Signals from cosmic strings with gravitational backreaction

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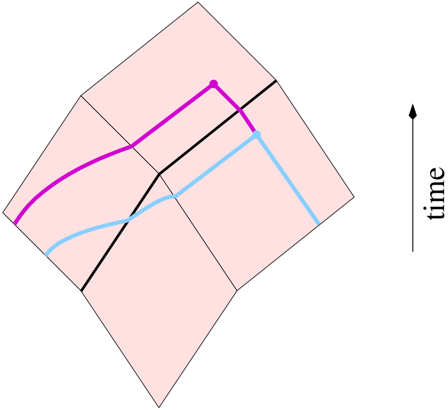
We evolve Nambu-Goto strings from simulation

Backreaction based on arXiv:1609.01685, arXiv:1903.06079

Population of piecewise linear loops from simulations:

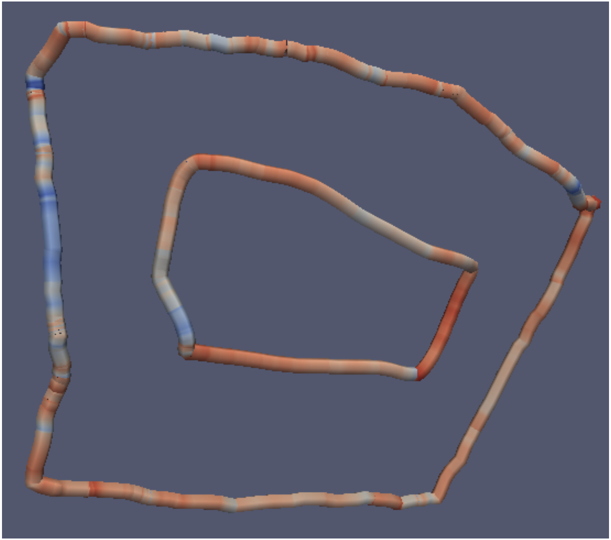
1) Each loop, each segment: find all causally-connected segments
2) For each source segment, calculate the linearized metric perturbation at the observer (closed-form expression!)
3) Sum across all sources
4) Repeat for all segments, apply changes, restart



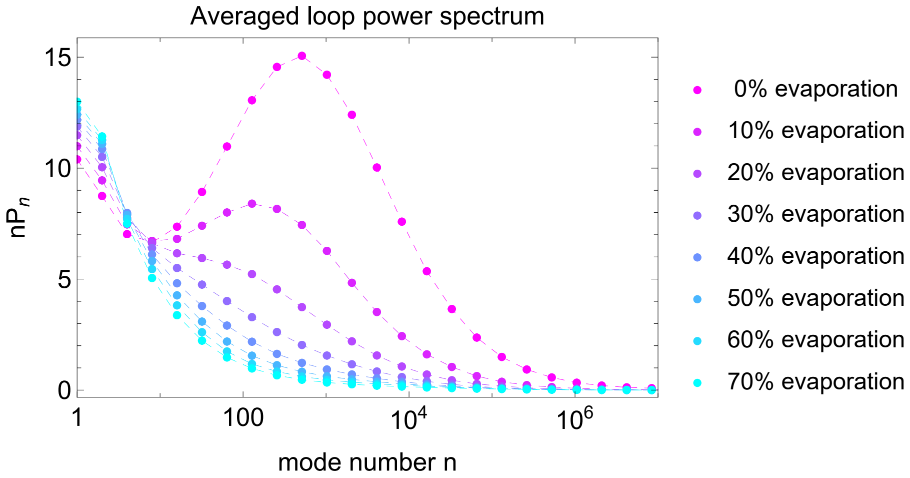
- Adaptive refinement to catch rapidly-changing regions
- Highly parallelizable

Backreaction smooths wiggles

Large-scale structure preserved



The power spectrum “bump” is quickly removed



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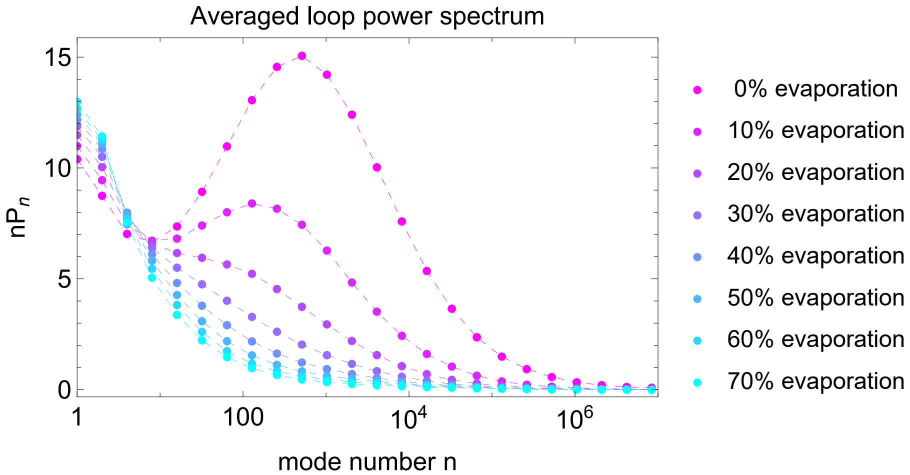
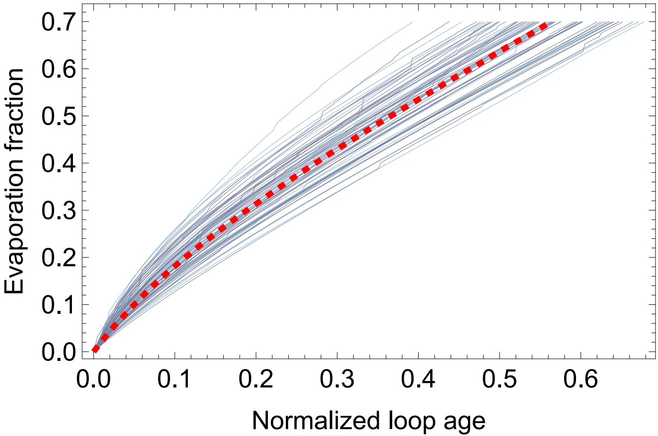


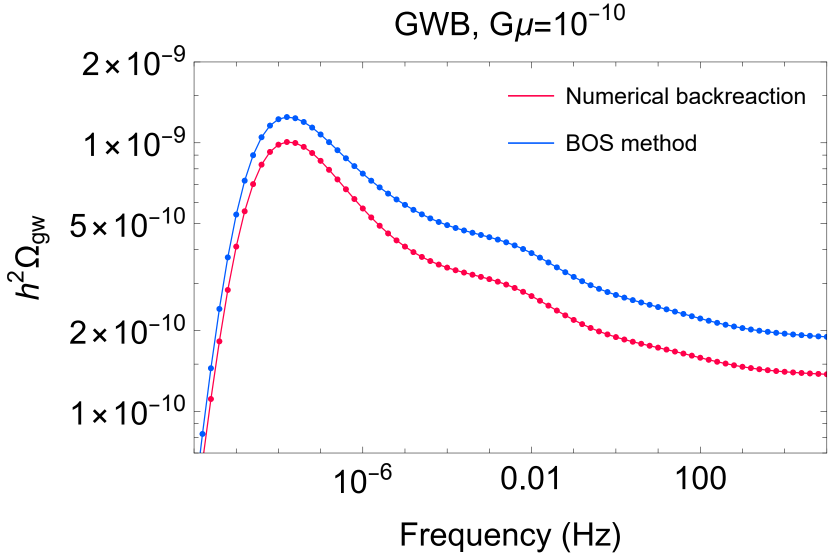
(N.B.: We extrapolate for real loops' initial spectra—greater initial segmentation!)

Rate of GW emission is higher for younger loops



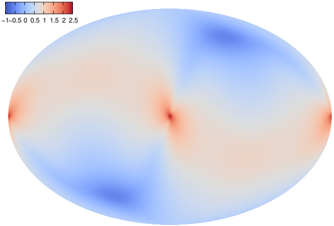
Evap. fraction: $1 - \frac{L}{L_0}$ Normalized age: $\frac{\Gamma_{\text{ref}} G\mu(t - t_0)}{L_0}$

Higher initial gravitational-wave emission lowers Ω_{gw}

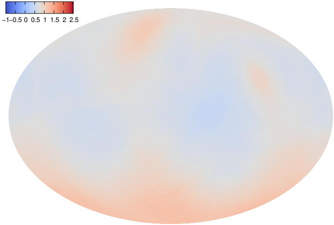


Cusps don't develop due to backreaction

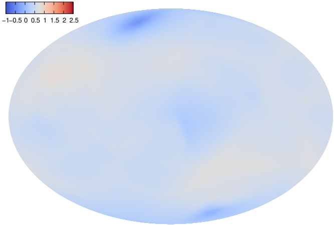
Kibble-Turok loop:



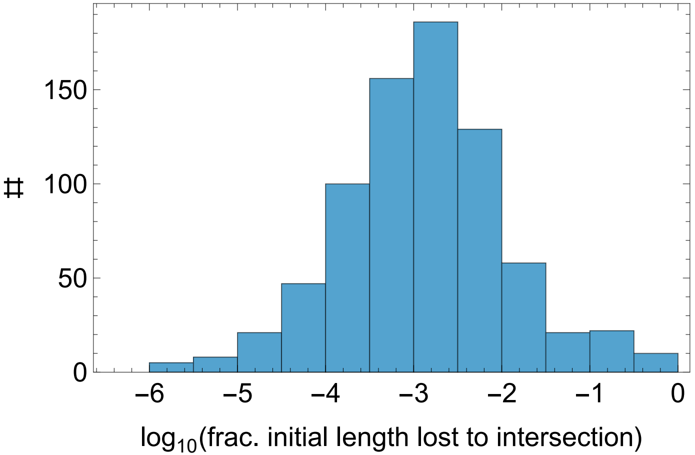
Sample loop, 10% evaporated:



Sample loop, 70% evaporated:



Most loops experience tiny self-intersections



Summary:

- Initial wiggles are smoothed out; large-scale shape remains
- P_n initially enhanced in higher modes; quickly dissipates
- Anything "cusp-like" is very weak
- Backreaction generally leads to (tiny!) intersections

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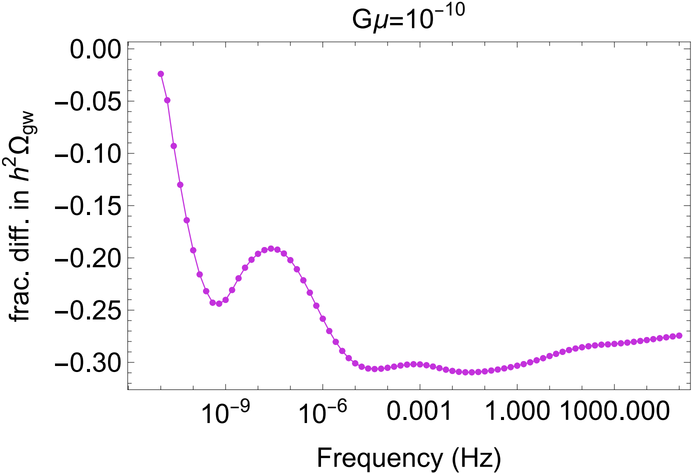
How does backreaction affect...

- ...measurements of the GWB?
- ...loop clustering in galaxies?
- ...loop collapse to black holes?

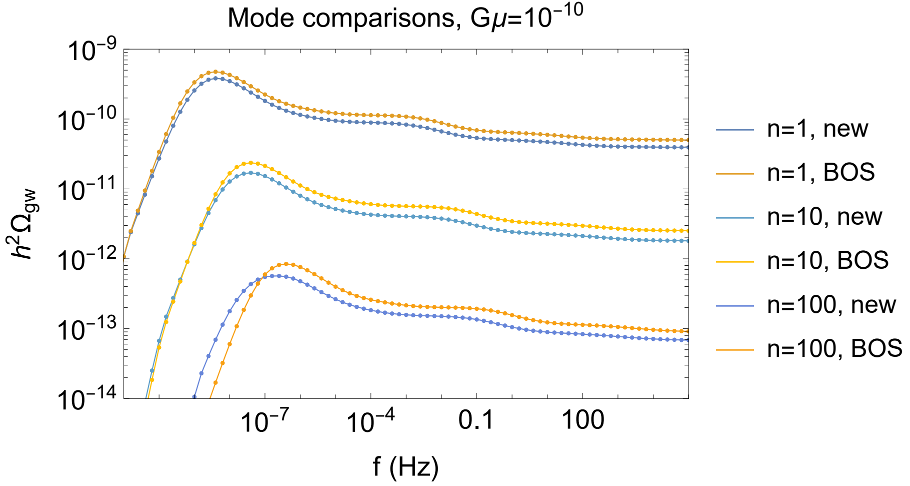
Bonus slides

Change to the GWB is frequency-dependent



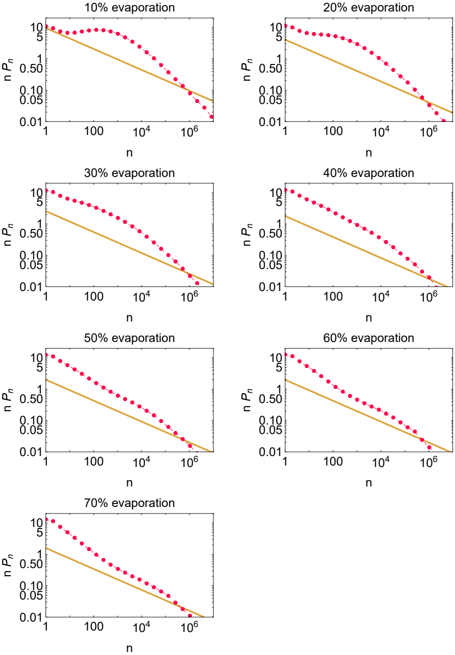
(Difference is between "new" numerical backreaction method and "old" BOS method, as shown in slide 5)

Young loops' peaked P_n matter for higher modes



(Recall: sum $\mathcal{O}(n)$ comparable quantities for each mode n to get the total GWB)

The “strongest possible” cusps found in our data are still weak



“Kicks” from self-intersections are generally small