Machine Learning in Cosmological and Gravitational Waves parameter estimation

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Fundamental physics and gravitational wave detectors

Pollica Physics Center, September 2024

Looking for Strongly Lensed Gravitational Waves

In collaboration with:

Jose Maria Ezquiaga (Niels Bohr Institute)

Wayne Hu (University of Chicago)

Marco Raveri (University of Genova)

We do not *see* GW lensing…

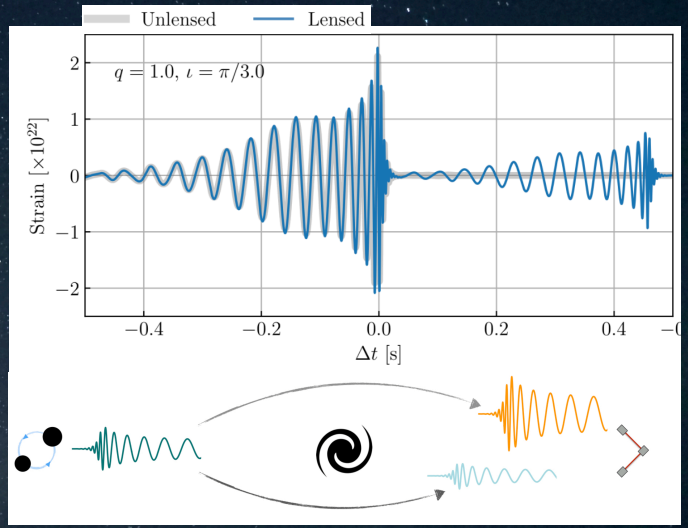
The "Twin Quasar" Q0957+561 (Walsh et al, 1979, HST).

multiple *images*

We do not *see* GW lensing…we *hear* it!

The "Twin Quasar" Q0957+561 (Walsh et al, 1979, HST).

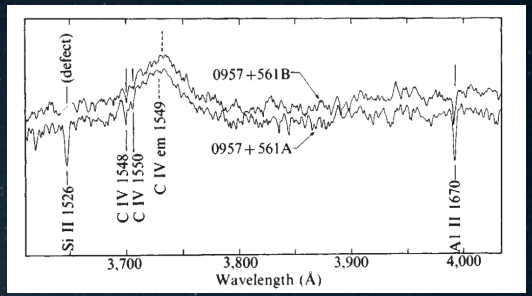
multiple *images*



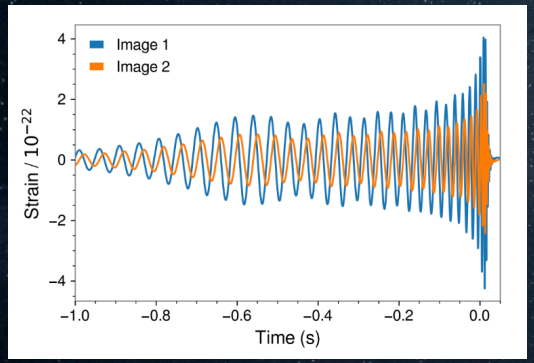
multiple *chirps*

On the right: Phase effects from strong gravitational lensing of gravitational waves, J. M. Ezquiaga, D. E. Holz, W. Hu, M. Lagos and R. M. Wald, arXiv: 2008.12814

How can we distinguish?



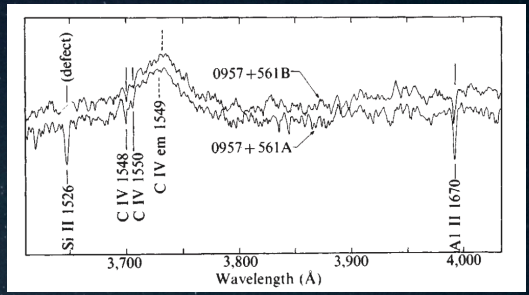
Spectroscopy



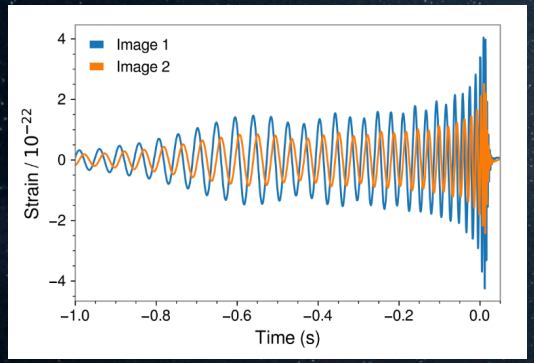
?

Top right: 0957+561 A, B: twin quasistellar objects or gravitational lens?, Walsh, D.; Carswell, R. F.; Weymann, R. J., Nature, Vol. 279, p. 381-384 (1979)

How can we distinguish?



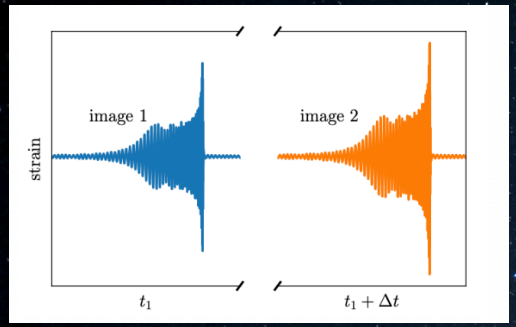
Spectroscopy



GW parameters!

Top right: 0957+561 A, B: twin quasistellar objects or gravitational lens?, Walsh, D.; Carswell, R. F.; Weymann, R. J., Nature, Vol. 279, p. 381-384 (1979)

Strongly lensed GW: *almost* twins



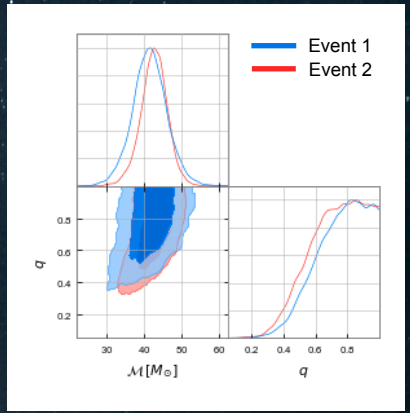
Follow-up Analyses to the O3 LIGO-Virgo-KAGRA Lensing Searches [arXiv:2306.03827].

Data compression

Time delay and magnification

Morse phase shift

Compatibility of instrinsic parameters



Paper in prep.

Giulia Campailla

Testing SL hypothesis in parameter space

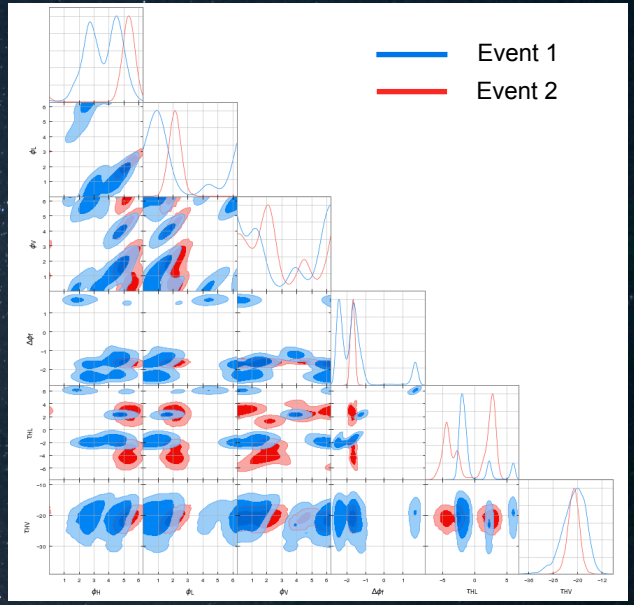
Identifying strongly lensed gravitational waves through their phase consistency, J. M. Ezquiaga, W. Hu and Rico K. L. Lo, arXiv: 2308.06616

- High dimensional space

  more details about parameters bases in Jose's and Wayne's talks!

- Non-Gaussianities

- Multimodality



Paper in prep.

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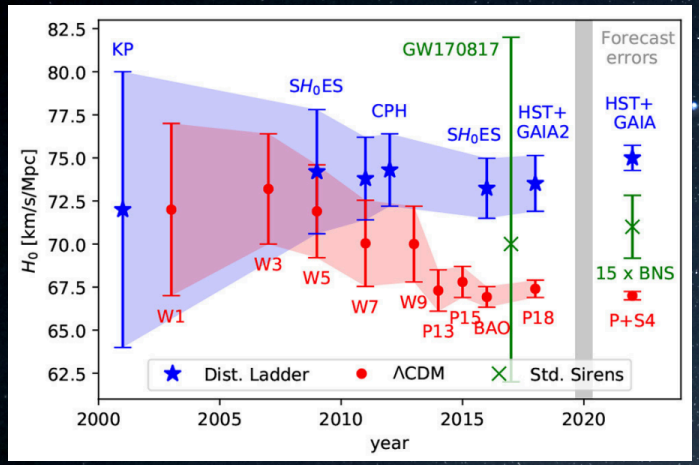
"*Tension*" between GW couples



The Hubble tension: measurements of H_0 in the local universe (in blue), derived values of H_0 from the CMB assuming ΛCDM (in red), direct measurements of H_0 with standard sirens following GW170817 (in green).

We compute 'distances' in parameters from two GW events (Machine learning!)

→

Small tension = high SL probability!

Top left: Dark Energy in Light of Multi-Messenger Gravitational-Wave Astronomy; J.M. Ezquiaga and M. Zumalacárregui; Front. Astron. Space Sci. 5:44. (2018)

Machine Learning for tensions and joint analyses in DES

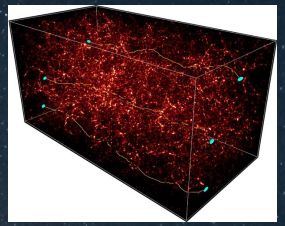
Main collaborators:

Marco Raveri; Marco Gatti (University of Chicago)

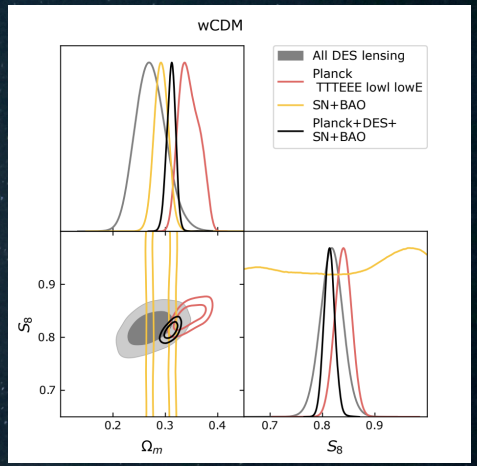
Weak lensing probes

mass mapping non- Gaussian statistics

simulation-based inference



Comparison between WL measurements and external data, combined constraints on cosmological parameters



Y6 release coming soon!

Gatti, Campailla, Jeffrey + [arXiv:2405.10881v1]

Thank you!