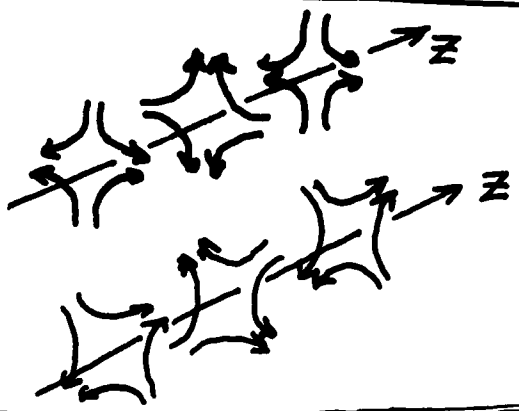
SCIENTIFIC OBJECTIVES AND BASIC CONCEPTS

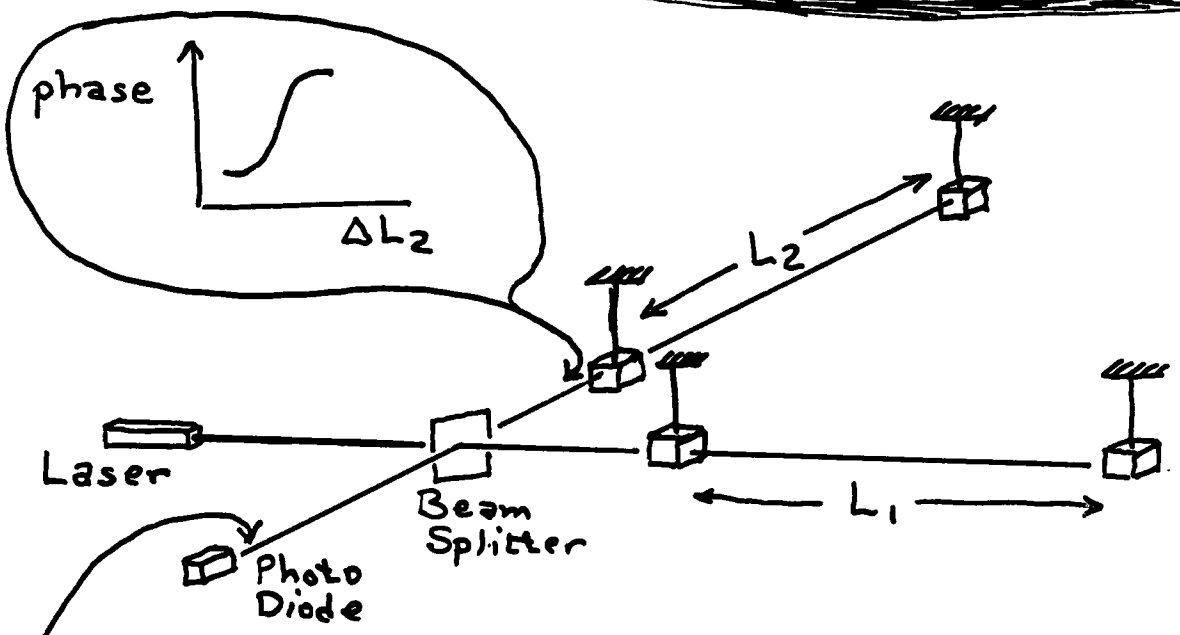
K. S. Thorne

December 11, 1992

Gravitational Waves & Interferometrk Detectors

$h_+(t-z/c)$ + 

$h_\times(t-z/c)$ ×



Intensity $\propto \frac{\Delta(L_2-L_1)}{L} = h_+(t)$ if source is overhead

$= F_+(\alpha,\delta)\,h_+(t) + F_\times(\alpha,\delta)\,h_\times(t)$

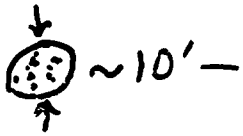
LIGO: Two detectors: Hanford, WA; Livingston, LA

parallel arms

measure <u>one</u> waveform 

LIGO + Foreign Partner(s)

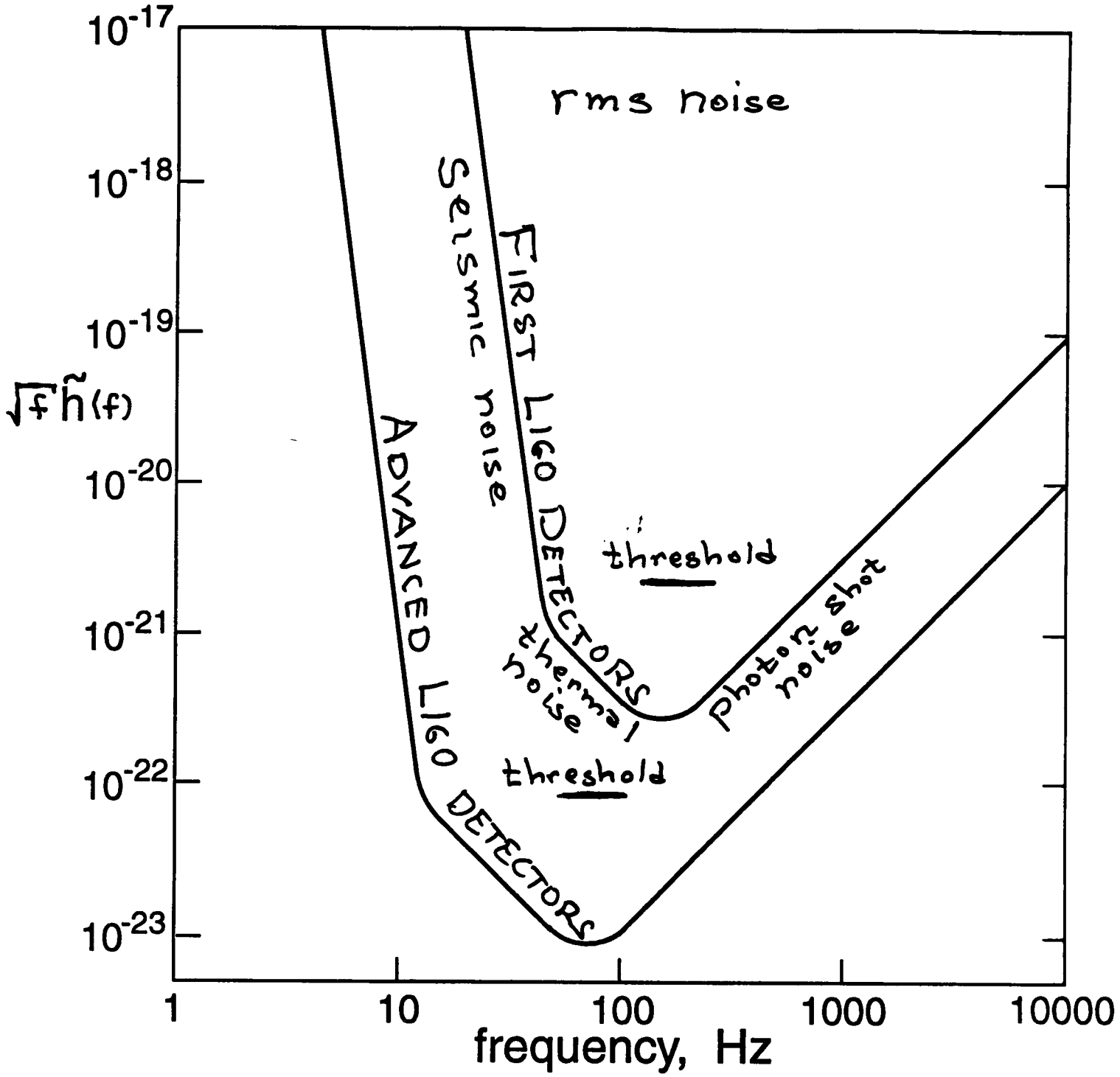
Extract full information from wave

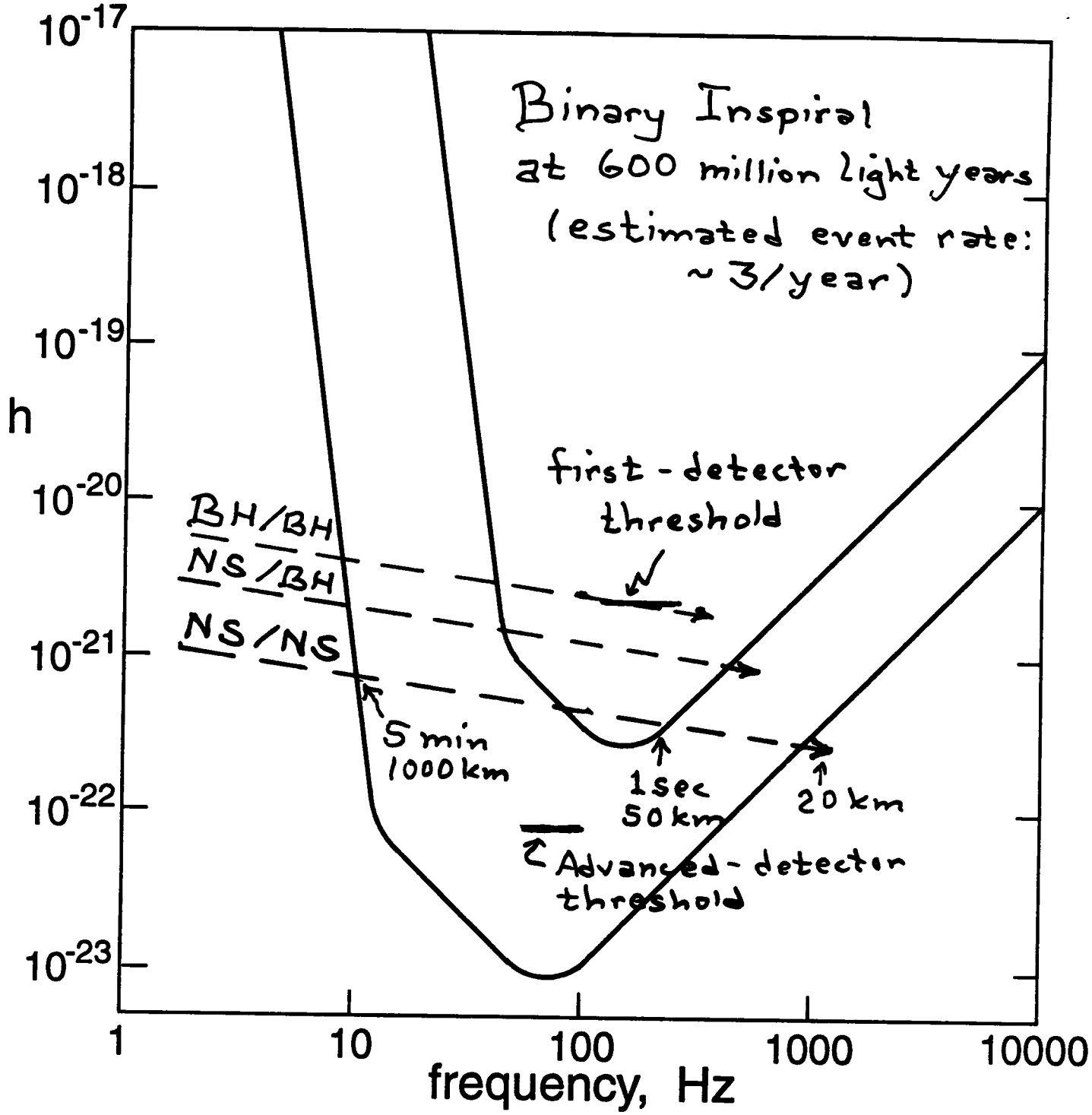
$h_+(t)$, $h_\times(t)$ 

INFORMATION TO BE EXTRACTED FROM WAVES

- **Background Issues:**
  - Enormous difference between EM & Grav'l Waves
    - emission mechanisms
    - interaction with matter

    ⇒ Most grav'l sources not seen EM'ly
      - and conversely
      - Potential for great surprises
  - Strongest sources:
    - Extragalactic... near cosmological
- **Coalescing Binaries [NS/NS, NS/BH, BH/BH]**
  - The "bread & butter (rice & potato)" sources
    - Map spacetime geometry of black holes
    - Explore nonlinear dynamics of spacetime curvature
    - Measure NS masses & radii
      → nuclear equation of state
    - Probe large-scale structure of Universe
- **Stochastic Background?**
- **Pulsars?**
- **Supernovae?**
- **The Unexpected**


rms noise
Seismic noise
First LIGO Detectors
Advanced LIGO Detectors
thermal noise
threshold
threshold
photon shot noise
10^{-17}
10^{-18}
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
$\sqrt{f}\tilde{h}(f)$
1
10
100
1000
10000
frequency, Hz



$$\text{Rate} \propto \frac{1}{(\text{threshold})^3}$$

Advanced Detector Threshold:

BH/BH: $r \simeq 2\times10^{10}$ l.yr., rate $\gtrsim$ 100/day

NS/BH: $r \simeq 1\times10^{10}$ l.yr., rate $\lesssim$ 10/day

(highly uncertain)

NS/NS: $r \simeq 3\times10^{9}$ l.yr., rate ~ 1/day

Example of a Binary Inspiral Waveform