Suspension Angular Stability

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Basic Idea

- Angular misalignment introduces a torque on the suspended mirrors
  - De-centered beam & intrinsic misalignment (T030039-00)
    => alignment fluctuations change cavity power
  - Purely geometrical (John Sidles & T030120-00)
    => alignment fluctuations change cavity axis
- If radiation induced torque becomes larger than restoring torque of torsion pendulum
  => Angular instability
- Any cavity with suspended masses can become unstable at high power!

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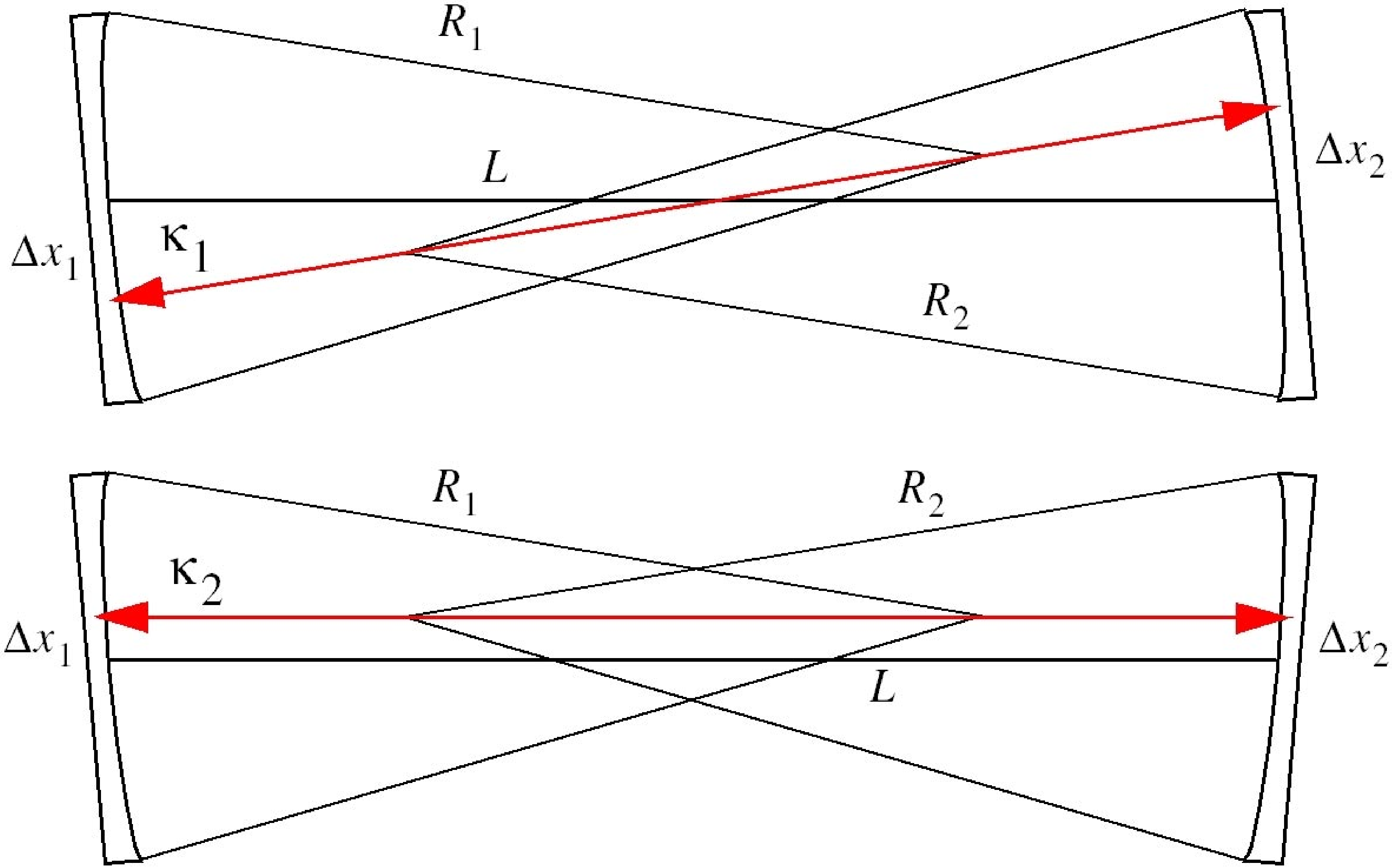
Cavity Geometry



Formulae

Cavity Axis:

$$\Delta x_1 = \frac{g_2}{1-g_1g_2}L\alpha_1 + \frac{1}{1-g_1g_2}L\alpha_2$$

$$\Delta x_2 = \frac{1}{1-g_1g_2}L\alpha_1 + \frac{g_1}{1-g_1g_2}L\alpha_2$$

Torsion Pendulum:

$$\frac{d^2}{dt}\vec{\alpha} = -(\Omega^2 + \omega^2)\vec{\alpha}$$

$$\Omega^2 = -\frac{2PL}{\Theta c}K \quad \text{and} \quad K = \begin{pmatrix} \frac{g_2}{1-g_1g_2} & \frac{1}{1-g_1g_2} \\ \frac{1}{1-g_1g_2} & \frac{g_1}{1-g_1g_2} \end{pmatrix}$$

$$\omega = \bar{\omega}\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

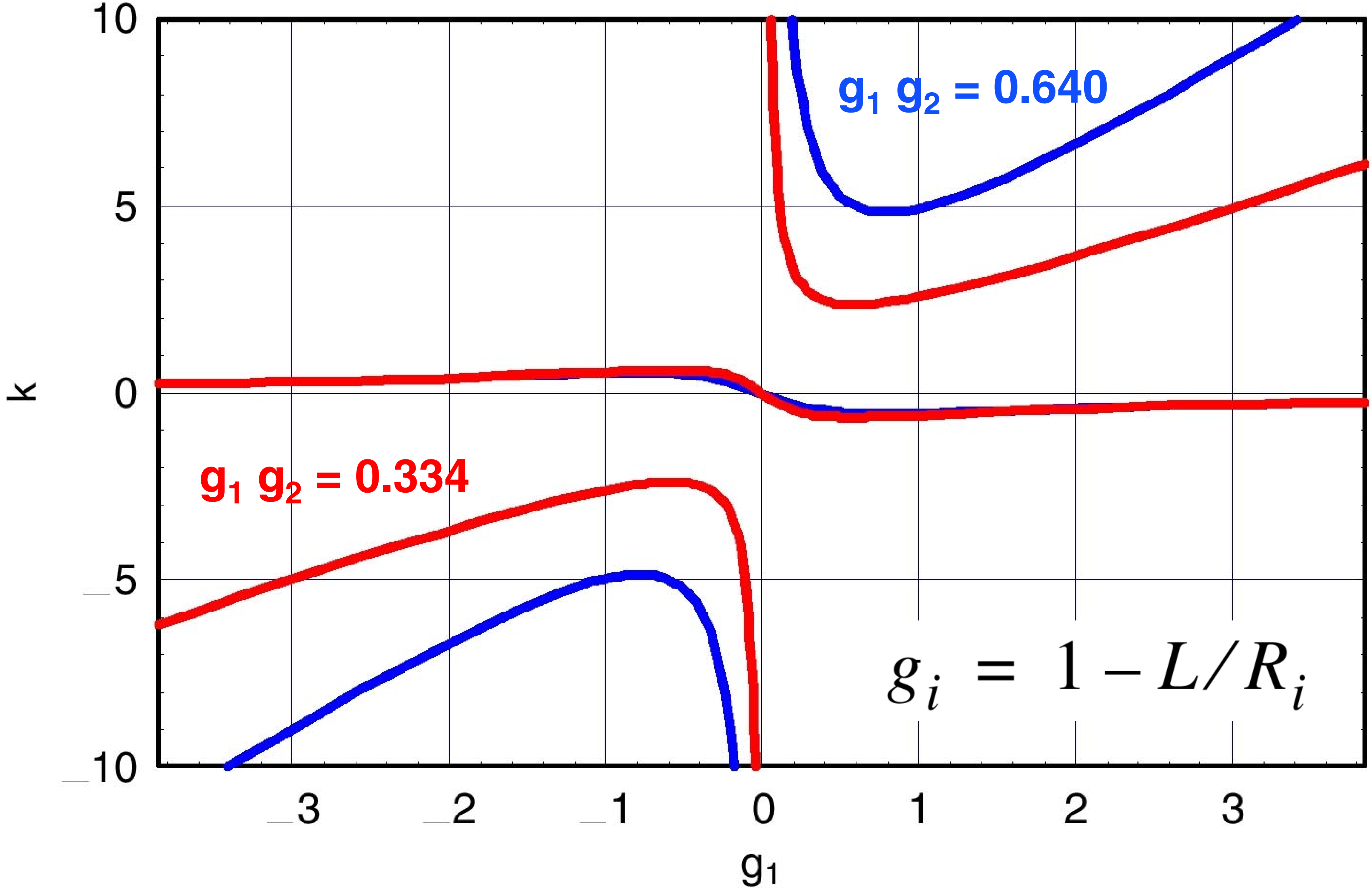
Stability Criterion:

$$k_i < \frac{\Theta c \bar{\omega}^2}{2PL}$$

$$\det K = -\frac{1}{1-g_1g_2}$$

Always one stable and one intrinsically unstable solution

Eigenvalues of K



Critical Power

	LIGO 4K	Adv. LIGO'
ETM curvature	7400m	2200m
ITM curvature	14600m	2200m
g_1	0.460	-0.800
g_2	0.726	-0.800
k_1	2.40	-5.01
k_2	-0.624	0.556
$P_{critical}$	7.3kW	198kW