Title: Observable Consequences of a Bounce

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Abstract: I discuss potentially observable signatures of scalar and tensor decaying modes, which do not exist in inflation, and could be a probe of a bouncing universe.

Observing a bounce

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June 26, 2017

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Cosmological Perturbations

- ▶ traditionally thought of as an initial value problem (IVP)
- ▶ challenges in specifying IVP at a singularity
- ▶ blinded by inflationary calculations
- ▶ bounce paradigm allows broader analysis

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Perfect Bouncing

- Gielen&Turok 2016, 2017
- generic early universe background: radiation domination, perturbations, classical and quantum
- compute from negative to positive (complex) scale factor
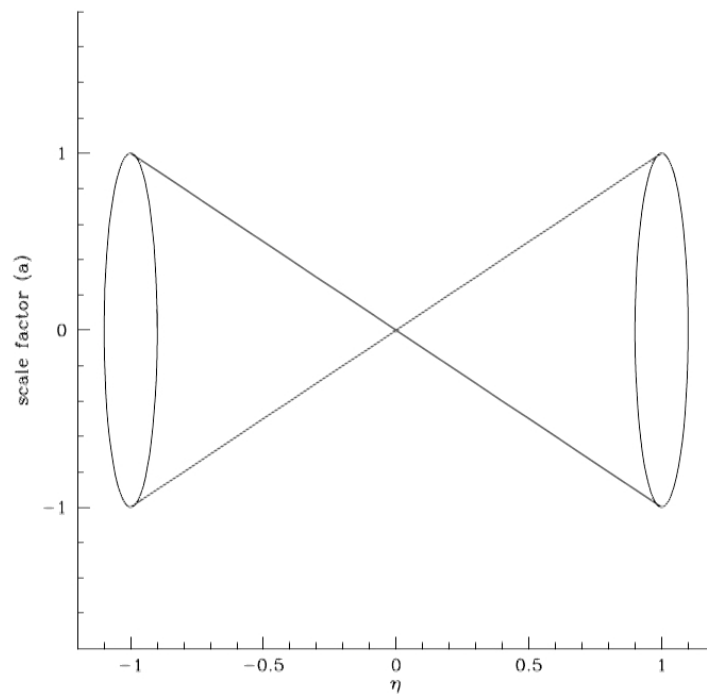
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Tensor Modes

- regular and irregular (decaying) mode
- decaying mode $h_T \propto \cos(k\eta)/k\eta$
- viewed going into a bounce, appears as a superhorizon anistropy
- c.f. Bianchi I, IX, Mixmaster
- used as BBN constraint (Rothman&Matzner 1984 etc)
- if two axes expand anisotropically between neutrino freezout (~ 1 MeV) and BBN (~ 0.1 MeV), results in anistropic ν DF, and higher He abundance (up to 0.9).
- thought to give stronger constraint than CMB (Saadeh et al 2016)

Distinguishing gravity from fluid forces

- consider crunch with perfect fluid and tensor modes only
- need to specify 2 tensor IC, 4 fluid IC
- only one of these 6 d.o.f. maps onto Bianchi
- consistent with Gielen and Turok leading and second order PT
- numerical study could show generic behaviour in crunch

Analogy: Milne Universe decaying mode

- Milne: $\Omega = 0$ hyperbolic reslicing of Minkowski
- $ds^2 = -d\tau^2 + \tau^2(\frac{d\chi^2}{1+\chi^2} + \chi^2 d\Omega)$
- Gauge transform from Minkowski
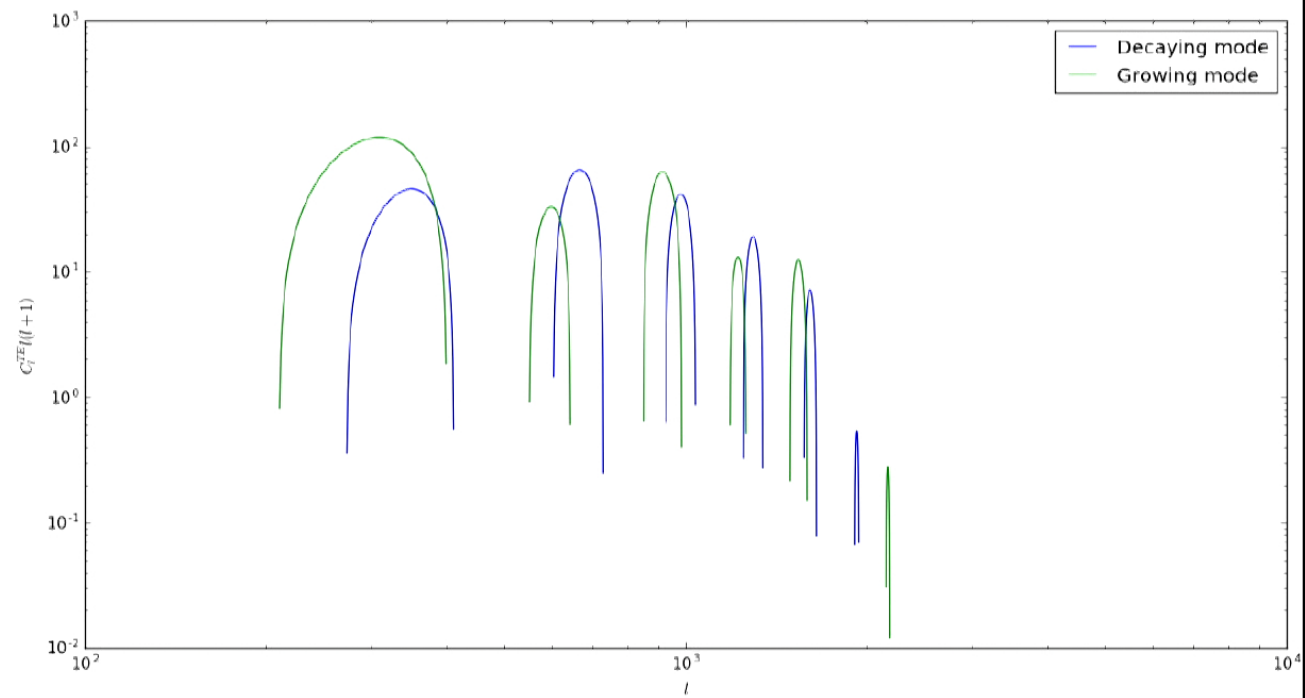- $r = \tau\chi$, $t = \tau\sqrt{1+\chi^2}$

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Decaying modes

- test fluid in Milne (empty) space:
- has decaying modes
- if viewed in crunch, decaying mode becomes growing mode!
- but by construction, no gravity at play.

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Scalar modes
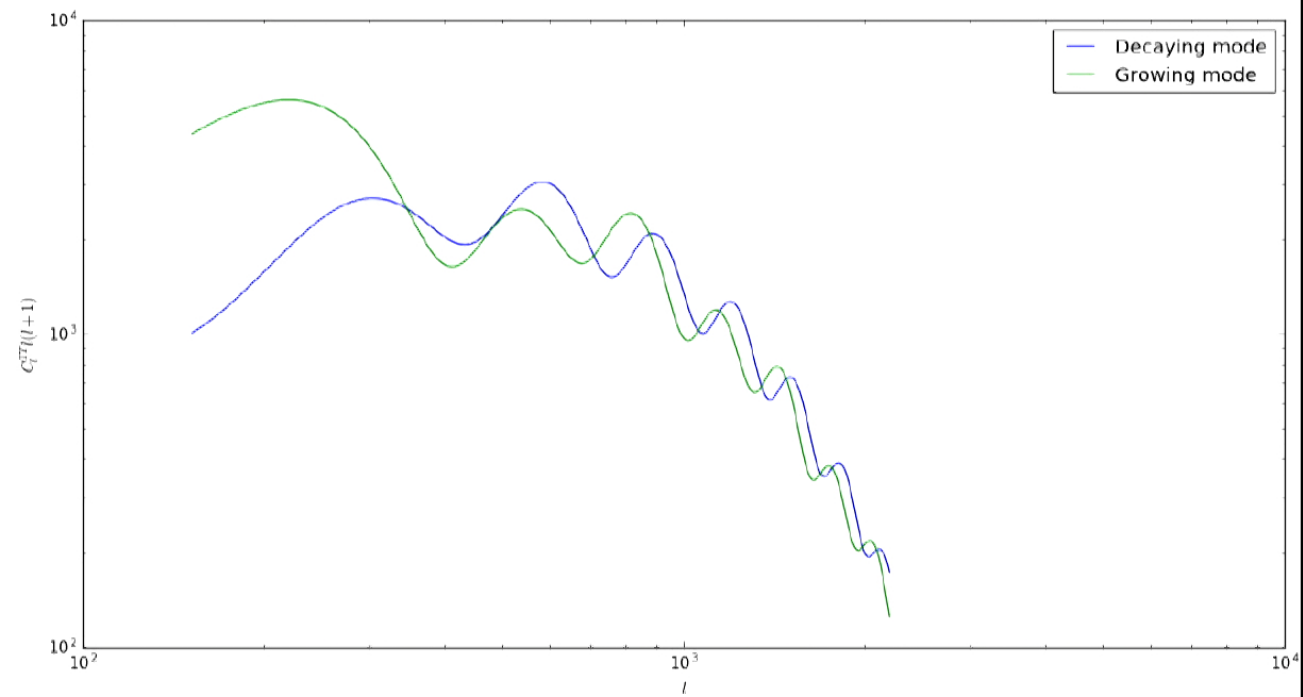
Kodwani et al in prep

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Open questions

- non-linear superhorizon decaying mode evolution - numerical?
- backreaction?
- vector modes?
- is Bianchi solution a singular fluid perturbation?

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Conclusions

▶ Bouncing cosmology allows a new and broader discussion of allowed linear modes

▶ constructive observational phenomenology

▶ e.g.: B modes do not necessarily constrain tensors

▶ doubles adiabatic mode count, adds fluid d.o.f.