Subject: mirror tilt
From: "Mark Barton" <mbarton@ligo.caltech.edu>
Date: Mon, 26 Jul 2004 23:22:31 -0700
To: "Carolyn Cantley" <c.cantley@physics.gla.ac.uk>, "Norna Robertson" <nornar@stanford.edu>, "Janeen Romie" <janeen@ligo.caltech.edu>, "Calum Torrie" <torrie_c@ligo.caltech.edu>

Hi,

Here are some preliminary observations on the consequences of setting the optic at some desired finite pitch angle, based on some modeling of asymmetric quad pendulums.

Basically, everything depends on d4, the vertical distance between the centre of mass of the optic and the effective flexure point of the fibres at the optic. The nominal value of d4 in the reference model of 14 Nov 2003 is 1 mm. This produces a static cross-coupling of order -6% to -10% from the optic to the pitch of the upper masses. That is, if you manipulate the length of the wires or the height of the fibre attachment points at the intermediate mass or optic to set the optic (in the local coordinate system of the affected mass) at some angle while keeping an average d4 of 1 mm, all the upper masses will tilt a small amount in the opposite direction.

For example, if you move the attachment points at the optic 0.3 mm (0.05% of the fibre length) up at the front and down at the back the pitch of the masses in order from the bottom will be 30.6, -3.31, -2.38 and -2.00 mrad. The 30.6 mrad for the optic is comparable to but a bit less than the 0.3/8 = 37.5 mrad expected if the upper stages were totally rigid in pitch.

The fact the upper masses pitch by different amounts may be awkward, because they can't be leveled by a single counterweight, say at the top mass. For example, turning 200 g of the top mass into a counterweight and moving it 4.46 mm longitudinally gives pitches of 31.8, -1.98, -0.81 and 0 mrad.

However if d4 is set to 0, the tilts are 37.1, 0, 0 and 0 mrad. The only change in the normal modes is a slight change in the lower pitch frequencies, and the new cross-couplings produced by this are negligible - all around the 10^-6 level. This is thus something to be seriously considered.

Note that these results assume infinitely flexible fibres, but should be valid for a real pendulum provided the fibre attachment angles are set to zero out any static stress at the flexure points, and provided d4 is interpreted as the distance to an effective flexure point.

Cheers,

Mark B.

