Note on Noise Due to Blade Magnetic Damping

Norna A Robertson
20th July 2006

T060169-00-R

I copy below an email in which I consider possible noise in the Advanced LIGO quadruple pendulum suspension due to coupling of the magnets used to damp internal modes of the lowest set of blades (those on the upper intermediate mass) with ambient magnetic fields. The conclusion is that if the magnets on one blade are opposite in polarity to the magnets on the other blade on the same mass, cancellation is enough that the noise level is acceptable (meets the “technical” noise requirement of 10^-20 m/rt Hz at 10 Hz).

Date: Mon, 17 Oct 2005 13:45:26 -0700
To: "Greenhalgh, RJS (Justin)" <J.Greenhalgh@rl.ac.uk>, "Norna Robertson" <n.robertson@physics.gla.ac.uk>
From: Norna Robertson <nornar@stanford.edu>
Subject: more on Possible noise due to stray field effects magnets in blade dampers
Cc: "Wilmut, I (Ian)" <I.Wilmut@rl.ac.uk>, <k.strain@physics.gla.ac.uk>, <ctorrie@ligo.caltech.edu>

Hi Justin and colleagues

More on this. I have now done a back of envelope calculation and also have a suggestion.

I am following the arguments used in Ken' s document T050105.

Using latest MATLAB quad model i find coupling of force at upper intermediate mass to motion at test mass to be around 7.6 x 10^-10 m/N . This is in long. direction. (Vertical times cross-coupling is slightly smaller at 6.6 x 10^-10). Since we dont know the direction of the ambient gradient it is best to assume the larger value.
Now assume target noise level is 10^-20 m/rt Hz at 10 Hz. So maximum allowed force is 1.3 x 10^-11 N/rt Hz.
What value to take for ambient gradient? Ken takes a number from E050159

I cant locate this document on the DCC, does anyone have a copy?

It gives 20 pT m-1/rt Hz due to the SEI 100mm below optics table. We are further away so i think it is reasonable to take the typical ambient field gradient in LIGO as Bob Schofield has measured. See T050087-00.pdf. If i am interpreting correctly ambient gradient is 10 pT m-1/rt Hz (Note Bob doesnt have per rt Hz - so need to confirm this number).

Anyway using this I find max dipole is 1.3 A m-2.

Now Calum thinks we have one magnet per blade (10mm diam times 10mm thick) with provision for two if needed. Let us be pessimistic and say 2 is needed. Also we have two blades, so we have equivalently the effect from 4 magnetic dipoles. Each magnet is 0.5 A m-2, so with 4 we have 2 A m-2 which looks like too large to meet the requirement.

This suggests we do want to pair them. However we already essentially have a pairing (one set on each blade). What if we just swap round one set with respect to the other? Assuming they are matched to 5% (see Ken's note T050105 page 2) this would reduce the overall moment to 10% of the above (assuming worst case of 2 strong ones on one blade and two weak ones on the other). Thus the overall dipole is 0.2 Am-2 which is acceptable.

I am assuming that the magnet(s) on the two blades are close enough that we do get reasonable dipole cancellation.

If the above estimation is right, this might be easier than designing a cancelling pair for each blade.

Thoughts?

Cheers
Norna
