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Alignment capabilities of the room temperature payload

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1 Introduction

1.1 Purpose and Scope

The aim of this report is the calculation of the alignment capabilities of the IM in roll and pitch when adjusting the position of the movable bodies within its upper and lower cavities. The body in the upper cavity produces tilts in roll and the lower one in pitch.

The first configurations considered is when the mirror is perfectly symmetric, whereas the second configuration the mirror has a wedge.

1.2 References

stuff

1.3 Version history

mm/dd/yy: Pre-rev-v1 draft.

1.4 Stuff

Fig. 1(a) shows the payload when it is perfectly balanced. The blue spot indicates the suspension point of the payload, the red one shows the position of the center of mass of the IM and the green one below identifies the center of mass of the TM. Fig. 1(b) shows the payload in equilibrium once the center of mass of the IM has moved to the left and has produced a tilt of the payload.

As a consequence of the limited elasticity of the 200 µm piano wires (with a Young's modulus of 190 GPa) which hold the TM, there is a displacement of the center of mass of the TM. This in turn produces a torque in the opposite direction than the torque produced by the center of mass of the IM. The equilibrium condition is characterized by the equation

$$\tau_{IM} + \tau_{TM} + \tau_{RM} = 0,$$

where each term represents the torque of one of the bodies of the payload. The horizontal displacement is $d_{TM} = 2l_b \sin\theta$, where l_b, which is the distance from the bending point to the clamping point, is

$$l_b = \sqrt{\frac{EI}{T}},$$

θ is the tilt of the payload, E is Young's modulus, T is the tension, $I = \pi d^4/64$ is the second moment of area and d is the diameter of the wire.

According to the 3D CAD model, the position of the centers of mass of the TM and RM (in meters) with respect to the bending point are

$$R_{TM} = (\,d_{TM}\,, -587 \times 10^{-3}\,, 0\,) + (\,0\,, 0\,, 1 \times 10^{-3}),$$

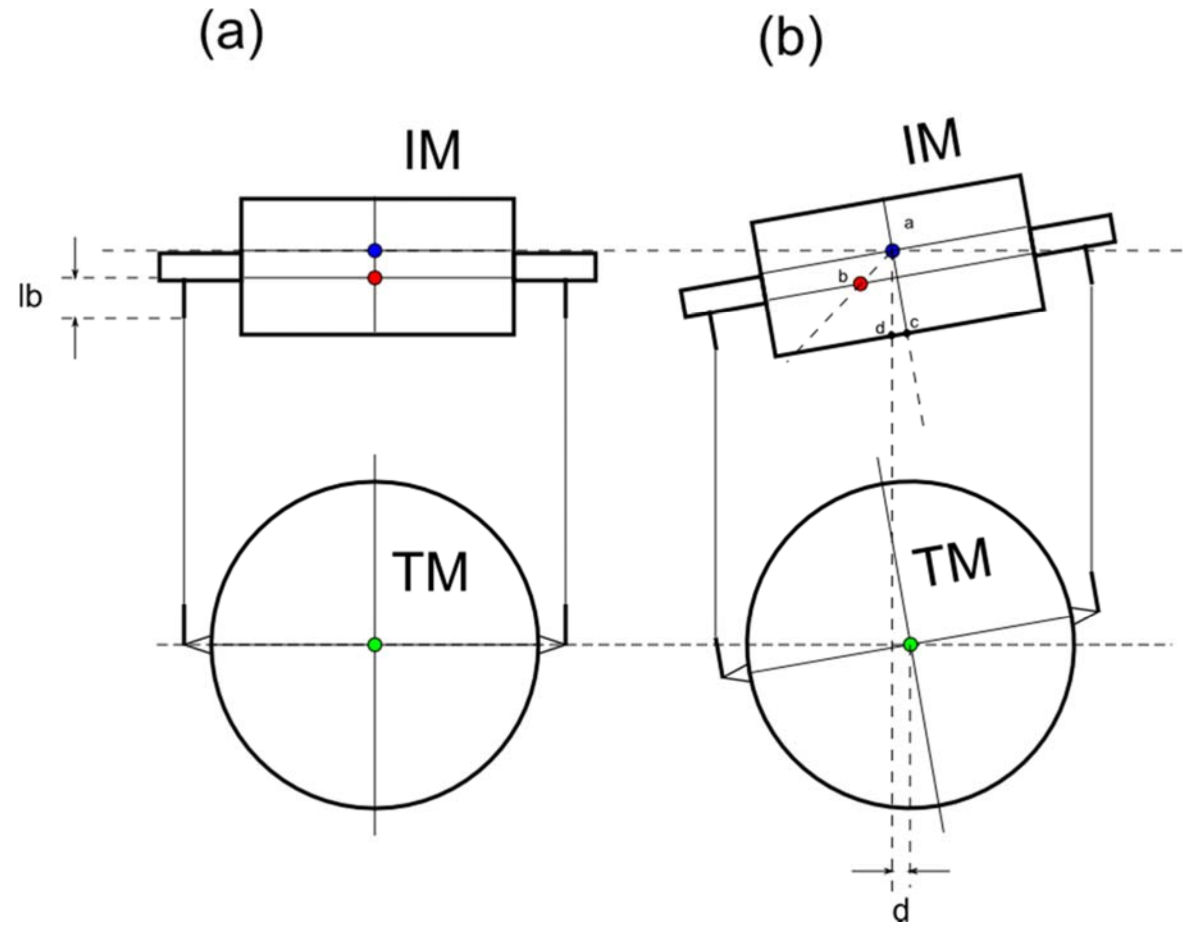

Figure 1. When the payload is tilted the centers of mass of the IM and TM produce torques in opposite directions.

$$R_{TM} = (\, d_{RM}\, , -587 \times 10^{-3}\, , 0\,) + (\, 0\, , 0\, , 1 \times 10^{-3}).$$

The torques can then be calculated as usual:

$$\begin{aligned} \tau_{TM}(\theta) &= R_{TM}(\theta) \times W_{TM}, \\ \tau_{RM}(\theta) &= R_{RM}(\theta) \times W_{RM}, \end{aligned}$$

where W_{TM} and W_{RM} are the weights of the TM and RM. Please note that these torques are a function of the tilt θ.

The torque produced the IM can be written as

$$|\tau_{IM}| = m_{IM}g\,|R_{IM}(x,z)|\sin[\alpha(x,z) - \theta],$$

where $\alpha = \measuredangle bac$ and $\theta = \measuredangle dac$. In this equation $R_{IM}(x,z)$ and $\alpha(x,z)$ are functions of the displacement (x,z) of the moving bodies inside the IM.

Solving Eq. (1) for θ provides the following plot for roll (x, z=0):