The cautious tale of GW200129

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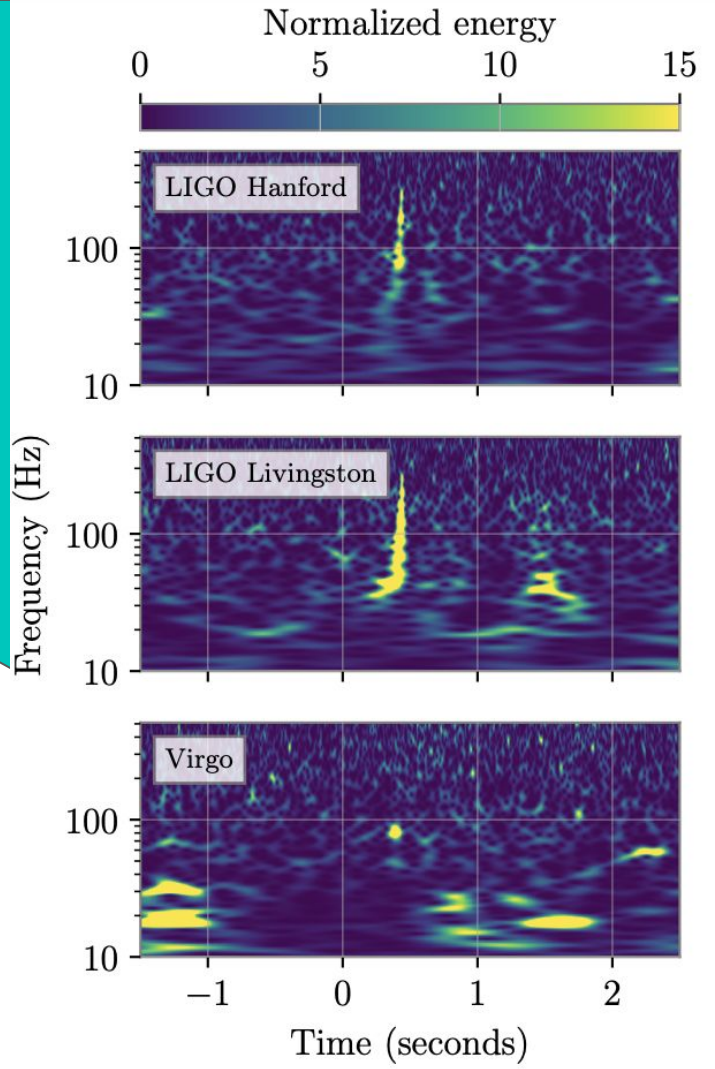
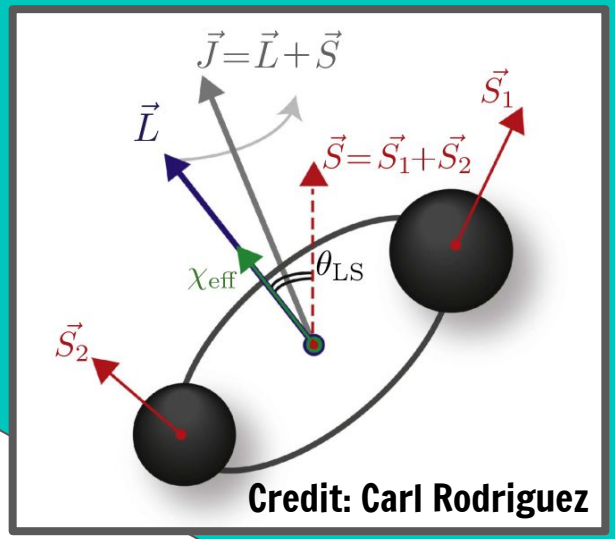
Caltech

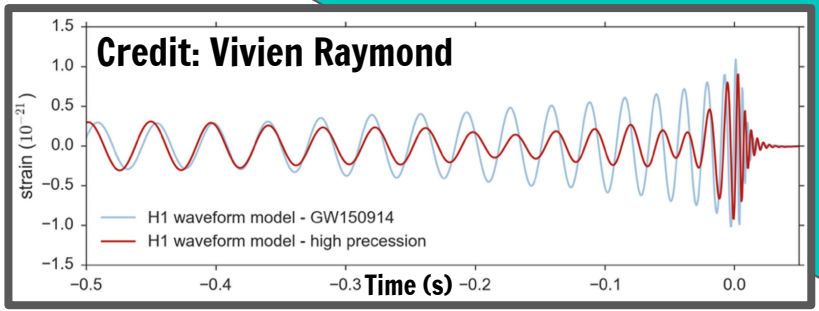


Spin-precession in binary black-hole mergers

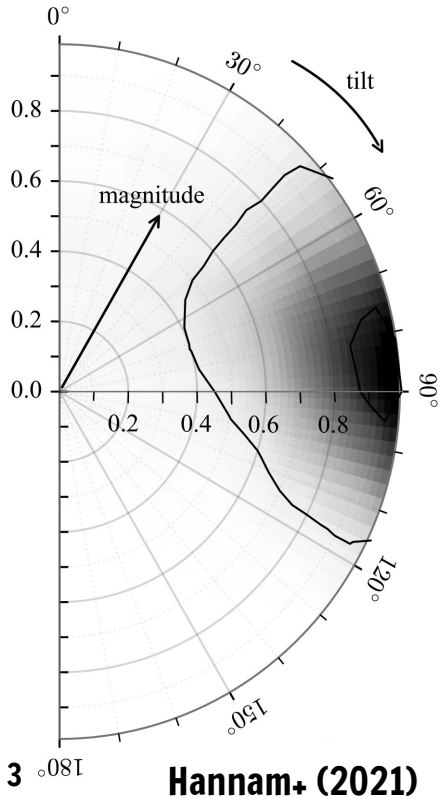
- Coupling between mis-aligned spins and orbital momentum lead to precession
- Precession modulates the amplitude of the gravitational-wave radiation
- Quantify spin effects with projections of individual black hole spins:
  - Effective spin parameter, χ_{eff}
  - Precession parameter, χ_p



Credit: Carl Rodriguez



GW200129: observation of precession



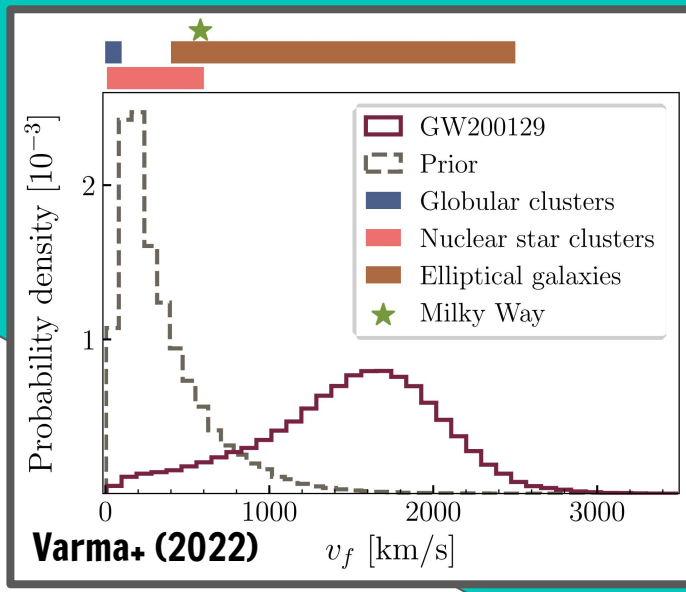
Hannam+ (2021)

Loudest event in LIGO-Virgo's third observing run: SNR ~ 26

Precession reported in Abbott *et al.* (2021): waveform dependent

Hannam *et al.* (2021) claim detection of precession using improved waveform models

Large mis-aligned spins → Large gravitational recoil velocity



Varma+ (2022)

Data quality issues: glitches!

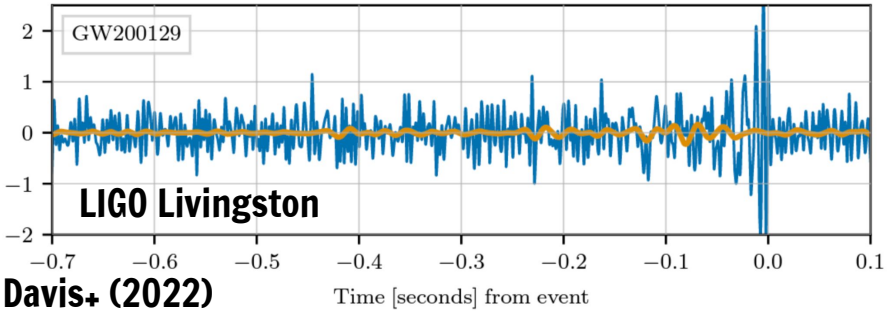
No glitch mitigation in LIGO Hanford or Virgo

- Scattering arches in Virgo - not coincident with event

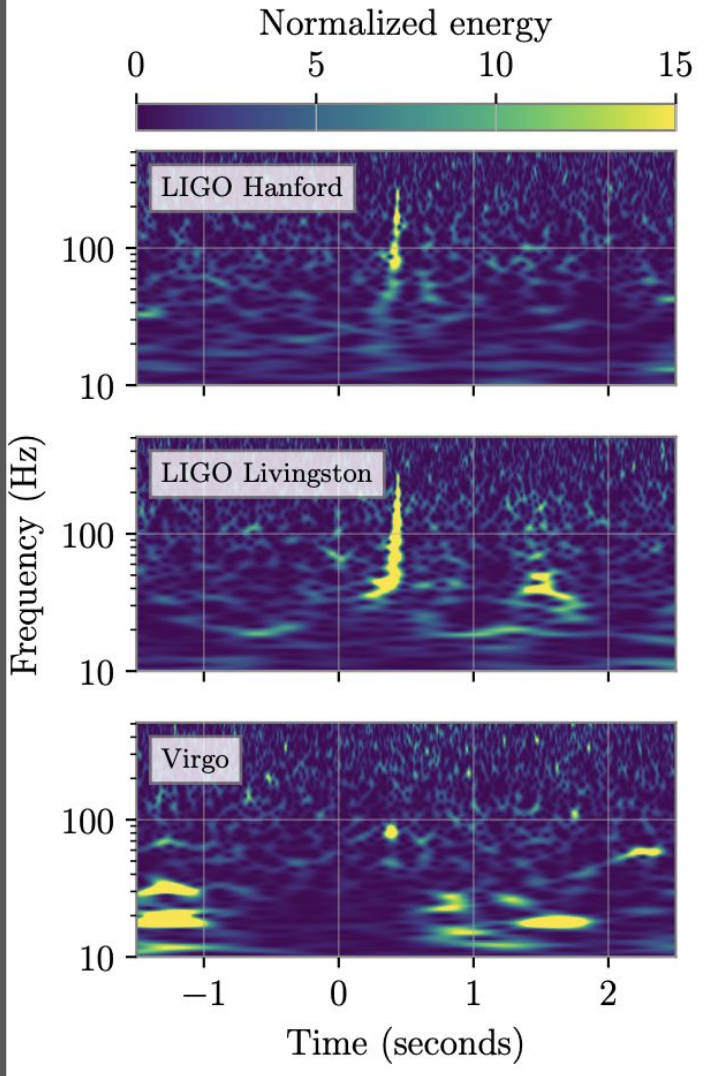
Glitch identified in LIGO Livingston

- Subtracted using gwsubtract algorithm (Davis+, 2022)
  - Relies on glitch witness channel
  - Produced the publicly released glitch mitigated data

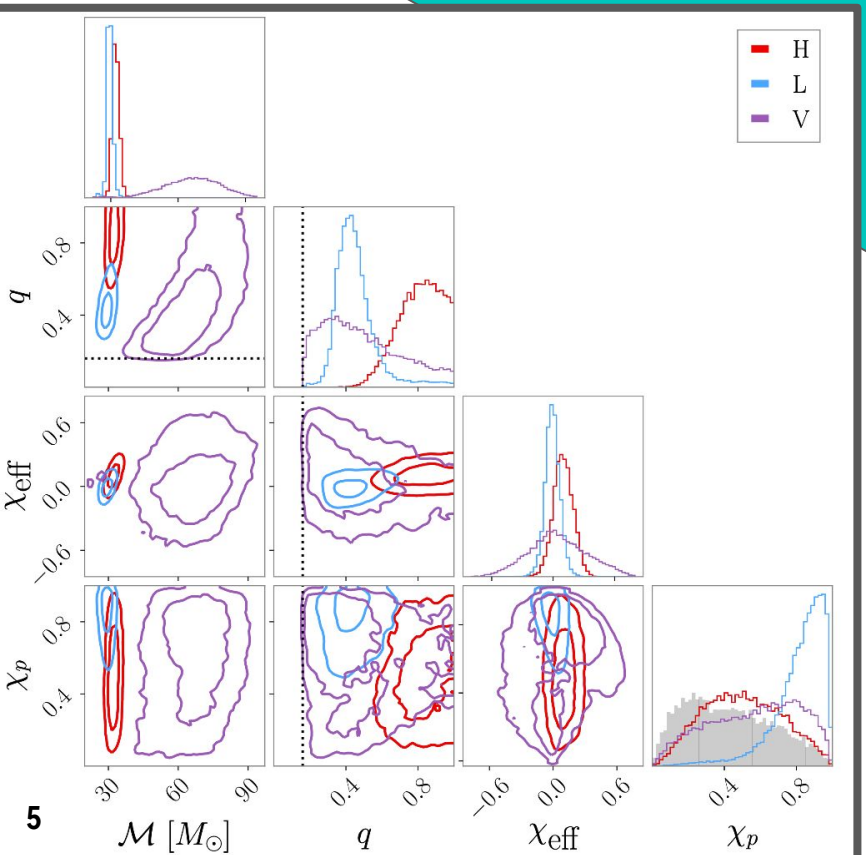
What if GW200129's "precession" is a result of a glitch?



Davis+ (2022)



Inferred signal from each individual detector



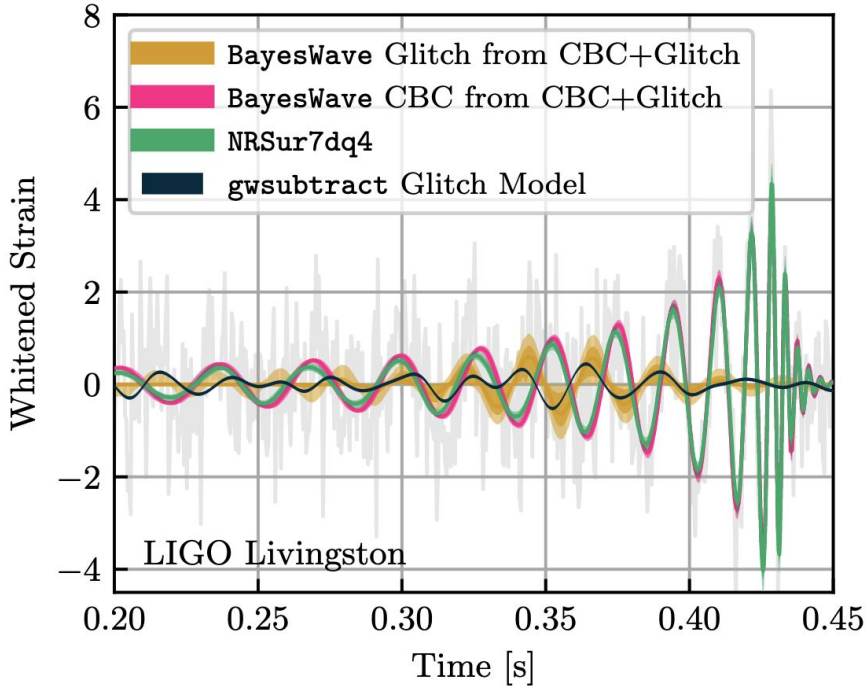
Parameter estimation using same waveform as Hannam+ (2021) (NRSur7dq4)

The posterior distributions from each individual detector should be consistent, but:

- Tension between LIGO detectors
  - E.g. χ_p - q
  - Rare in simulated detections
- Virgo infers different (heavier) signal
  - E.g. $\mathcal{M}$ - q
  - Associated with a coincident glitch in Virgo

LIGO Livingston data quality

- Model gravitational wave and glitch simultaneously (BayesWave; Hourihane+, 2022)
  - Limited to aligned spins
- Little difference between aligned (IMRPhenomD; pink) and precessing (NRSur7dq4; green)
- BayesWave glitch model reports a large uncertainty
  - Larger than waveform differences

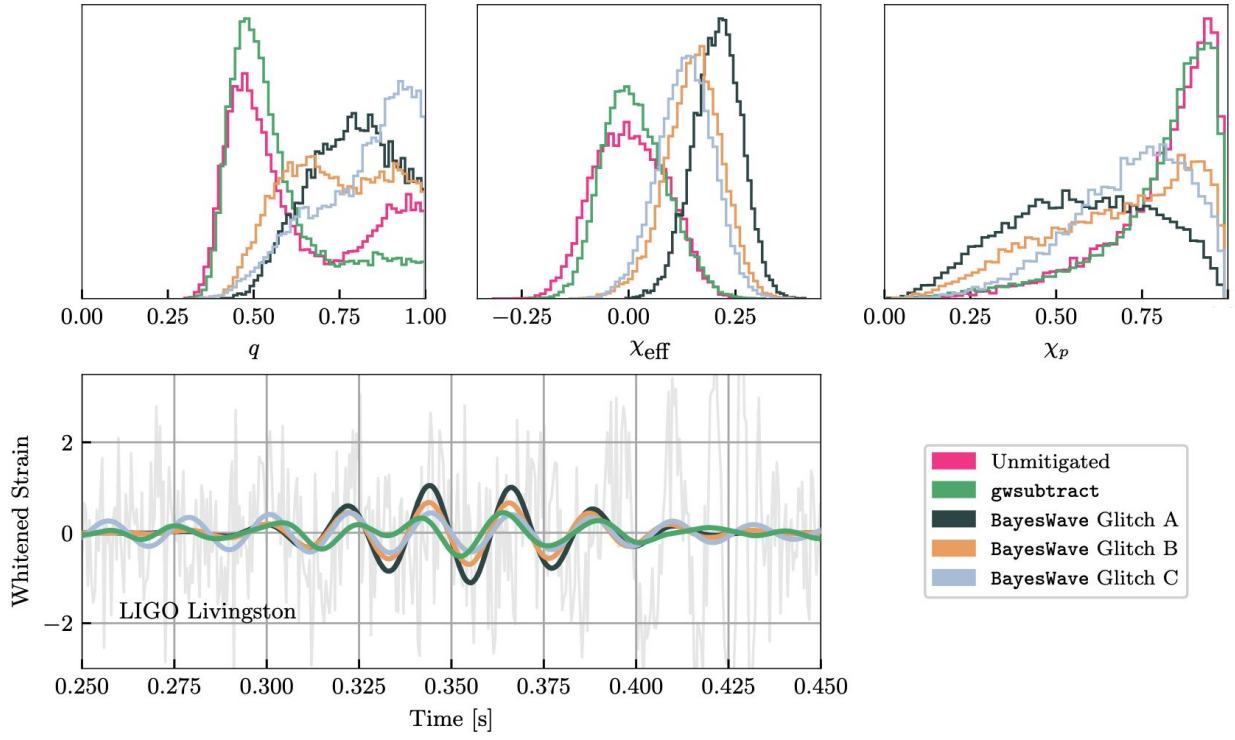


Origin of evidence for spin-precession

Draw from BayesWave glitch model for subtraction

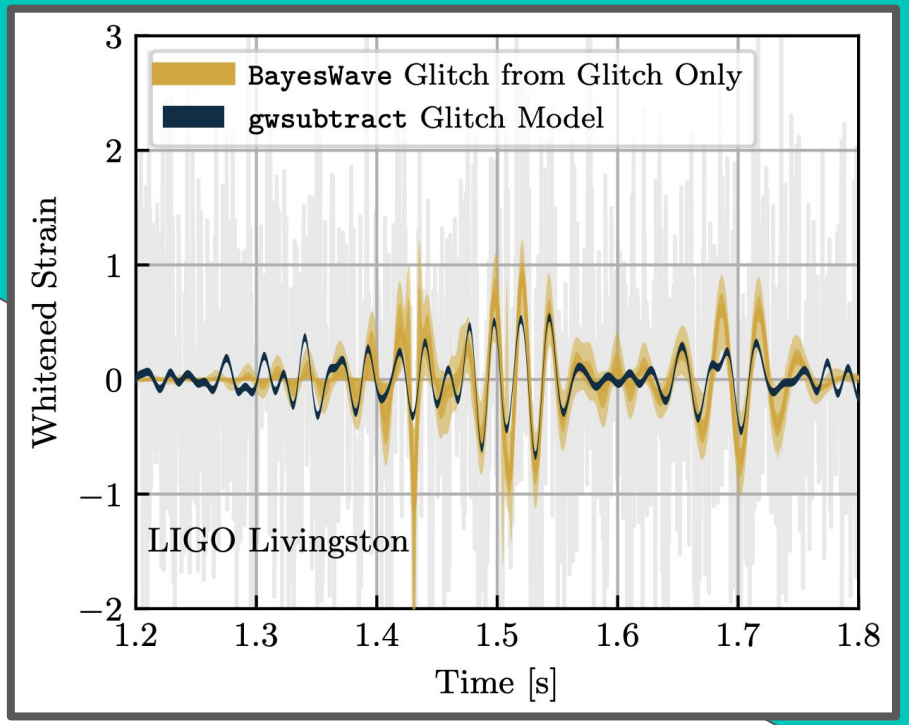
Large glitch amplitude ↔ less precession

Inference of precession linked to the glitch model choice



Potential glitch model systematics

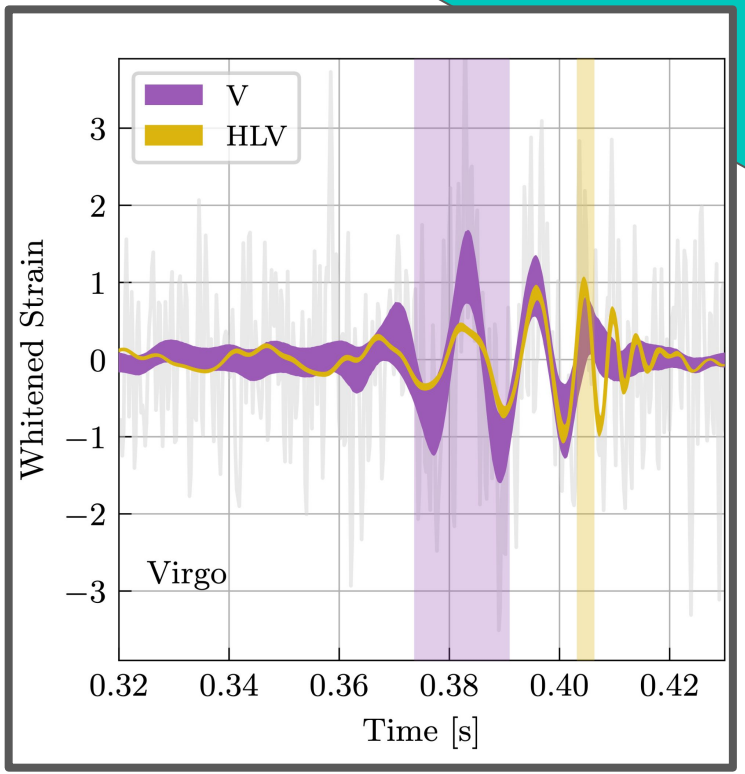
- Model another glitch in Livingston ~ 1s after event
- BayesWave glitch typically larger than gwsubtract result
  - At the ~90% level
- Larger glitch amplitudes lead to less precession
  - Glitch originally undersubtracted?



Conclusions

- Evidence for spin-precession in GW200129 is exclusively coming from data with quality issues in LIGO Livingston
- LIGO Hanford does not observe precession (not unexpected) but is also inconsistent with LIGO Livingston (unexpected from Gaussian noise)
- **Evidence for precession very sensitive to choice of glitch model**
- Use caution when interpreting signatures of important astrophysics (particularly in the presence of a glitch)

Extra slides: Virgo data quality



Likely CBC signal and glitch overlapping