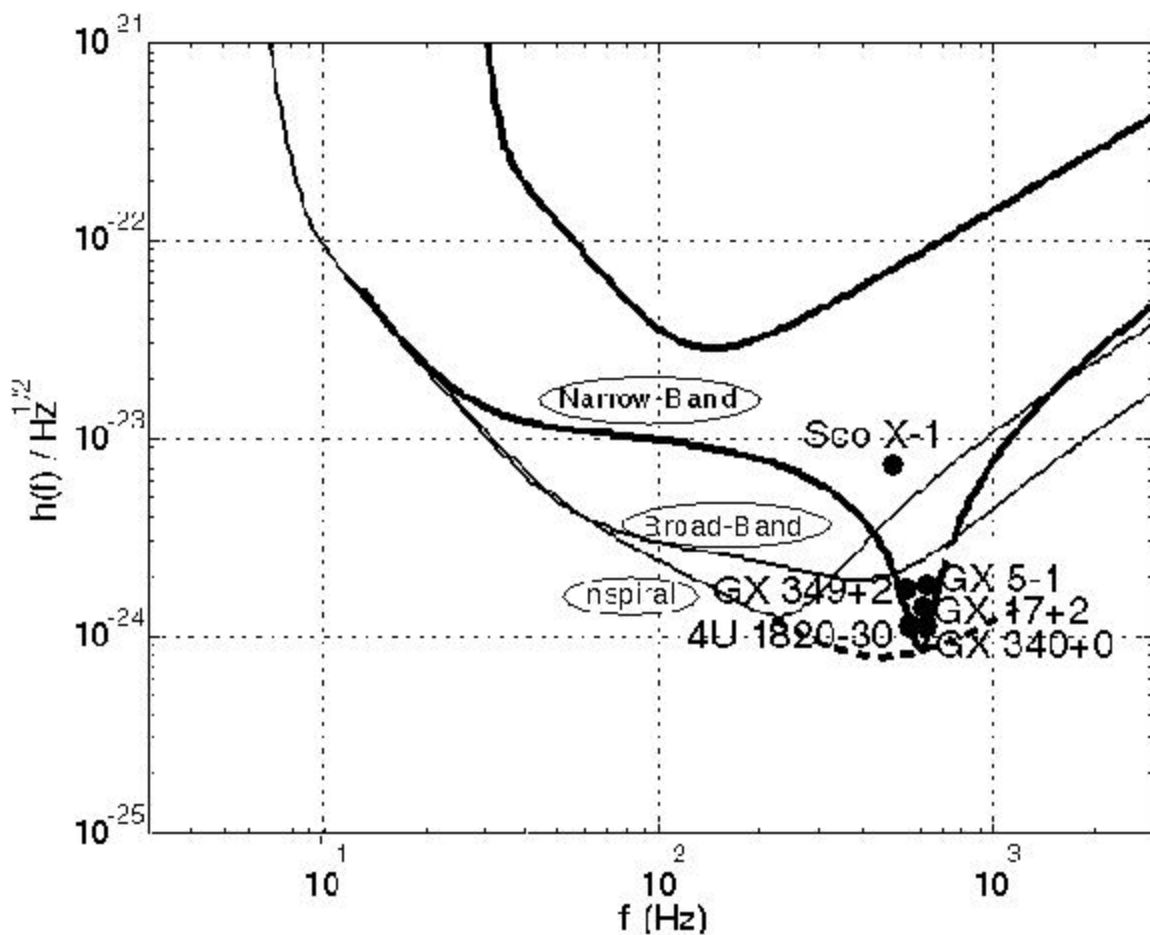
# General Relativity: BH-BH INSPIRAL & MERGER (cont)

- Nonlinear dynamics of spacetime curvature

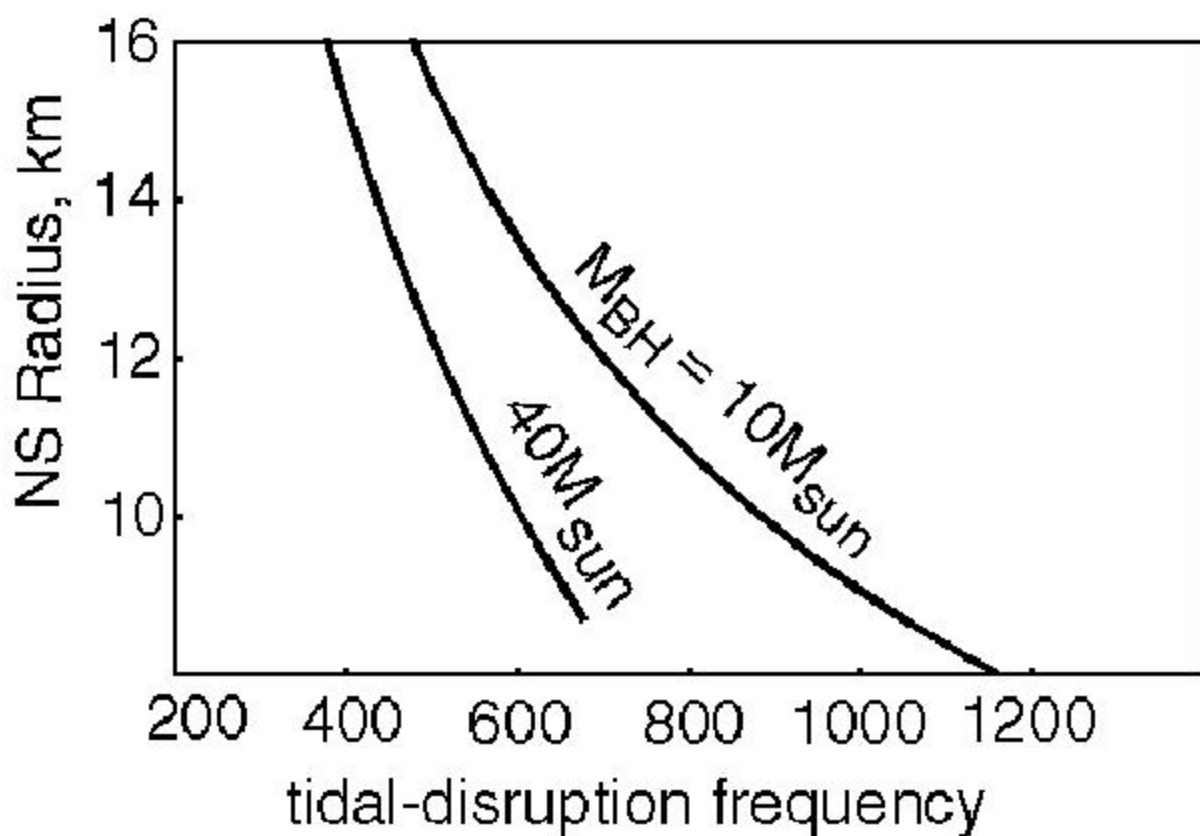
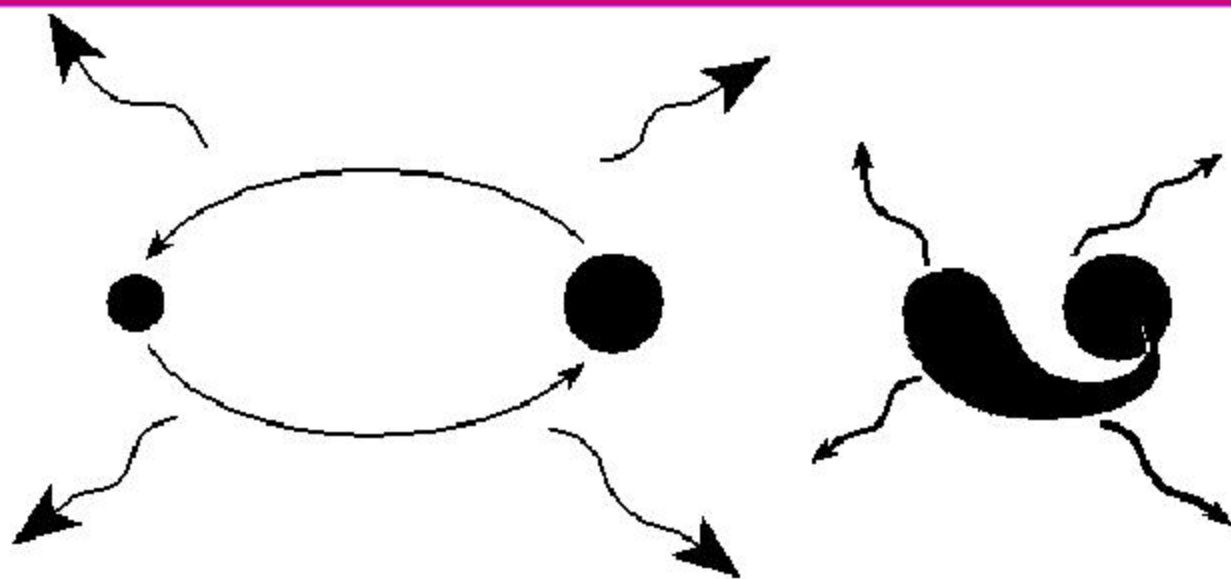


# Astrophysics: Low-Mass X-Ray Binaries

- Observed spins all  $\sim 250 - 350$  Hz
- Proposed explanation [Bildsten]
  - » Accretion torque balanced by gravitational-radiation torque



# Nuclear Physics: Tidal Disruption of Neutron Star by Black Hole



# Unknown Sources

---

- Big Surprises are Likely

- » Two years ago:

- Black hole / black-hole binaries thought to be exceedingly rare
- Low-Mass X-Ray Binaries not thought to be GW sources
- Neutron-star tidal disruption not known to lie in LIGO band