Low-Frequency Impact

JAN HARMS & JENNE DRIGGERS

GWADW 2016
Underground Seismic Spectra

Requirement ET
(conservative: underground displacement dominated by compressional waves)

Beker et al, 2012
Seismic NN

Seismic NN in a surface detector  Seismic NN in an underground detector

- Seismic models: Body wave: $3x - 12x$ LNM, Surface: $50x - 1000x$ LNM
- Rayleigh dispersion model: $1.5\text{km/s} @ 1\text{Hz} \rightarrow 300\text{m/s} @ 10\text{Hz}$
- Includes contributions from cavity-wall displacement
- Homogeneous half space (except for Rayleigh dispersion)
• **Atmospheric NN**
  - (So far poorly modelled) quasi-static temperature perturbations advected along (so far poorly modeled) streamlines
  - Sound propagation inside atmosphere and laboratory buildings (scattering not yet simulated)
Atmospheric NN

Temperature NN
Uniform air flow, $v=20m/s$

Infrasound NN

- Atmospheric NN limits sensitivity of ET-type detectors if built at the surface
- Going underground very efficiently suppresses atmospheric NN
- Atmospheric NN will be extremely challenging to cancel
Cosmic Explorer
NN in Advanced LIGO

Driggers et al, 2012
Anisotropic, plane-wave model gives qualitatively good match with observation.

Mismatch is not minor. It demonstrates inhomogeneity of the seismic field, due to local seismic sources.
NN Cancellation

Nikhil Mukund, 2016
Advanced Virgo

Complicated surface structure

- Lab space below test masses
- Poles supporting foundation
So far, calculations of topographic scattering only carried out in Born approximation

Measurements with Sweetwater array confirm that seismic correlations are complicated in regions with rough topography
Constrains on Observatory Designs

- **Surface**
  - Wind noise – Few meters underground or aerodynamically shaped buildings?
  - Strong seismic noise from local sources – Improve design of laboratory infrastructure?
  - How much digging required for 40km arms?

- **Stick ends into mountains**
  - Strong mitigation of atmospheric NN
  - Detrimental effects on seismic NN cancellation (necessarily complex topography)

- **Underground**
  - Detector infrastructure – How to avoid elevated underground seismic noise?