Outline Chapter 18: Pre-stabilized lasers (B. Willke)

1. laser parameters and the relevance of their fluctuations in GWDs
   a. which parameter describe laser beam
   $$\vec{E}(\vec{r},t) = E_0\,(\vec{r},\omega,t) \cdot \vec{e}_p(\vec{r}) \cdot cos\big(\omega t - \vec{k}\vec{r} + \varphi(t)\big)$$
   b. coupling of laser fluctuations into GWD channel (qualitative discussion of relevant coupling paths)
   c. requirement for 2nd generation GWDs, outlook to 3rd generation GWDs
2. Laser characterization, free running fluctuations of lasers and their typical physical sources
   a. Diagnostic breadboard: resonator as frequency, spatial and modal reference
   b. control loops to convert these references into linear sensors (PHD and length stabilization, differential wave-front sensing and automatic alignment, unity gain frequency dependent readout of control or error signal
   c. length scan for modal decomposition of laser beam
3. Advanced LIGO PSL Layout as example
   a. brief description of laser system
   b. Pre-modecleaner as noise filter and spatial reference for ISS and FSS and as interface to GWD (IO in this case)
      i. need for long range actuator to compensate temp. and pressure fluctuations
      ii. filter bandwidth / thermal loading trade-off
   c. miscellaneous:
      i. ISS sensing after IMC including pointing-> RIN coupling
      ii. FSS: VCO-AOM units as actuator for IFO LSC loops
      iii. pickoff beam for ALS
4. Power stabilization
   a. cause and transfer of laser power fluctuation
   b. trade-off between different actuators [with respect to range, speed, cross coupling]: pump diode current of different laser stages / AOM at different locations / detuning of PMC
   c. sensor noise: shot noise / pointing coupling / scattered light / light in wrong polarization / electronic noise in PD
   d. performance of aLIGO ISS and outlook (optical AC coupling)
   e. (maybe rf power noise filtering of PMC)
5. Frequency stabilization
   a. suspended rigid spacer reference with thermal tuning
   b. nested high bandwidth control loop (maybe current lock actuator)
   c. actuator for LSC control loop: VCO-AOM combination, error-point summation
   d. transfer of frequency stability from reference cavity to IFO (Doppler shift, PMC length fluctuations)
6. Spatial filtering and reduction of pointing fluctuations (I'm not sure if this deserves a full chapter or if it can go into 3.b)
   a. the mode-cleaning effect of a PMC
   b. description of pointing via HG_10 mode content
   c. reduction of pointing noise by aLIGO PMC
   d. (maybe spatial filtering of higher order Gauss modes)
7. Outlook
   a. challenges for 3rd Generation IFOs
   b. novel techniques
   c. ...

chapters with possible cross-links
7. how to think about and control non-fundamental noise sources (Ballmer)
8. control systems (Evans)
9. cavity optics: longitudinal modes, higher order modes, stability (Barsuglia, Ando)
11. EO components / photodiodes (Quetschke)
14. lasers (Munch)
19. Input mode cleaners and associated input optics (Mueller, Genin)
21. Length sensing and control (Grote)