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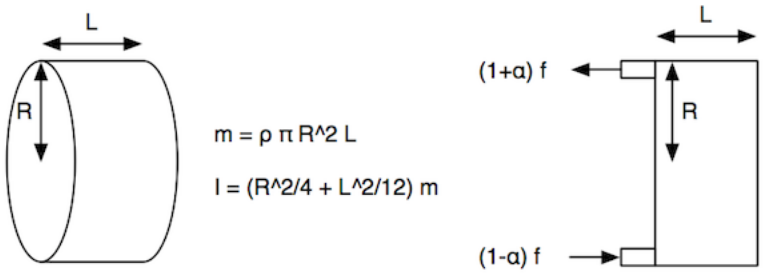
This document provides some additional background for the calculation of the input mode cleaner beam spot position by coil drive imbalance, as described in LLO alog #5010 and 40m elog #2863. The method works beautifully, but the formulae are defined in terms of a the actuator imbalance, while the measured quantity is a gain in either the pitch-to-length (P2L) or yaw-to-length (Y2L) channels of the Drivealign matrix on the M3 stage.



Looking at the right side of the image included in the 40m elog, notice the actuation force defined as some constant f times either $(1 + a)$ or $(1 - a)$. The conversion between gain and imbalance is not difficult to calculate. Without loss of generality, I will discuss this in terms of the P2L gain, G_{P2L}.

When the P2L channel is activated in the Drivealign matrix, a factor of $c_P G_{P2L}$ is added to the counts in the length channel, c_L.

$$c'_L = c_L + c_P G_{P2L}. \tag{1}$$

The output of the Drivealign is changed to the OSEM basis by the Eul2OSEM matrix. It can assumed that count values in the OSEM basis are directly proportional to the true actuation force; variations in actuators as installed may vary, but the error in actuator force should not be comparable to the error in the estimation of the beam spot position. This conversion is required because the Eul2OSEM conversion factor for pitch (E_P) is not the same as the Eul2OSEM conversion factor for length (E_L).

For OSEMS UL and UR, or the top of the test mass, the output of the Eul2OSEM matrix is the sum of the length, pitch, and yaw, or,

$$f_U = c_L E_L + c_P G_{P2L} E_L + c_P E_P \pm c_Y E_Y. \tag{2}$$

Analogously, the value for OSEMS LL and LR is

$$f_L = c_L E_L + c_P G_{P2L} E_L - c_P E_P \pm c_Y E_Y. \tag{3}$$

Since we are only interested in the coil drive imbalance in pitch, the length and yaw terms can be neglected. This leaves, for the f_U term,

$$f_U = c_P E_P + c_P G_{P2L} E_L \tag{4}$$

or equivalently,

$$f_U = c_P E_P \left(1 + \frac{E_L}{E_P} G_{P2L}\right). \tag{5}$$

The leading factor, $c_P E_P$, is in the OSEM basis and is therefore proportional to f. Therefore, the conversion factor from G_{P2L} to a is given by the ratio of the Eul2OSEM value for length and the Eul2OSEM value for pitch,

$$a = \frac{E_L}{E_P} G_{P2L}. \tag{6}$$