CITA | ICAT

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L'institut Canadien d'astrophysique théorique

Jamboree 2015

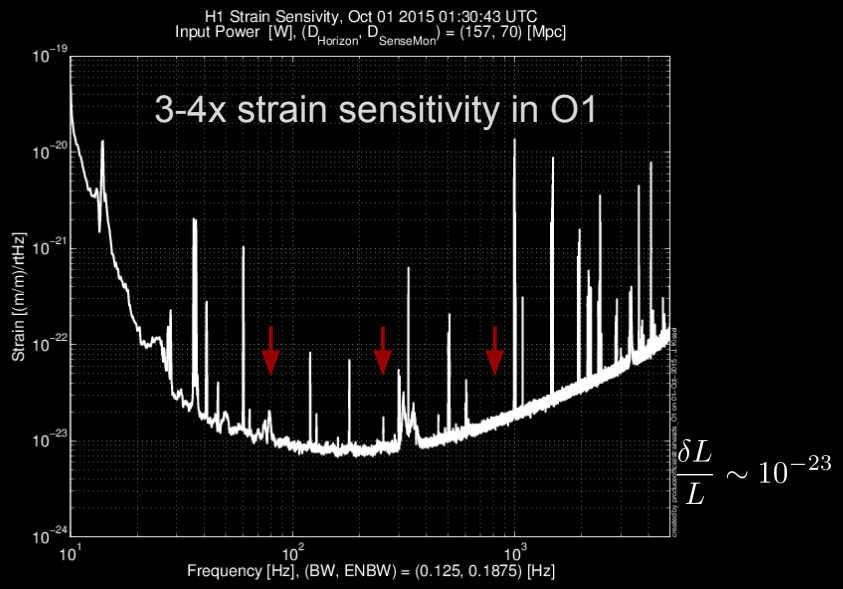
General Relativity

Gravitational-waves & Binary black holes : Advanced LIGO

Prayush Kumar

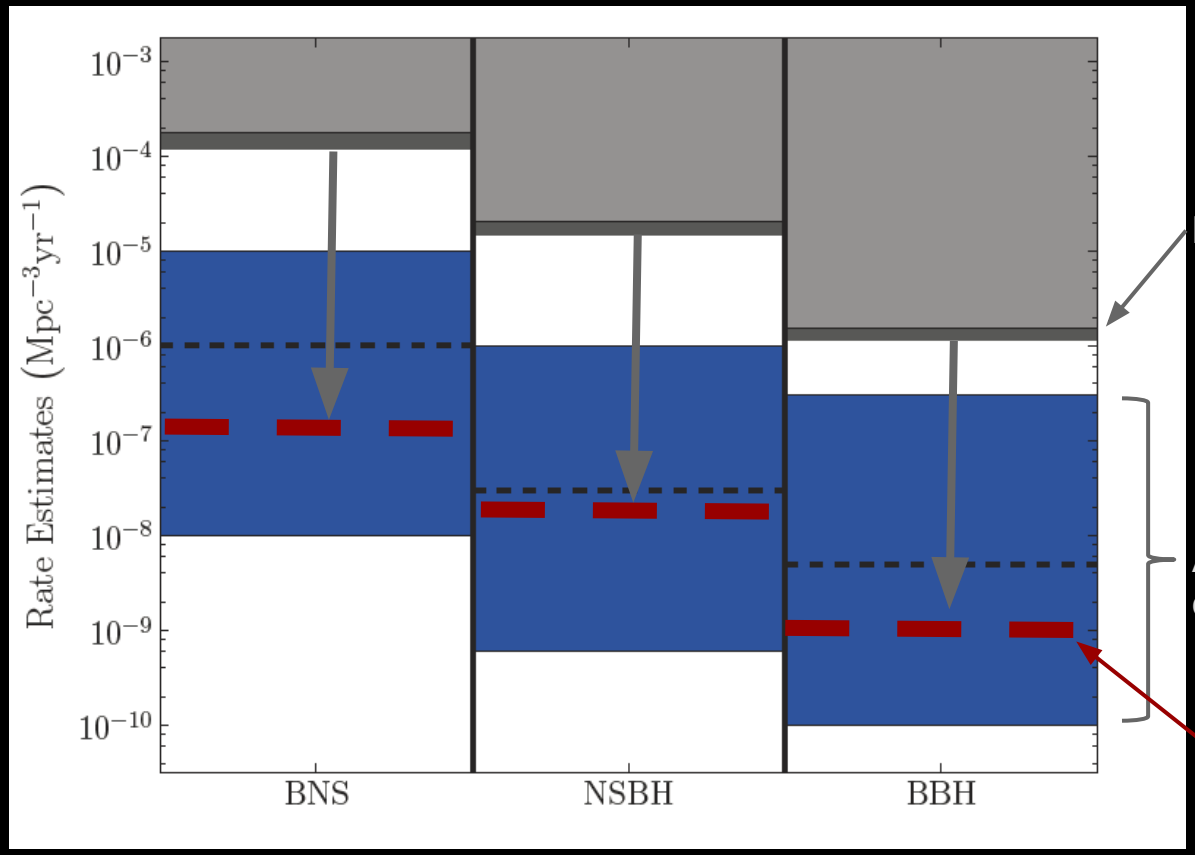
Gravitational waves : Detection

- Any matter distribution with changing quadrupole moment emits gravitational-waves.
- GWs couple very weakly with matter. Therefore we look for GWs emitted by astrophysical sources.
- Binary systems of compact objects, like black-holes and neutron-stars emit in 10-1000Hz band.
- Advanced LIGO detectors now taking data in “O1” ! Will reach their design sensitivity by 2018-19.



Images : http://www.ligo.org https://www.advancedligo.mit.edu

Detections of GWs from Compact-Object binaries: How likely?



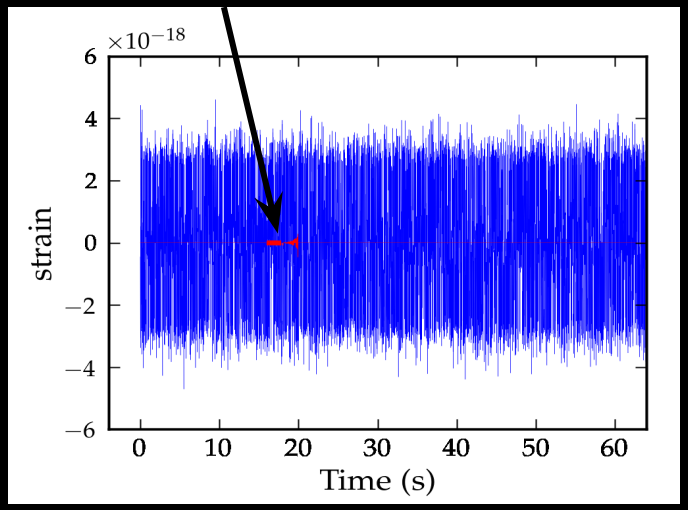
Binary Black-holes : 0.4 - 1000 per year (at design sensitivity) *

Image : Abadie et al (2012) [LVC]

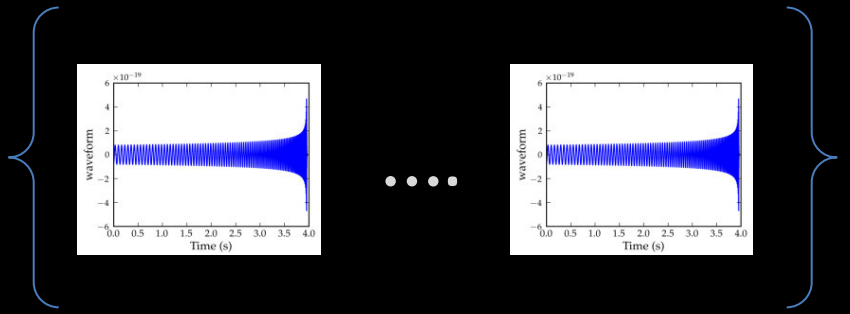
* Abadie et al (2010) [LVC]

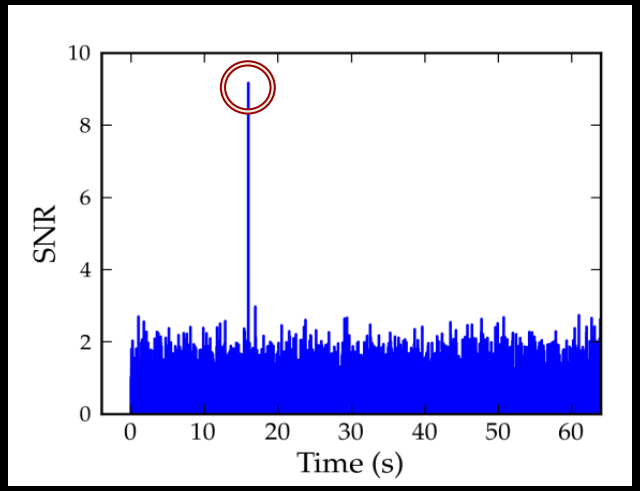
Finding signals in instrument noise

Signal embedded in strain data



Model waveforms as filter templates





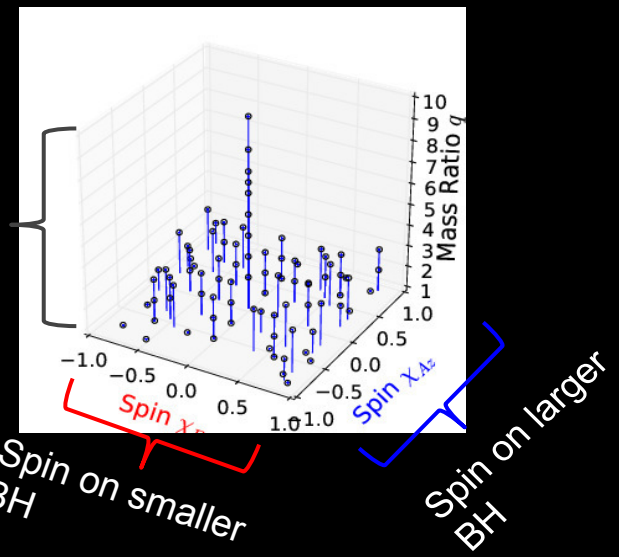
Sensitivity of searches depend on accurate template banks!

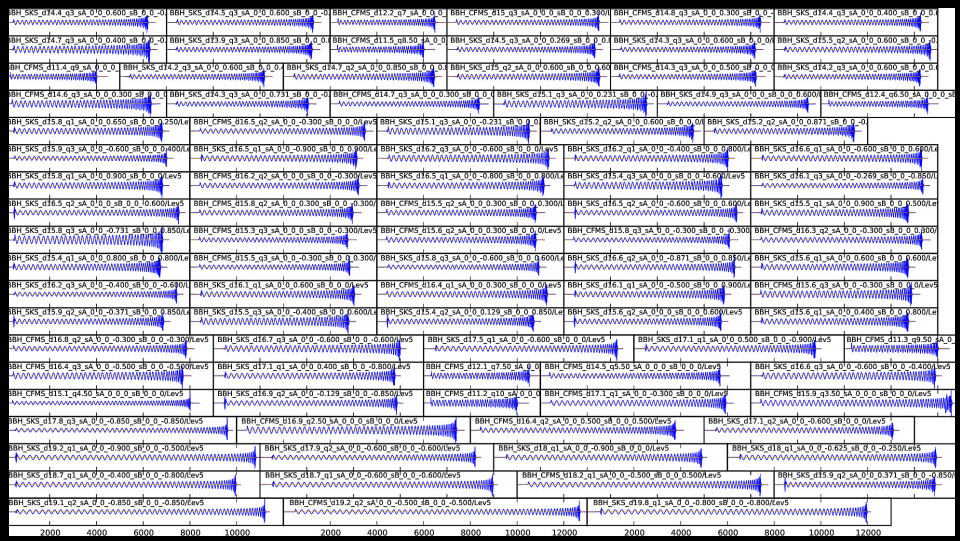
What we do

We simulate the coalescence of binary black-holes using Numerical Relativity.

These simulations are used to optimize detection searches in many ways, e.g.

- **To test and develop *<u>better waveform models</u>* for searches & parameter estimation [1],**
- **Can be directly used as *<u>search templates</u>* [2],**
- **To *<u>test search pipelines</u>* by injecting NR waveforms and to assess their efficiency [3]**
- **...**





Images: Chu et al (2015, in prep) ; Kumar et al (2015, in prep)

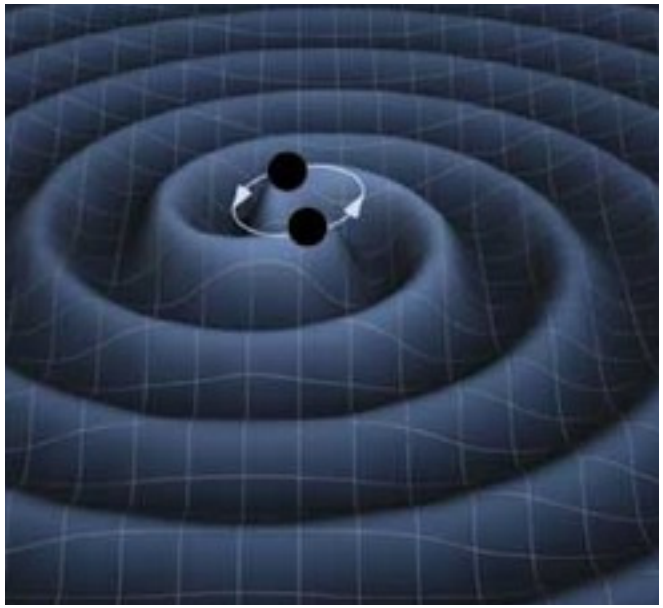
[1] Taracchini et al (2014); Kumar et al (2015)
[2] Kumar et al (2014)
[3] NInjA-2 project : Aasi et al (2014) [LVC]

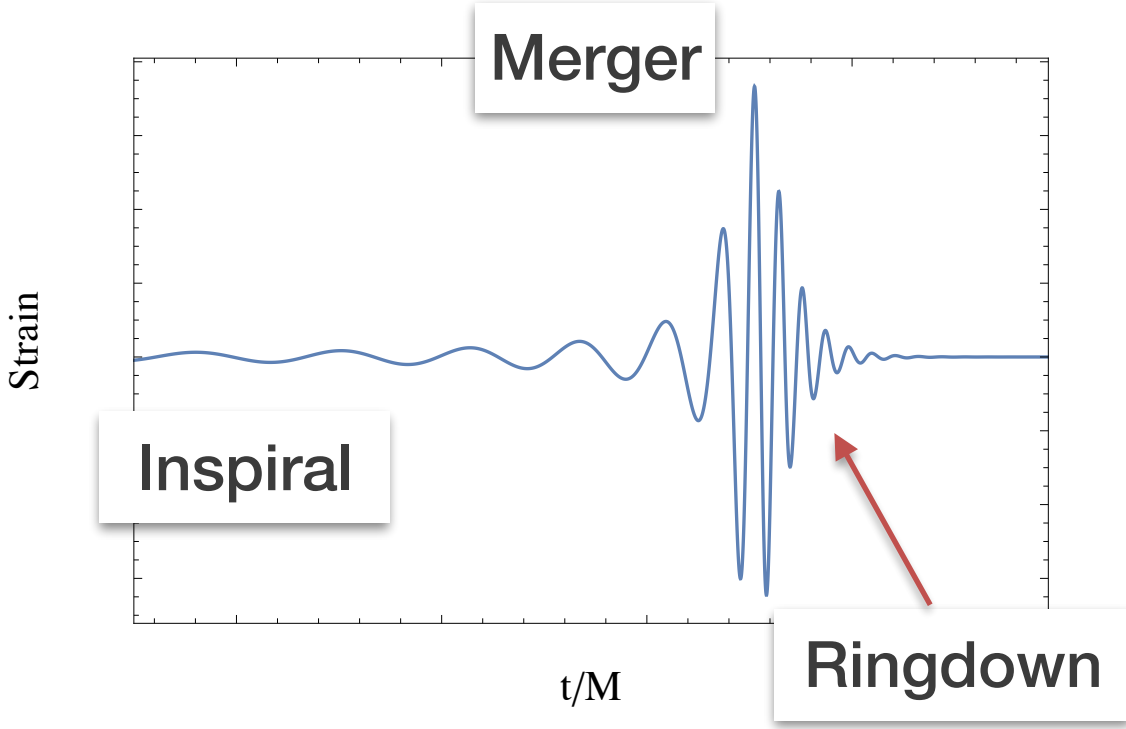
Perturbation theory and black holes

Aaron Zimmerman

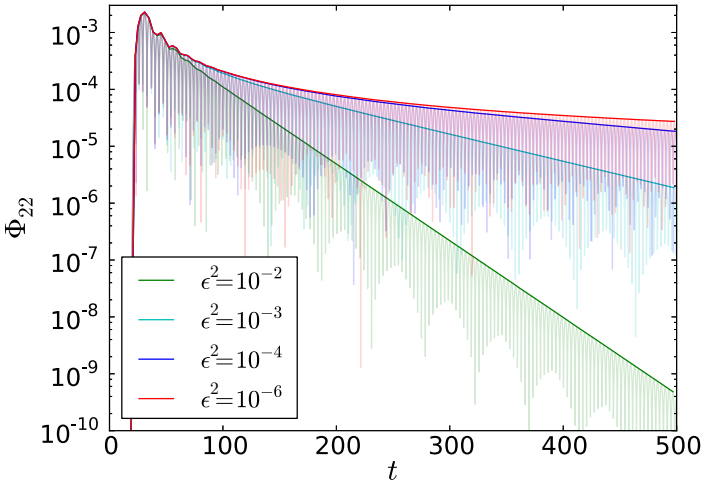
October 7, 2015

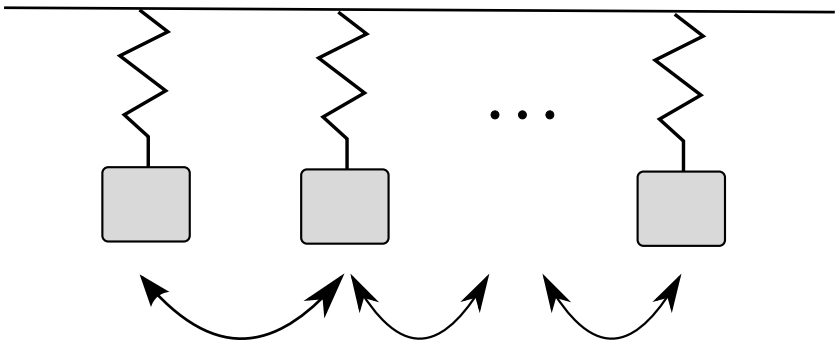
Oscillations of black holes



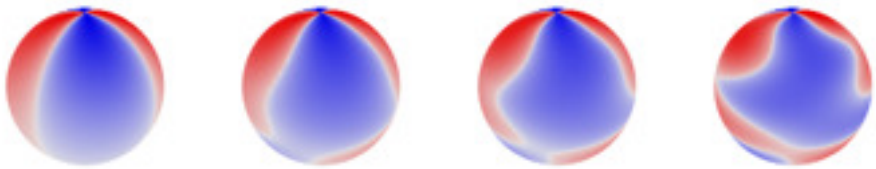


Oscillations of black holes

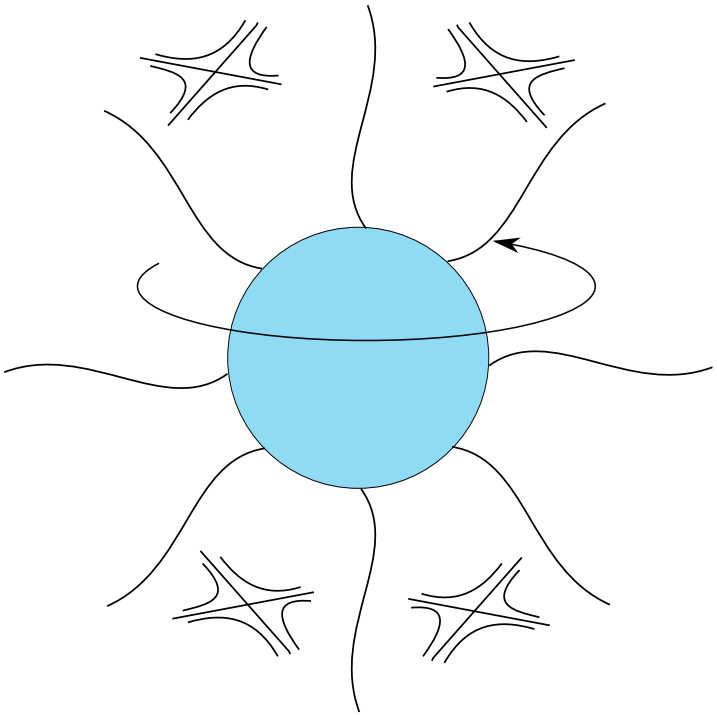


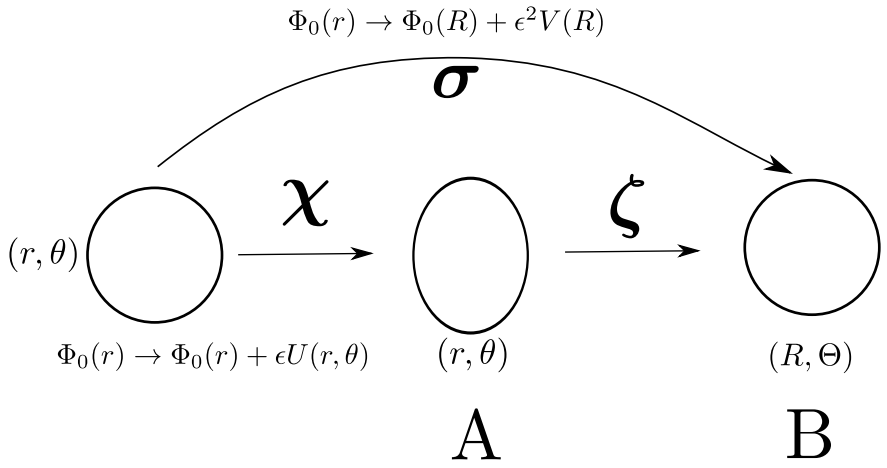


$$a = 1 - \epsilon^2 \quad \Rightarrow \quad \omega \sim \frac{m}{2}$$
$$\gamma \sim \epsilon$$



Oscillations of black holes and neutron stars





Extreme mass ratio inspirals