

The Optical Lever
 Longitudinal Coupling
 J. Kissel, T. Vo
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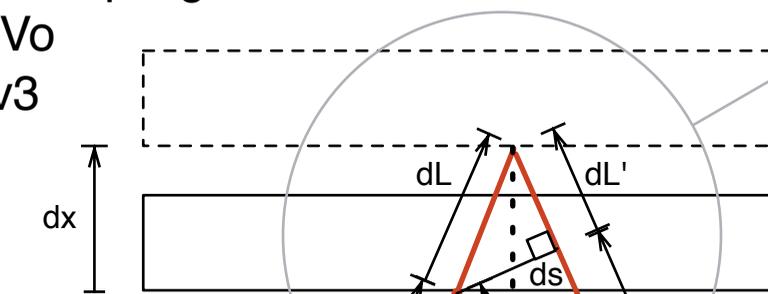
(Follow the enumerated thought process)

(2) Initially, the source is projected onto the mirror (thick dotted line).

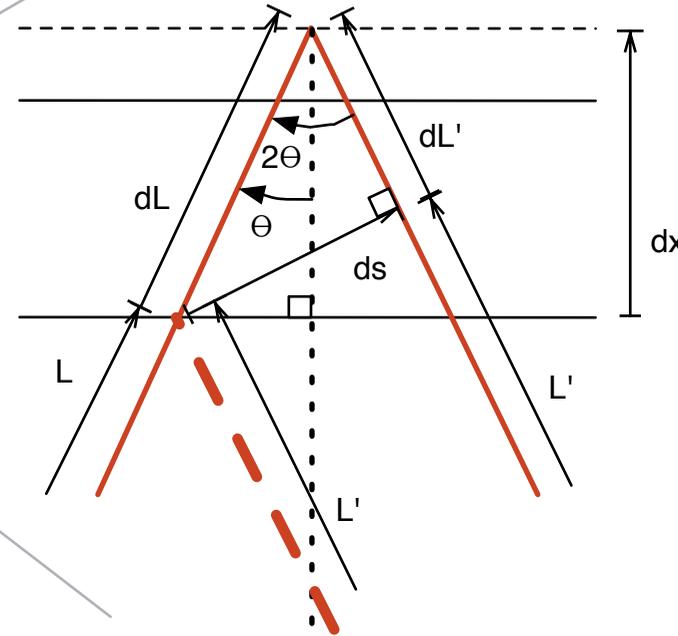
(1) The mirror is initially stationary and aligned, with its normal at $\theta=0$

(3) Initially, the light reflects off the optic and hits the fixed QPD at point P_i

(6) And the spot has moved a displacement ds to P_f .



(4) The mirror then displaces longitudinally by an distance dx



(5) This increases the total path length from $L + L'$ to $L + dL + dL' + L'$

(7) The displacement on the QPD is:
 $dL = dx / \cos(\theta)$

$$ds = dL \sin(2\theta) = dx \sin(2\theta) / \cos(\theta) = 2 dx \sin(\theta)$$

(8) This displacement ds is misinterpreted as an angular displacement $d\theta$:

$$\Rightarrow d\theta = ds / (2L) = 2 dx \sin(\theta) / (2L) = dx (\sin(\theta) / L)$$

(9) This cross-coupling assumes the lever sits on the plane of the vertical Center of Mass, and the QPD crosshairs are aligned to the plane, and therefore yaw-only. If the triangle plane is rotated about the optical axis (e.g. the laser is higher than the receiver), then rotates ds with respect to our pitch and yaw coordinates.

(10) The projection of our ds in pitch or yaw, is merely the component of ds with respect to that angle of rotation, ϕ
 $ds'(\text{pitch}) = ds \sin(\phi) = 2 dx \sin(\theta) \sin(\phi)$
 $ds'(\text{yaw}) = ds \cos(\phi) = 2 dx \sin(\theta) \cos(\phi)$

$$\Rightarrow d\theta'(\text{yaw}) = ds'(\text{yaw}) / (2L) = (dx / L) \sin(\theta) \cos(\phi)$$

$$d\phi'(\text{pitch}) = ds'(\text{pitch}) / (2L) = (dx / L) \sin(\theta) \sin(\phi)$$

