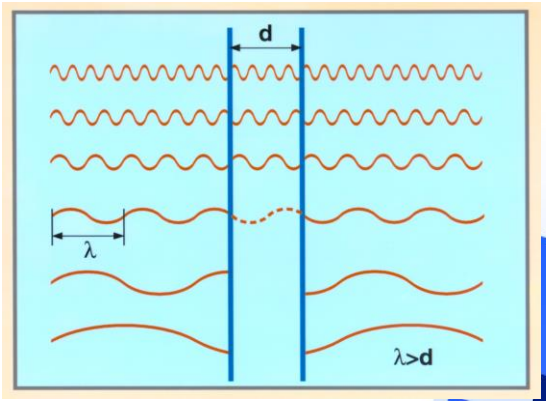
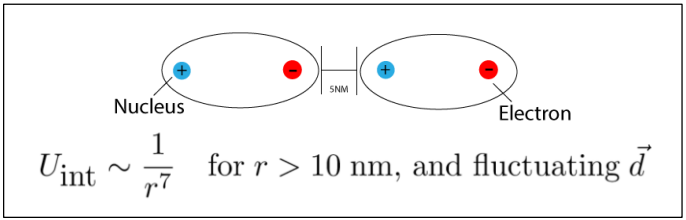
Casimir Friction at Finite Temperature

Aaron Swanson
Dr. Kim Milton

Origin of Quantum Vacuum Physics

- Two neutral conducting plates in a vacuum environment attract each other
- Explainable via zero-point energy OR via long range van der Waals forces



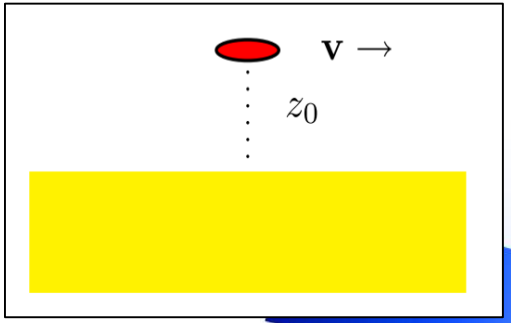


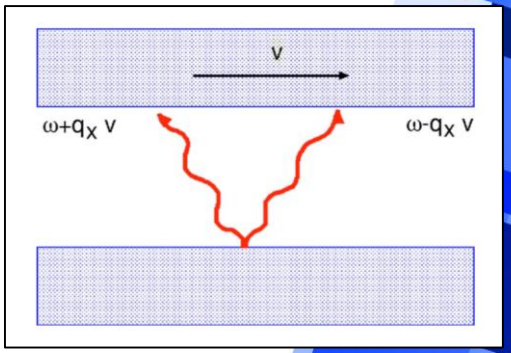
$$U_{\text{int}} \sim \frac{1}{r^7} \quad \text{for } r > 10 \text{ nm, and fluctuating } \vec{d}$$

Hendrik Casimir

Casimir Friction

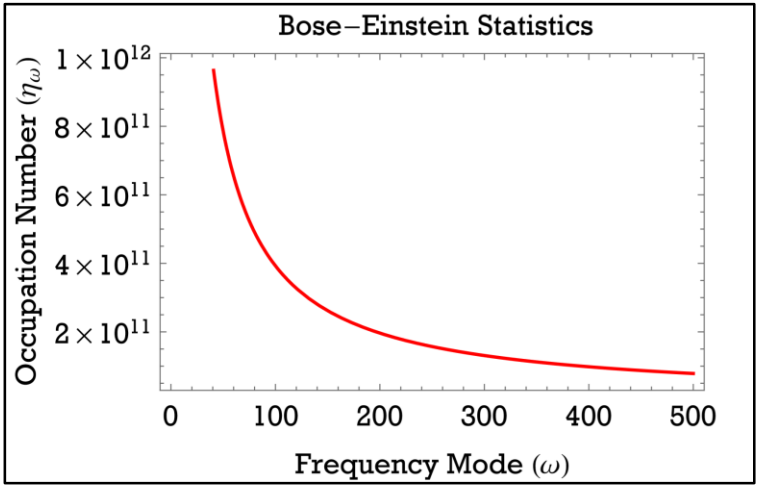
- When an atom travels parallel to a dielectric slab with some v, it experiences lateral "friction"
- Differing theoretical methods, differing physical interpretations
- At T=0, with typical parameters, $F \sim 10^{-21}$ N
- Could finite temperature make Casimir friction physically relevant?





Task: Incorporate Temperature

- Assume relativity
- Use fluctuation-dissipation relations to incorporate Bose-Einstein statistics
- T>0 case not entirely tractable yet



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(Note: blue font means corresponding to extra slides)

Web Image Sources

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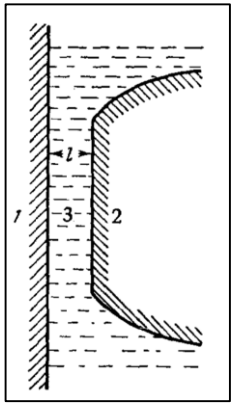
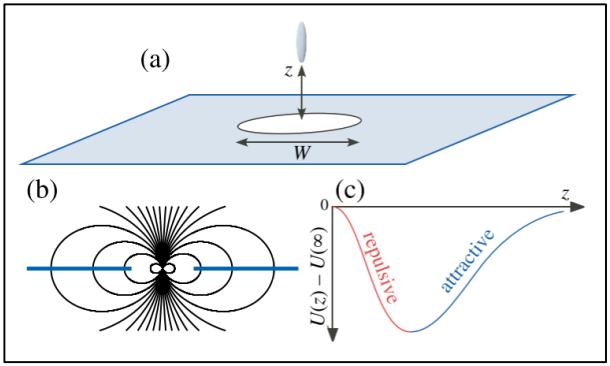
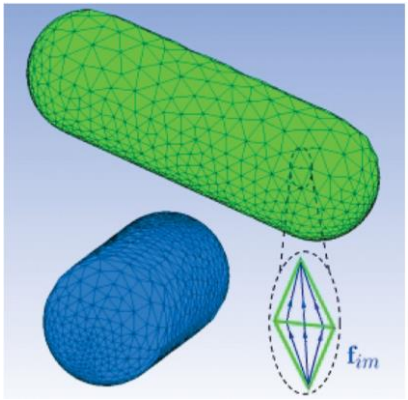
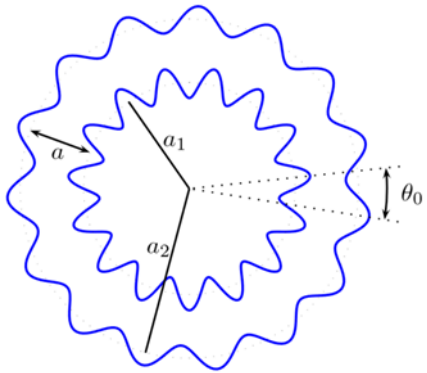
http://www.ipam.ucla.edu/wp-content/uploads/2017/03/Julian-Schwinger.jpg

Development and Impact of Casimir Physics









Basic Formalism: Source Theory

- No zero-point energy; instead, Green's function emphasis:

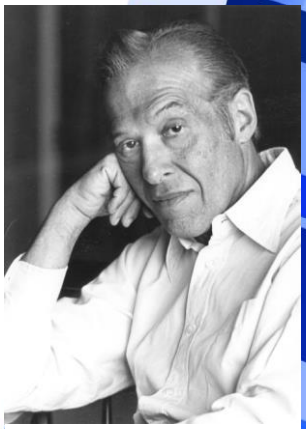
$$\left[\frac{1}{\omega^2}\nabla\times\frac{1}{\mu(\omega)}\nabla\times-\varepsilon(\omega)\right]\vec{E}(x)=\vec{P}(x)$$

$$\left[\frac{1}{\omega^2}\nabla\times\frac{1}{\mu(\omega)}\nabla\times-\varepsilon(\omega)\right]\overleftrightarrow{\Gamma}(x,x')=\overleftrightarrow{1}\delta(x-x')$$

- Extract force by directionally varying effective action, the latter derived by

$$\delta_P W=\int \mathrm{d}x\;\delta P(x)E(x)$$

$$W_{ij}=\frac{1}{2}\int \mathrm{d}x\;\mathrm{d}x'\;P_i(x)\Gamma_{ij}(x,x')P_j(x')$$



Julian Schwinger