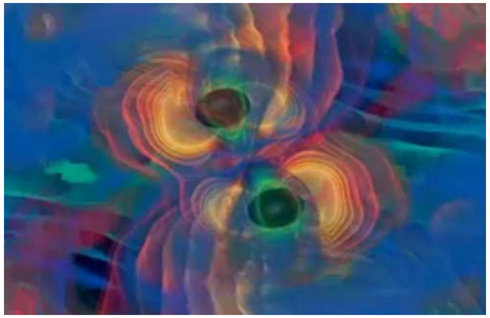
LIGO

LSC



Gravitational Waves: a new window to the Universe

Gabriela González

Physics and Astronomy, Louisiana State University

For the LIGO Scientific Collaboration

February 22, 2007

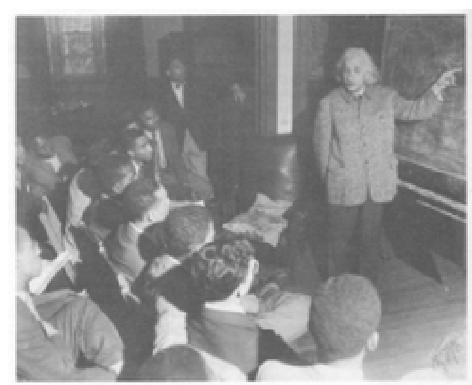
NATIONAL SOCIETY OF BLACK PHYSICISTS

Annual Conference

NSBP

National Society of Hispanic Physicists

NSHP



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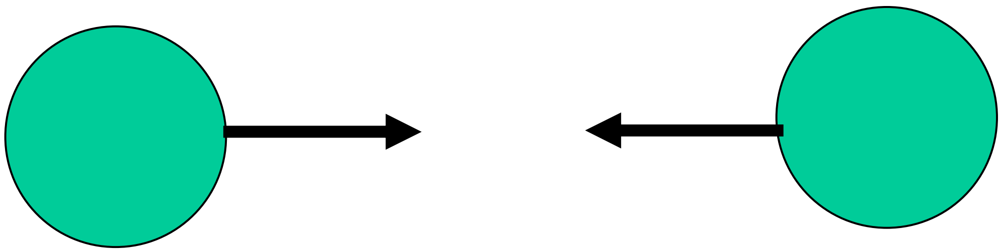
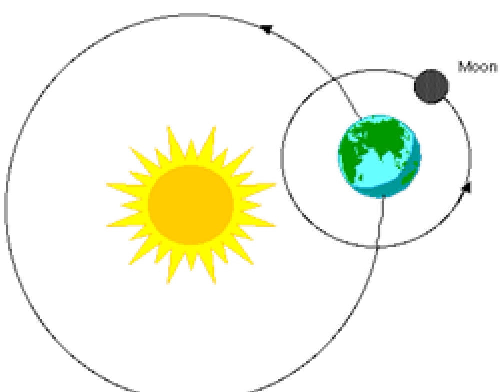
Newton’s gravitation



Newtons’ law: $F=Gm_1m_2/r^2$

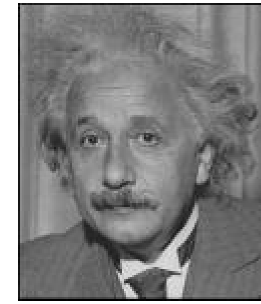
Explains why things fall down,

and planetary motion.



Einstein's gravitation

When masses move, they wrinkle the space time fabric, making other masses move…

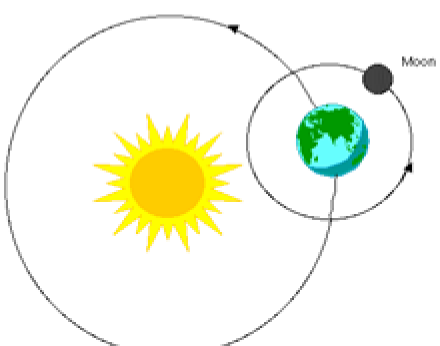


ckTime™ and a

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

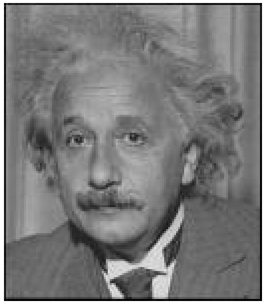
Explains just as well why things fall and planetary motion…

sciencebulletins.amnh.org



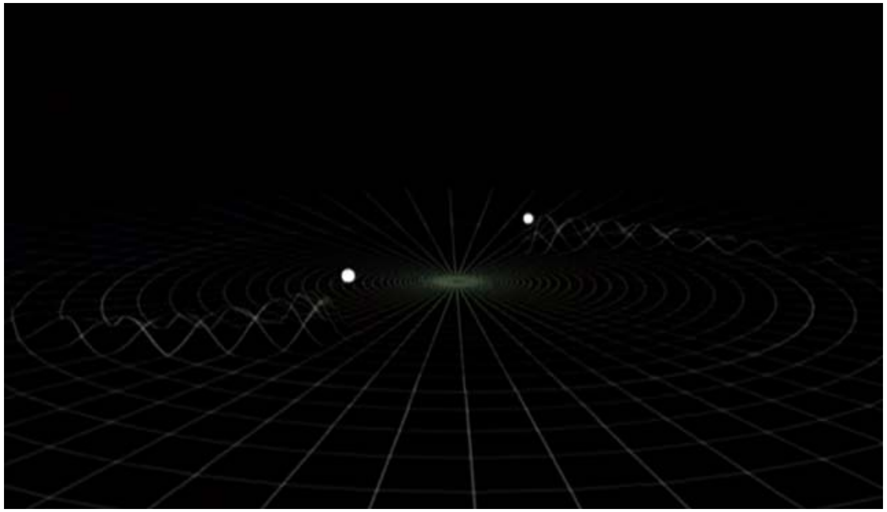
"Einstein's" gravitation

When masses move, they wrinkle the space time fabric, making other masses move…

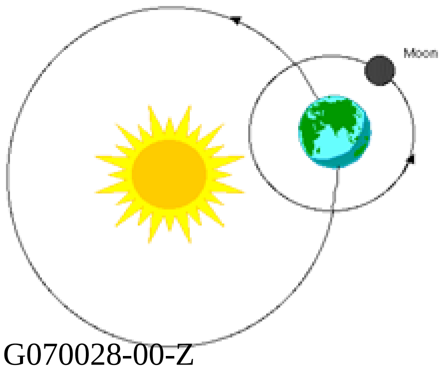


ckTime™ and a

Explains just as well why things fall and planetary motion…



Einstein's messengers,
National Science Foundation video



.. but it also predicts gravitational waves traveling away from moving masses!

From stars living in galaxies…

Where do gravitational waves come from?

From stars living in galaxies…

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

Supernova explosions

Where do gravitational waves come from?

Credits: Animation: NASA/CXC/D.Berry & A.Hobart

From stars living in galaxies…

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YUV420 codec decompressor
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Supernova explosions

Rotating stars (pulsars)

Where do gravitational waves come from?

Credit: NASA/CXC/ASU/J.Hester et al.

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Binary systems
(black holes, neutron stars)

Credit: John Rowe Animation/Australia Telescope National Facility, CSIRO

From stars living in galaxies…

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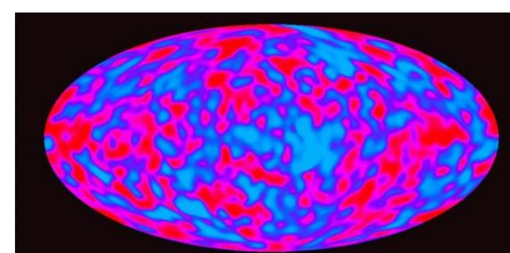
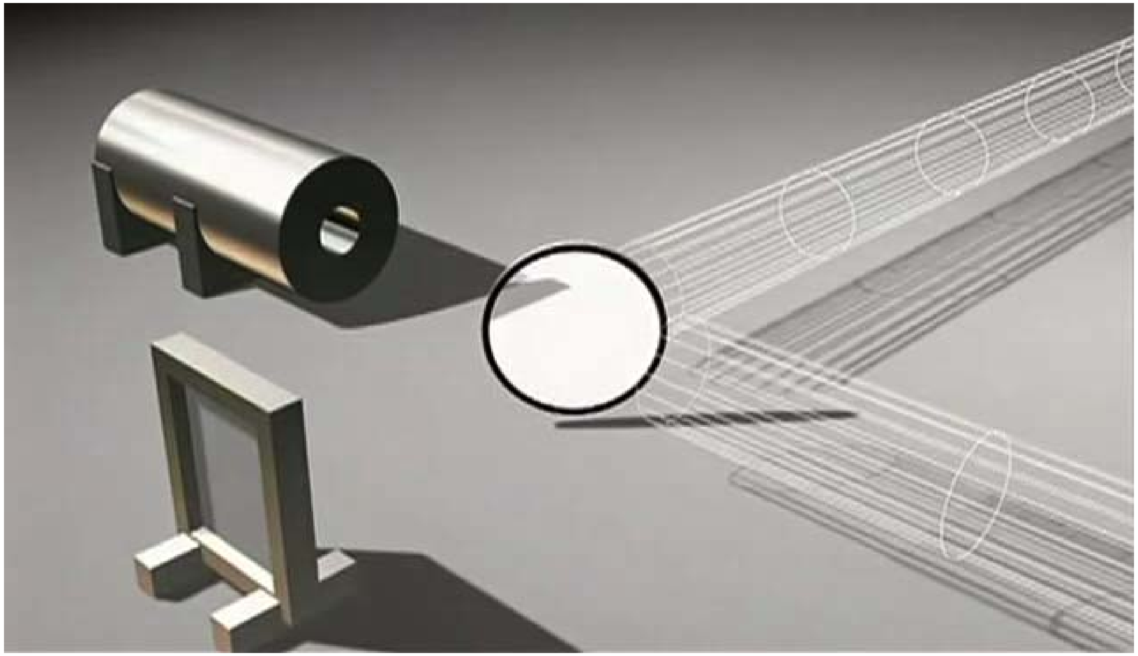
Binary systems
(black holes, neutron stars)

..and from the beginning of the Universe!



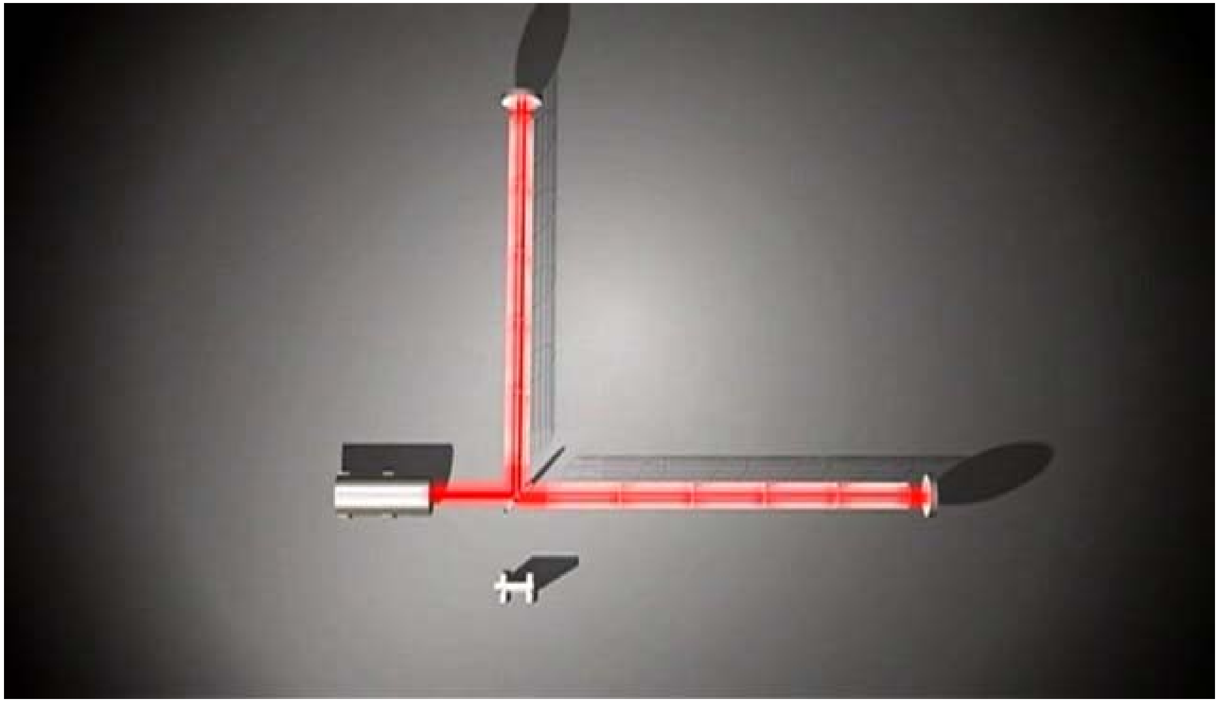
Credit: NASA/COBE

How to detect gravitational waves



Einstein's messengers,
National Science Foundation video

How to detect gravitational waves



Einstein's messengers,
National Science Foundation video

How to detect gravitational waves in Louisiana!

QuickTime™ and a
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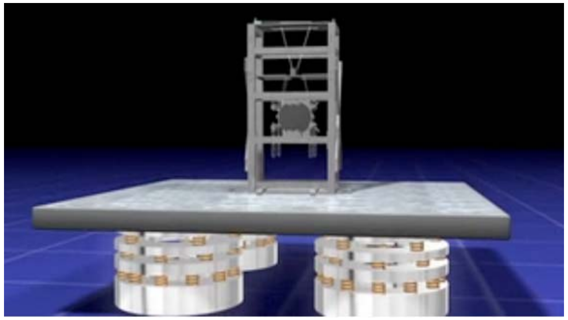
are needed to see this picture.

sciencebulletins.amnh.org

GW Detection: a difficult and fun experiment

QuickTime™ and a
Animation decompressor
are needed to see this picture.



QuickTime™ and a
Animation decompressor
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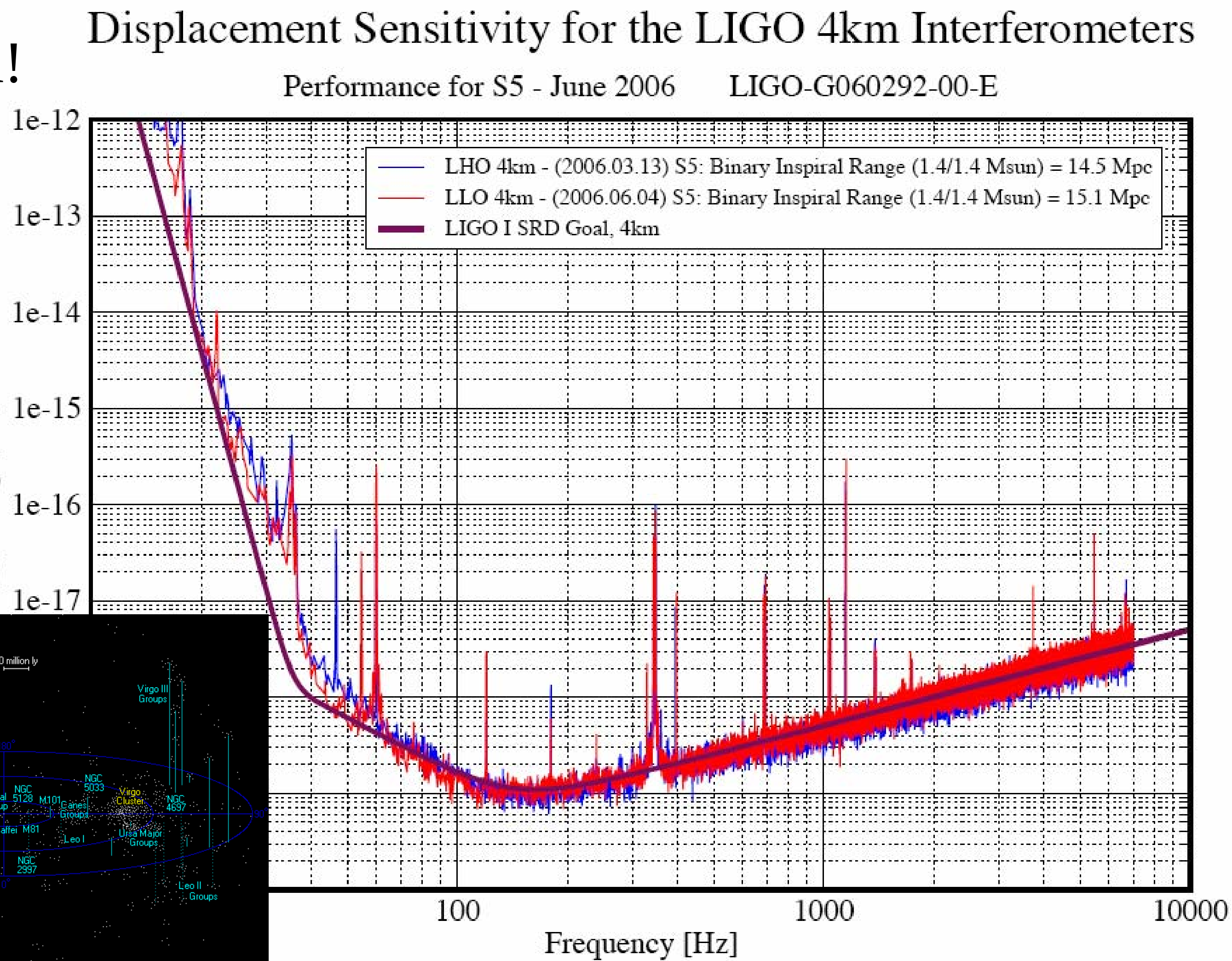
The LIGO project

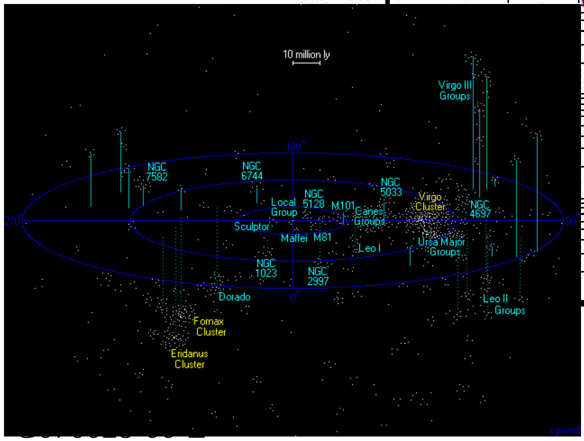
Hundreds of people working on the experiment and looking at the data: LIGO Scientific Collaboration

Current sensitivity

$x = L_x - L_y$

$L_{x,y} \sim 4$ km!



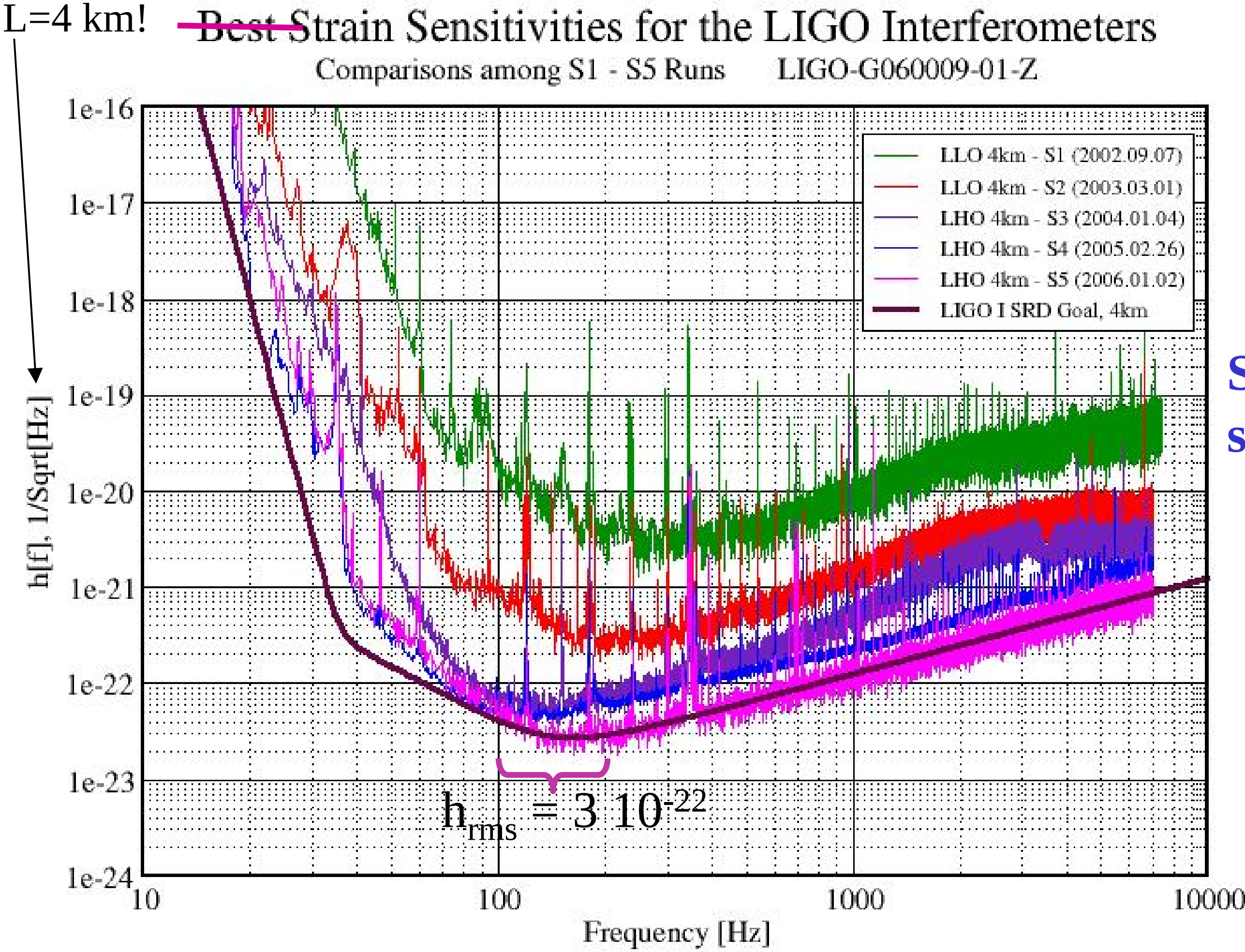


www.atlasoftheuniverse.com, Richard Powell

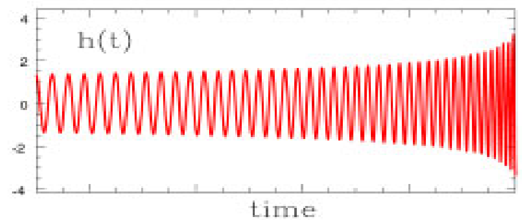
LIGO: Steady progress

x=ΔL/L

L=4 km!

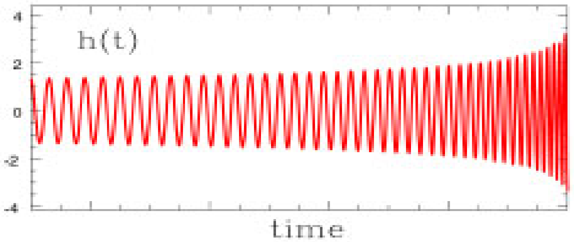


S5 started Nov 4, 2005, still ongoing!

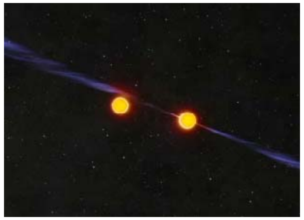


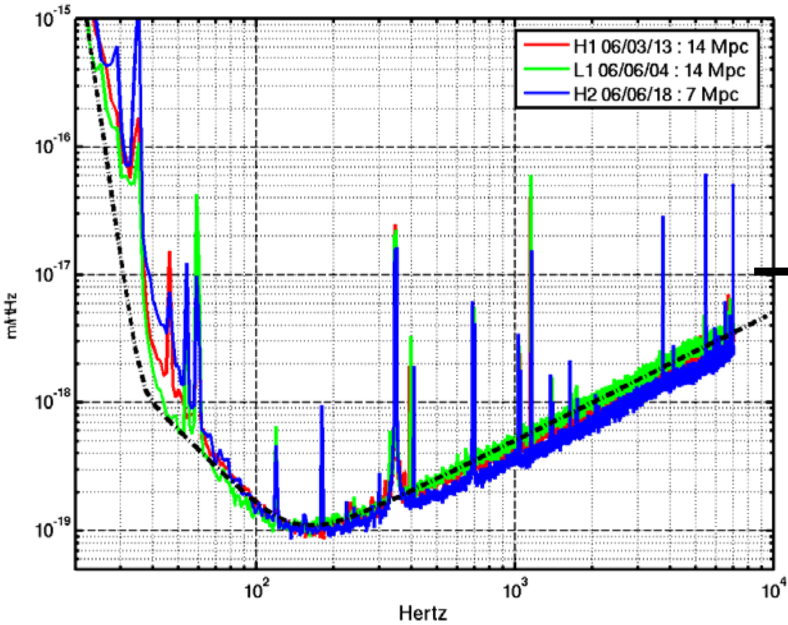
A binary neutron star system in the Virgo cluster (~15 Mpc away) produces GWs of amplitude $h \sim 10^{-21}$ on Earth, with freqs <1400 Hz.

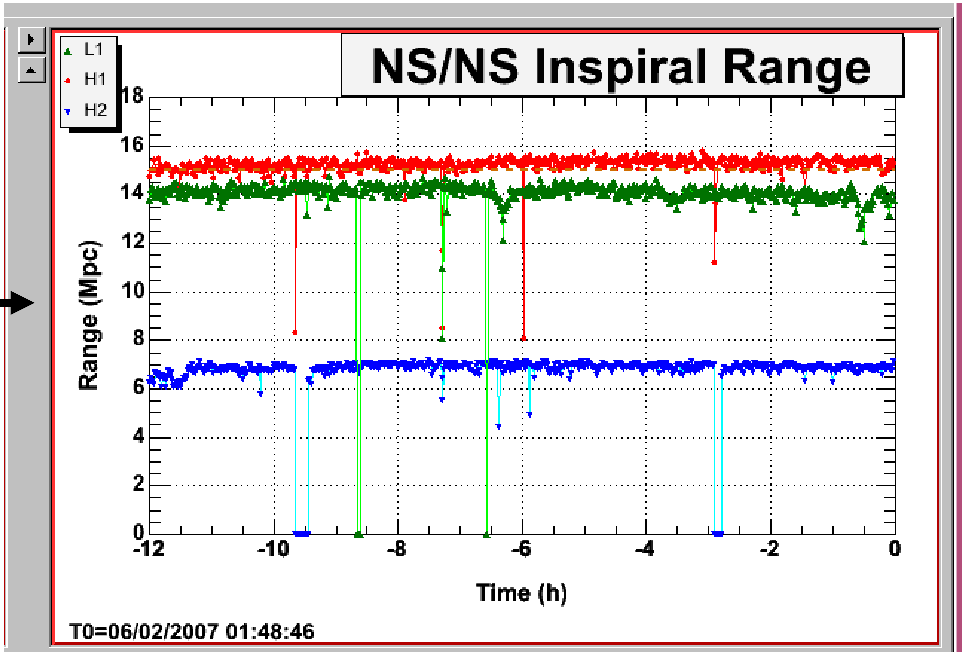
Looking for Binary systems



Can translate strain amplitude into (effective) distance







If system is optimally located and oriented, we can see even further: we are surveying <u>hundreds of galaxies</u>!

Electronic logs are public!
www.ligo.caltech.edu

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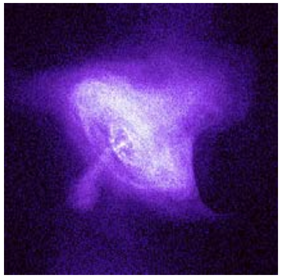
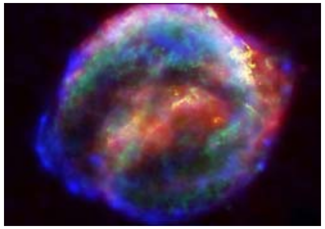
When will we see something?

Predictions are difficult… many unknowns!

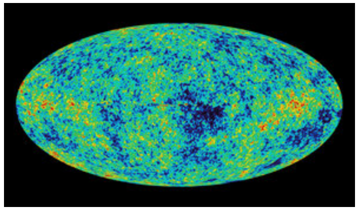
- Rotating stars: how lumpy are they?



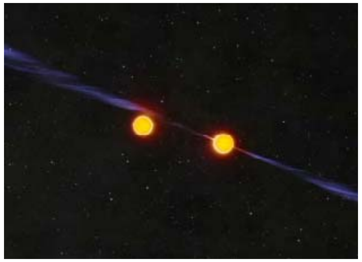
- Supernovae, gamma ray bursts:
  how strong are the waves
  (and what do they look like)?



- Cosmological background:
  how did the Universe evolve?



- Binary black holes: how many are there?
  What masses do they have?



- Binary neutron stars: from observed systems
  in our galaxy, predictions are up to 1/3yrs,
  but most likely one per 30 years,
  at LIGO’s present sensitivity.
- From rate of short GRBs, much more optimistic
  predictions for BNS and BBH rates? Ready to be tested with S5!

LIGO detectors: future

- **Neutron Star Binaries:**

  Initial LIGO: ~10-20 Mpc →

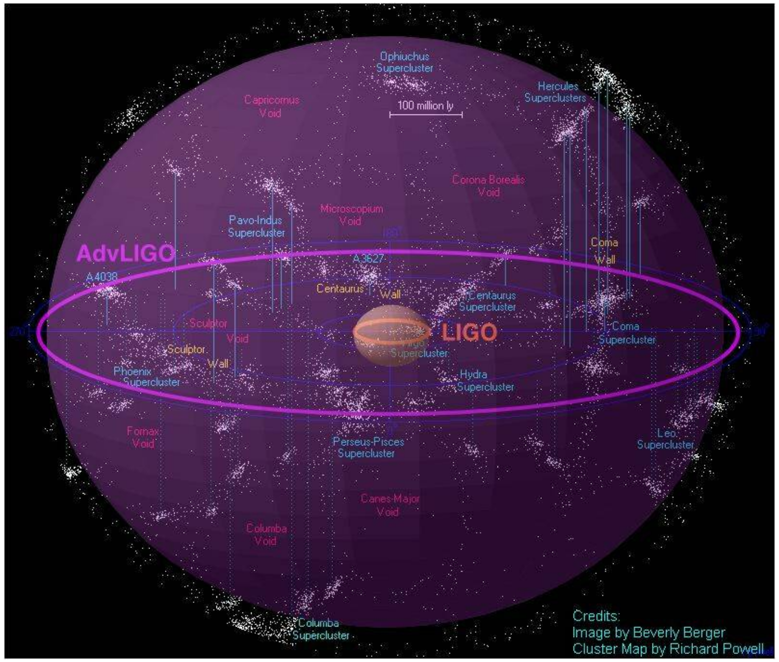
  Advanced LIGO: ~200-350 Mpc

  Most likely rate: 1 every 2 days !

- **Black hole Binaries:**

  Up to 30 M_o, at ~ 100 Mpc

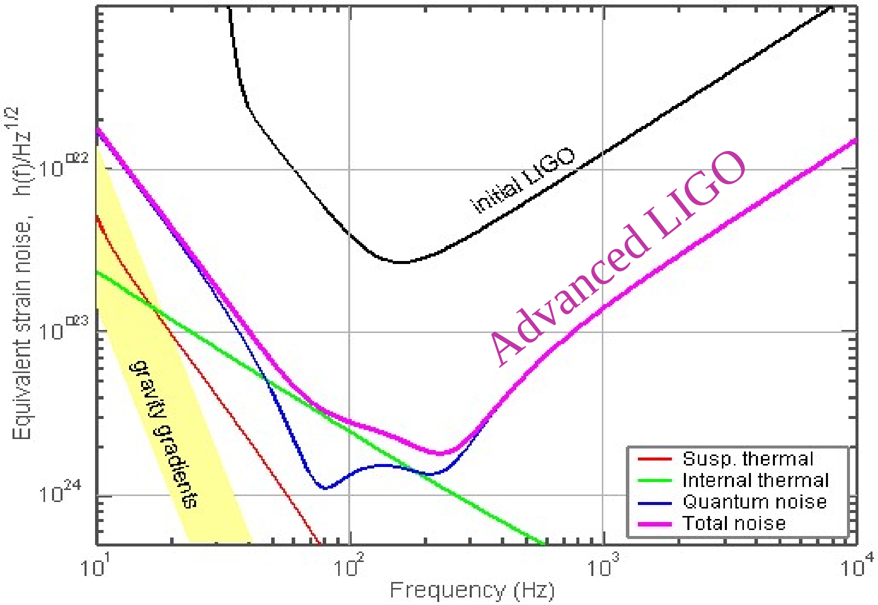
  → up to 50 M_o, in most of the observable Universe!



x10 better amplitude sensitivity

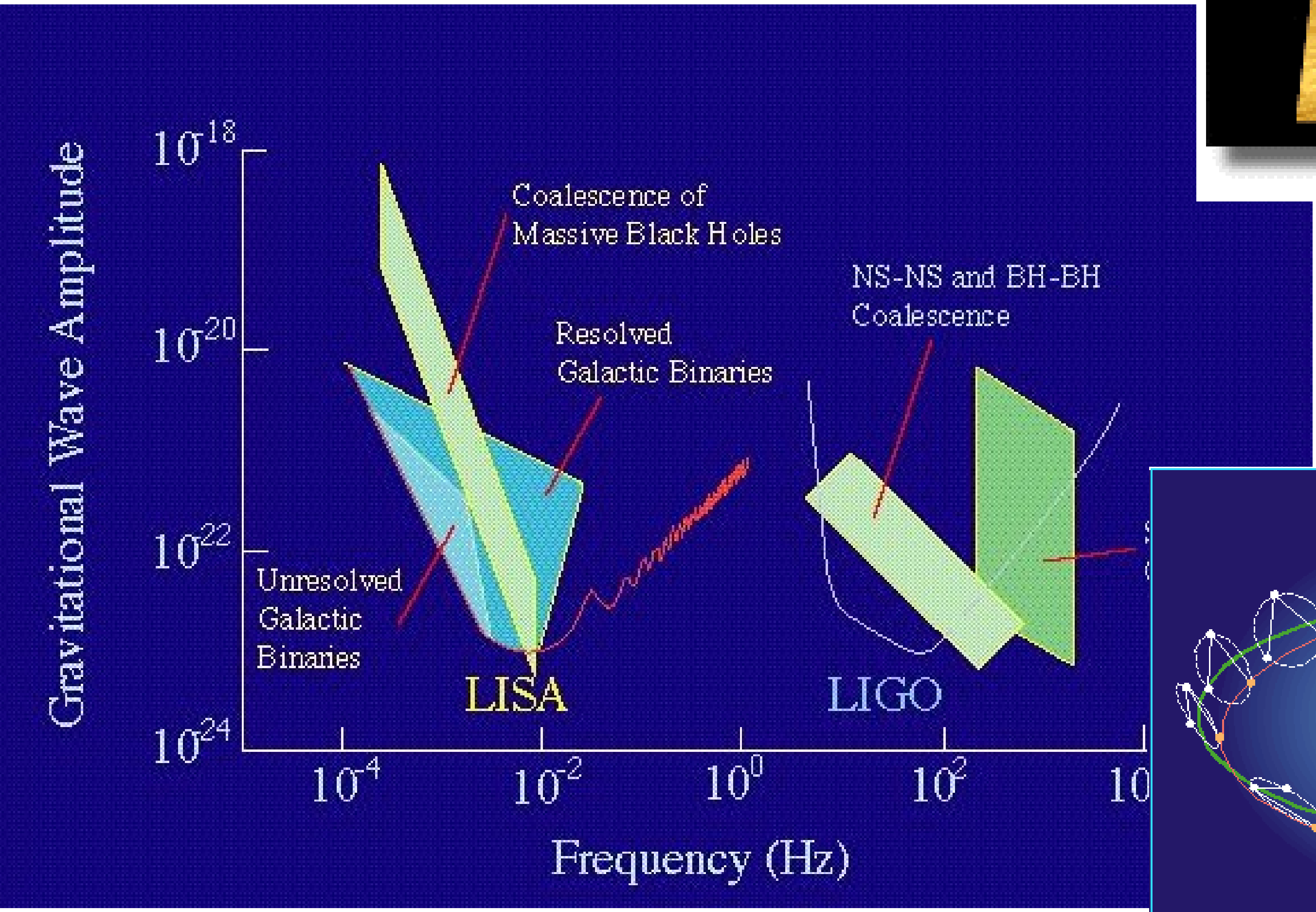
⇒ x1000 rate=(reach)^3

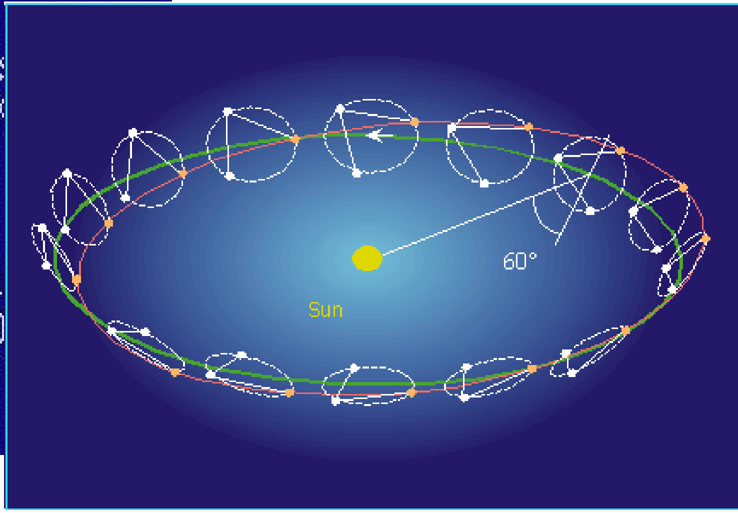
⇒ 1 year of Initial LIGO < 1 day of Advanced LIGO !



Planned NSF Funding in FY'08 budget (being discussed right now!).

Space interferometer: LISA





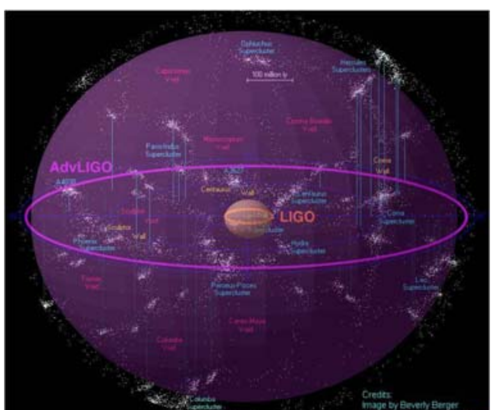
These are very exciting times!

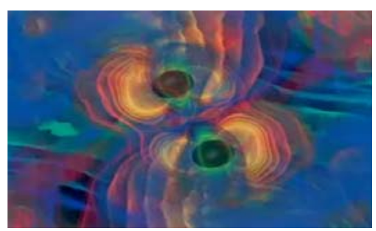
• We are taking data at unprecedented sensitivity, and we are searching for gravitational waves.

• We are getting ready for Advanced LIGO.

• We are preparing ourselves for a direct observation of gravitational waves: *not if, but when!*

• LIGO detectors and their siblings will open a new window to the Universe: what's out there? **Join us to find out!**





www.ligo.caltech.edu

www.ligo.org