3, 6, 10
Low Loss Needs
(food for thought)

Lee McCuller

Rough numbers
and thoughts for
discussion of future
squeezing levels

Loss

Be aware of this distinction:

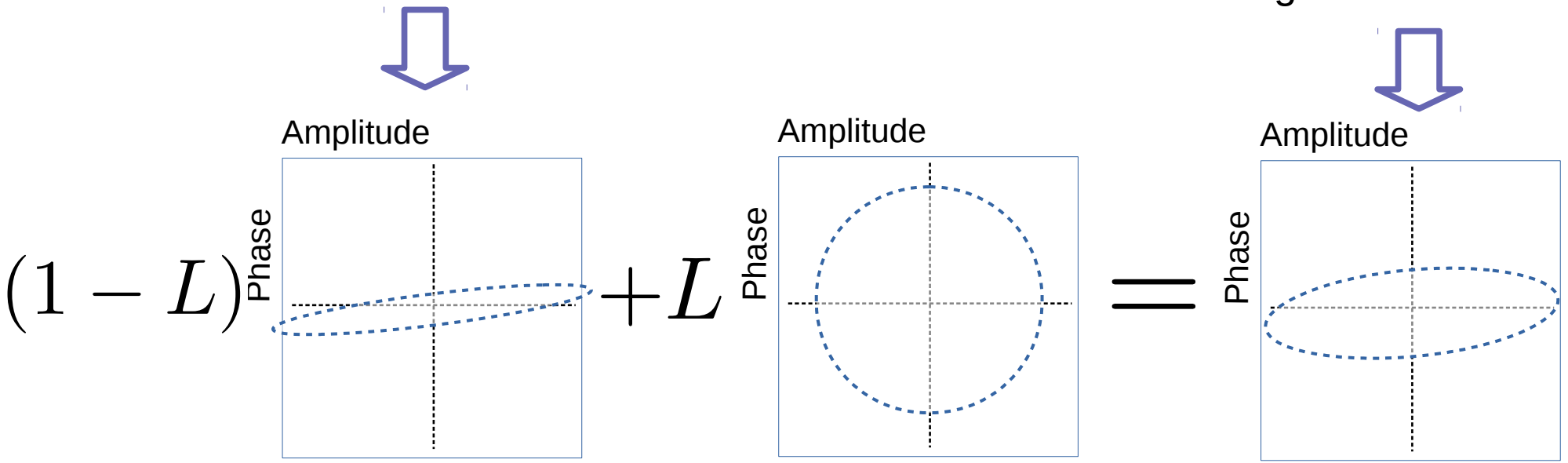
Generated squeezing

- can be determined from calibration measurements
- Perfect relation between sqz and antisqz

Measured squeezing

Measured Antisqueezing

- Degraded by loss and dephasing
- Different effects in each characterizes degradation



$$(1-L)\begin{bmatrix} e^{-r} & 0 \\ 0 & e^{r} \end{bmatrix}\frac{E_\lambda}{2} + L\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}\frac{E_\lambda}{2} \xrightarrow{r=\infty} \begin{bmatrix} L & 0 \\ 0 & e^{r} \end{bmatrix}\frac{E_\lambda}{2}$$

What's Needed?

- Loss and Phase noise limits
- Can in principle achieve <10mRad (need to understand this in 2G..)
- But RMS includes Filter Cavity intrinsic mismatch
- Practically limited to injecting ~15db (speculating), unless >1 Filter cavity.

$$10\log(L + 2\theta_{\mathrm{RMS}}^2)$$

$$10\log(L + 0.03)$$

Can We Get below 7% Loss?

- 2G Loss budgets
  - Faradays (being improved)
    - ~4%/pass now, 1%/pass developed, no idea about other wavelengths
    - Need 2-pass/filter-cavity, unless we move to bow-tie (same loss/m as linear)
      - Loss likely worse from finesse-sq backscatter cplg.
    - Currently can't assume no OFI, needed for SQZ injection
  - OMCs
    - ~3% loss for LIGO, what about virgo double OMC config?
    - 3% not fundamental, can/should improve
  - <<<controls residuals>>>
    - ??% (not negligible)
  - Pickoff mirrors
    - 1-2%. Needed for alignment sensing, could reduce SOME, but may trade with better ASC.
      - Rana: 0.2% possibly sufficient for WFS.shotnoise limit
  - OPO
    - 1%, but consistent with chosen CLF mirror, could be less (LIGO, other AEI, GEO ANU more efficient?)
  - Mode matching
    - Hoping for 0% in AUX (some hope)
    - How important in IFO?
  - Intrinsic Scatter
    - Next slide

Tensions

- Low Frequency
  - (back) scatter vs. isolators
  - AUX D.O.F. residuals (alignment controls)
    - Usual consequences of RMS vs. DARM contamination
    - Helped by 3G seismic?
    - We don’t yet know how much this is affecting 2G
- All/High Frequency
  - Contrast Defect
    - OMC Finesse
  - High power → loss tension
    - High power → dropping PRG
    - ARM loss cavity enhanced
    - L_1 = 50ppm, T_itm = .015% => 1.5% loss, but when PRG dropping..?
      - This is pessimistic, ignoring SRM
      - Less important for longer IFOs
  - Intrinsic (non-cavity enhanced)
    - ARM RT loss is limit
    - PhysRevX.9.011053 (Miao et al)