

Gravitational waves from compact binary mergers



Antoni Ramos-Buades and Maria Haney

MSc and BSc students: Suzanne Lexmond, Jord Muffels, Amin Rouan Serik, Pieter Oehlers

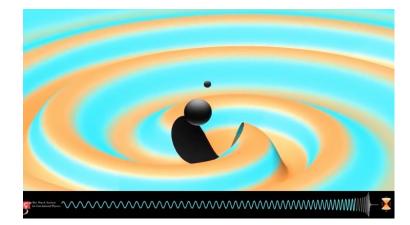




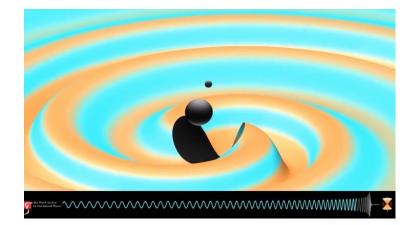
Gravitational waves group Nikhef Amsterdam



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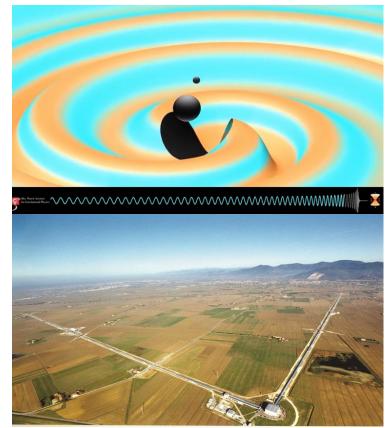


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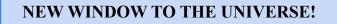
Credit: SXS and Virgo Collaborations

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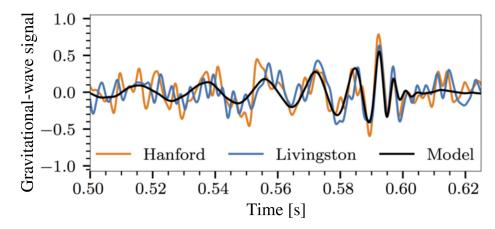
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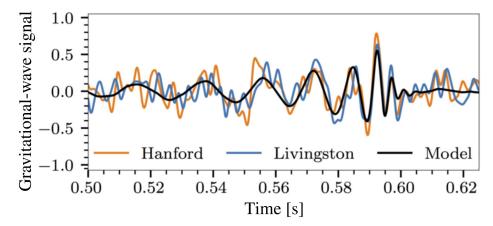
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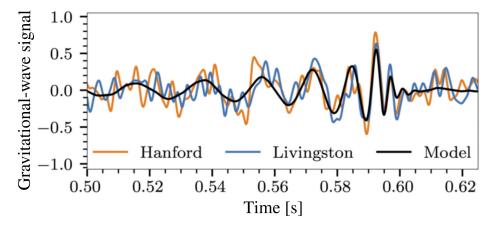
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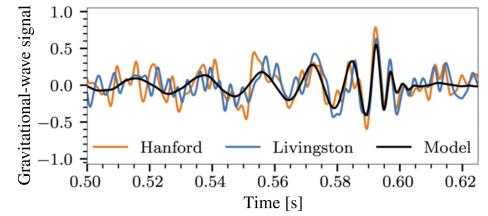
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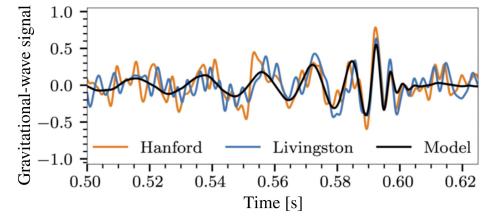
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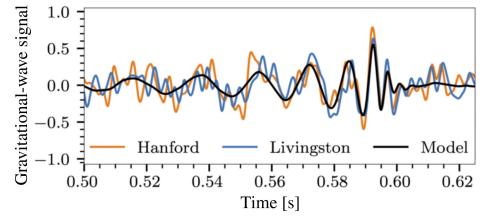
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- **Detection** of gravitational waves
- Estimate source properties: masses, spins, ...



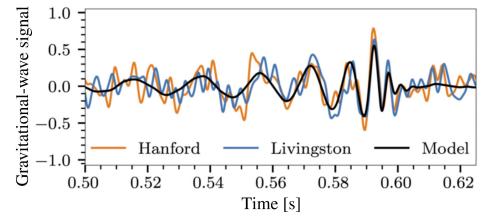
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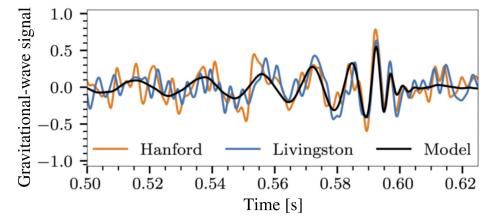
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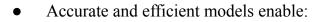


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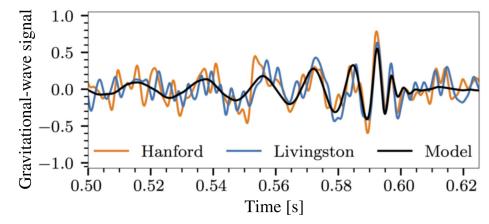
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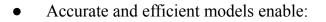


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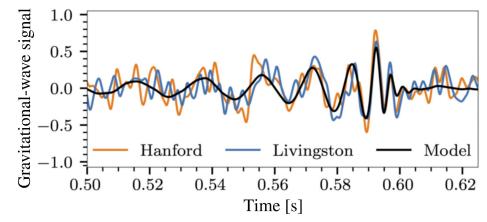
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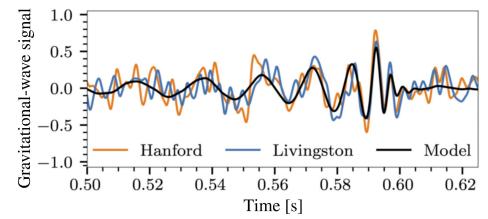
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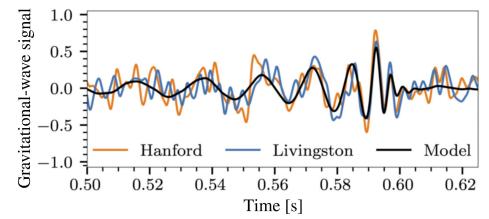
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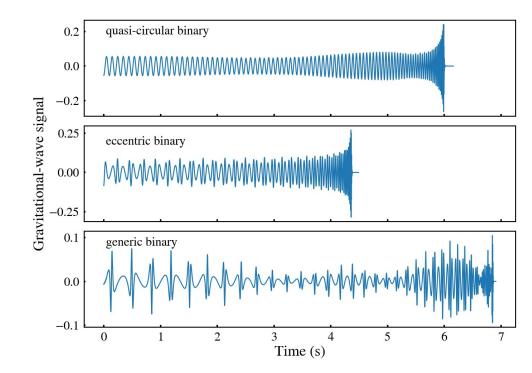
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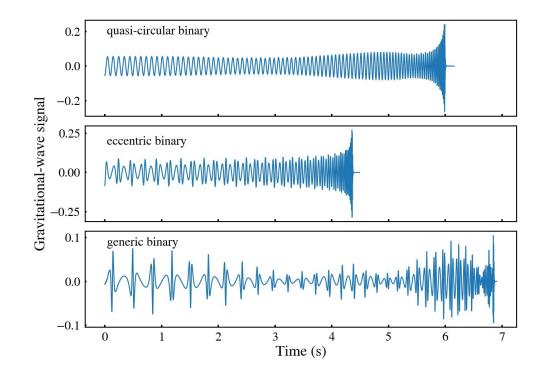
Fundamental physics

A more complete understanding of the Universe!

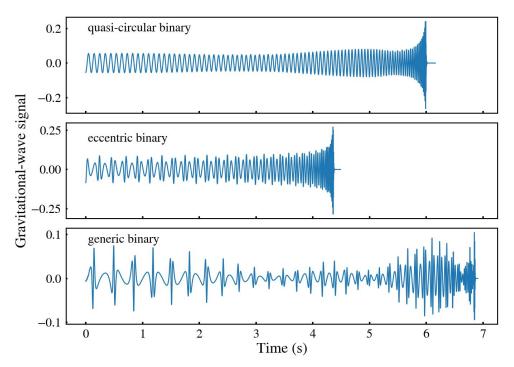
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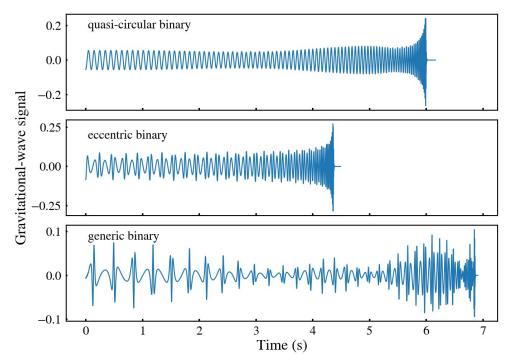
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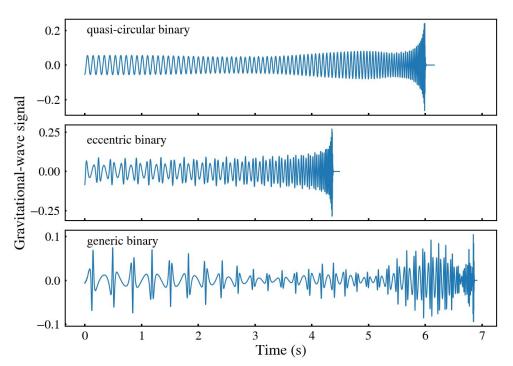


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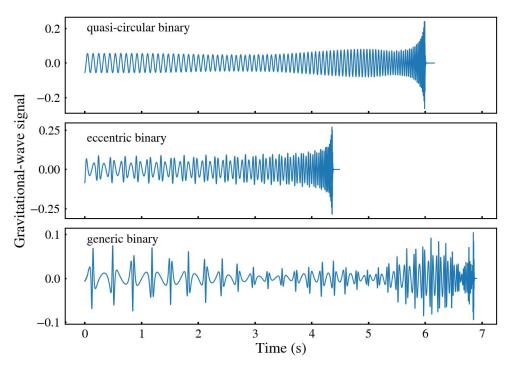
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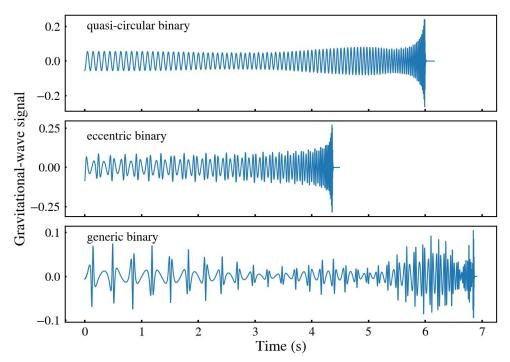
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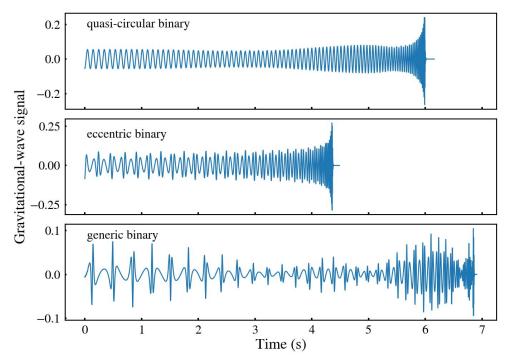
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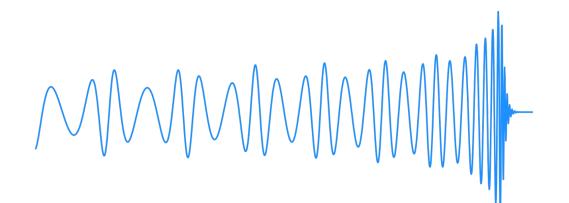
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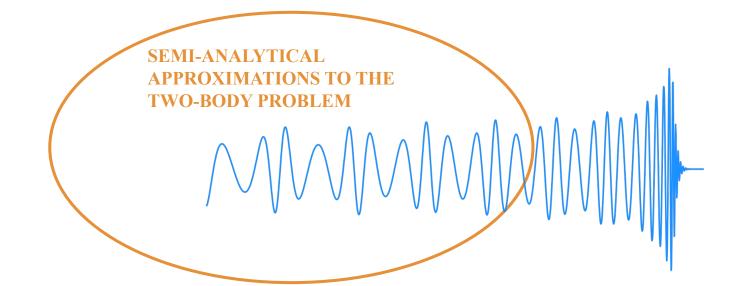


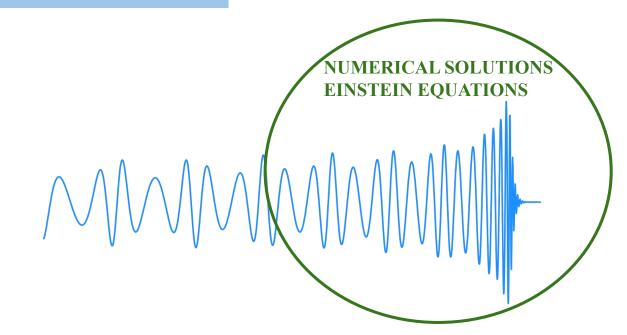
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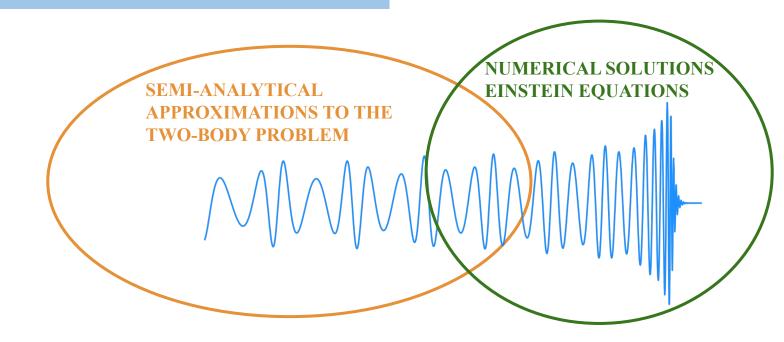
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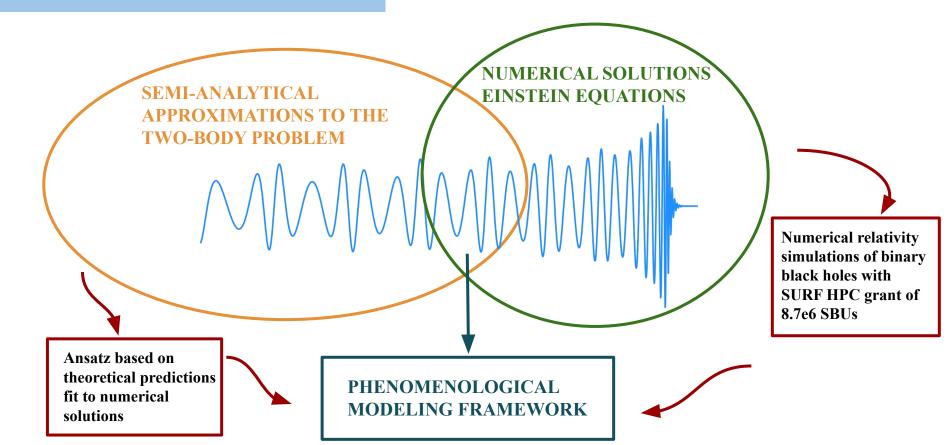












RESEARCH PROJECT

Waveform model development

Efficient and accurate model for gravitational waves (GWs) from **generic binary black holes** (BBHs)

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Algorithms to detect, estimate parameters and test General

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Observational results on open detector data

- Search for generic BBHs
- Measure eccentricity of binaries (origin)
- Test General Relativity

GRAVITATIONAL WAVE MERGER DETECTIONS

| OBSERVING RUN ———————————————————————————————————— | | | | \longrightarrow SINCE 2015 |
|--|---|--|--|--|
| 01 2015-2016 | 02 2016-2017 | | | 03a+b 2019-2020 |
| 36 31 23 14 14 14 56 56 56 56 56 56 56 56 56 56 56 56 56 | • • | а 34 35 24 31 25 80 56 53 60/170809 60/170814 | 1.5 1.3 35 27 40 <2.8 60 GW170817 GW170818 GW | 29 55 55 105 6W190403 6W190408 |
| | 2 41 32 2 1.4 107 70 3.2 0 1.4 107 50/190421 00/199425 00/1 | • • • • • • • • • • • • • • • • • • • | * * * * * * * * * * * * * * * * * * * | 25 59 101 54 59 59 101 156 69 156 69 156 69 156 69 156 69 156 |
| | 8 57 36 35 24 54 87 56 6W196420 6W196438 6W | 41 67 38 12 84 90 99 99 199701 6W199706 6W190707 | 18 13 37 21 13 30 55 GW190708 GW190719 GW | 7.8 12 6.4 38 29 20 17 6.4 99720 0W190725 0W190727 |
| | 76 26 5 | 26 24 10 44 36 55 33 76 09828 CW19828 CW190910 | | 2.1 8.9 5 21 16 11 13 35 19917 CW19972A CW199725 |
| | 6 12 7.9 11 7.7 65 19 18 18 GW191103 GW191105 GW1 | 47 29 5.9 12 83 107 34 20 191169 6W191113 6W191126 | | 19 12 8.2 25 18 45 19 41 91204 GW191204 GW191215 |
| 12 7.7 31 1.2 45 19 32 76 GW191216 GW191219 GW191225 | 5 49 37 9 1.9 36 82 11 ownsist290 pw259105 own | 28 5.9 1.4 42 33 61 7.2 71 200112 GW2200115 GW2200128 | 34 29 10 7.3 38 60 17 6w280129 6w280202 6w2 | 27 51 12 36 27 53 61 60 50206 60 60 60 |
| 27 78 62 GW200210 GW200216 GW202021 | | 33 19 14 38 20 69 32 56 200224 ewzeezes ewzeezes | 42 47 | 28 13 7.8 34 14 59 20 53 50311 600200316 600200322 |
| KEY | | Note that the mass estimates shown here | to not include uscattalizing | |
| BLACK HOLE PRIMARY MASS FINAL MASS SUM157215 | VEUTRON STAR UNITS ARE SOLI UNITS ARE SOLI SECONDARY MASS 1 SOLAR MASS = 1 DATE | AR MASSES which is why the final mass is sometime primary and secondary masses. In actual than the primary plus the secondary mass | I larger than the sum of the ity, the final mass is smaller a. Seeholds for debection. Straphysical of at least 59%, | MIRGO |



Short term



Short term **Origin of binary black holes**



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Fundamental physics

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Maximize science output of GW experiments

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Long term

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Data analysis techniques for upcoming observing runs of LIGO-Virgo-KAGRA

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Modular pipeline for the broader community

| Short term | Origin of binary black holes | The Gravitational Wave Spectrum | | |
|------------|--|---|--|--|
| | Fundamental physics | Binary Supermassive Black Holes in galactic nuclei | | |
| | Maximize science output of GW experiments | Compact Binaries in our Galaxy & beyond Compact objects | | |
| | | wave period age of universe years hours sec ms | | |
| Long term | Data analysis techniques for upcoming observing runs of LIGO-Virgo-KAGRA | log(frequency) -16 -14 -12 -10 -8 -6 -4 -2 0 +2 Cosmic microwave Pulsar Timing Space Terrestrial background interferometers | | |
| | Modular pipeline for the broader community | background polarization | | |
| | Eccentric binaries → Science case of Einstein Telescope, LISA, | Credit: NASA Goddard Space Flight Center | | |

Rotating NS, Supernovae

Terrestrial interferometers