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Sources workshop
Friday March 22

4th roundtable:

inspiral of stellar mass objects into supermassive black holes

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Template Counting & Data Analysis with Kludged Waveforms

Plan: Use incorrect (but qualitatively plausible) waveforms to determine the costs and performances for various analysis methods

- E.g. Scott Hughes' fake R.R. waves
  Curt Cutler's fake P.N. waves

→ Method and performance should not change significantly when Correct™ waveforms become available

Key issue: Waveforms are complicated!

- Ideally, match waveform to within 1 cycle over entire length

→ *Each parameter* λ requires a number of samples

$$\sim \max_{\lambda, t} \left\{ \Delta N_{cycles} \right\}$$

- Over a dozen search parameters!

  (≥ 9 significantly affect wave phase)

  Ignorant estimate of # flops / datum:

$$N_{flops} \sim \left(N_{cycles}\right)^9 \log\left(N_{cycles}\right) \times \left(\frac{v_\oplus}{c}\right)^2$$

E.g. $N_{cycles} \sim 10^5$ → $N_{flops} \sim 10^{38}$

Data analysis tricks:

Semi-coherent analysis:

- Divide data into M shorter stretches; combine these incoherently
- Effectively reduce N_{cycles} by factor M, raise amplitude threshold by factor $\sqrt[4]{M}$.
- To get N_{flops} down to around 10^{12}, need

$$N_{cycles} \sim 100 \quad \rightarrow \sqrt[4]{M} \lesssim 10$$

Correlated parameters:

- When two parameters affect the waveform similarly, we can reduce (or even eliminate) search over one of them.
- E.g. early work with geodesics shows that radius and eccentricity have 2 to 10-fold correlations.

	Parameter	# Search Points
Position & orientation	Right ascension	$\sim \left(\frac{v_\oplus}{c}\right) N_{cycles}$
	Declination	$\sim \left(\frac{v_\oplus}{c}\right) N_{cycles}$
	Polarization angle	~ 1
	Inclination angle	~ 1
	Axial rotation angle	~ 1
System constants	Central body mass	$\sim N_{cycles}$
	Central body spin	$\sim N_{cycles}$
	Orbiting body mass	$\sim N_{cycles}$
Initial conditions	Initial orbit eccentricity	$\sim N_{cycles}$
	Initial orbit inclination	$\sim N_{cycles}$
	Initial apsidal anomaly	$\sim N_{cycles}$
	Initial nodal angle	$\sim N_{cycles}$
	Start time	$\sim \log(N_{cycles})$