



# Eletrodinâmica Quântica em Baixas Energias

Felipe Rosa – IF/UFRJ – 04/2018

Mas espera aí um minutinho...  
Eletrodinâmica quântica??



<https://straightfromtherecliner.wordpress.com/tag/pinky-and-the-brain/>

Eletrodinâmica **Clássica**

*vs.*

Eletrodinâmica **Quântica**

# Eletromagnetismo **Clássico**

## Equações de **Maxwell**

$$\vec{\nabla} \cdot \hat{\mathbf{E}} = 4\pi\hat{\rho}$$

$$\vec{\nabla} \cdot \hat{\mathbf{B}} = 0$$

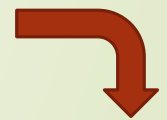
$$\vec{\nabla} \times \hat{\mathbf{E}} = -\frac{1}{c}\partial_t\hat{\mathbf{B}}$$

$$\vec{\nabla} \times \hat{\mathbf{B}} = \frac{4\pi}{c}\hat{\mathbf{J}} + \frac{1}{c}\partial_t\hat{\mathbf{E}},$$

# Eletrromagnetismo **Clássico**



Dispersão



Miragem

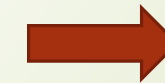
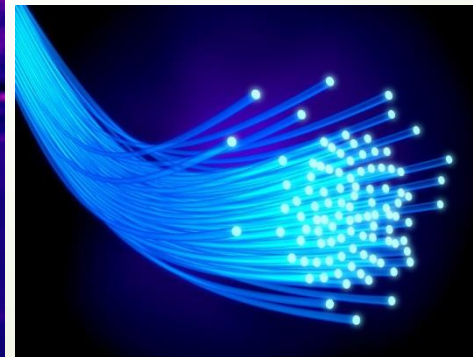
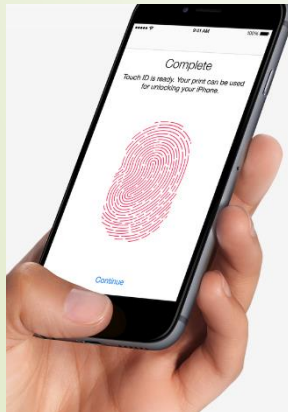
# Eletromagnetismo Clássico



<http://kids.britannica.com/elementary/art-90423/The-Very-Large-Array-is-a-group-of-27-bowl>



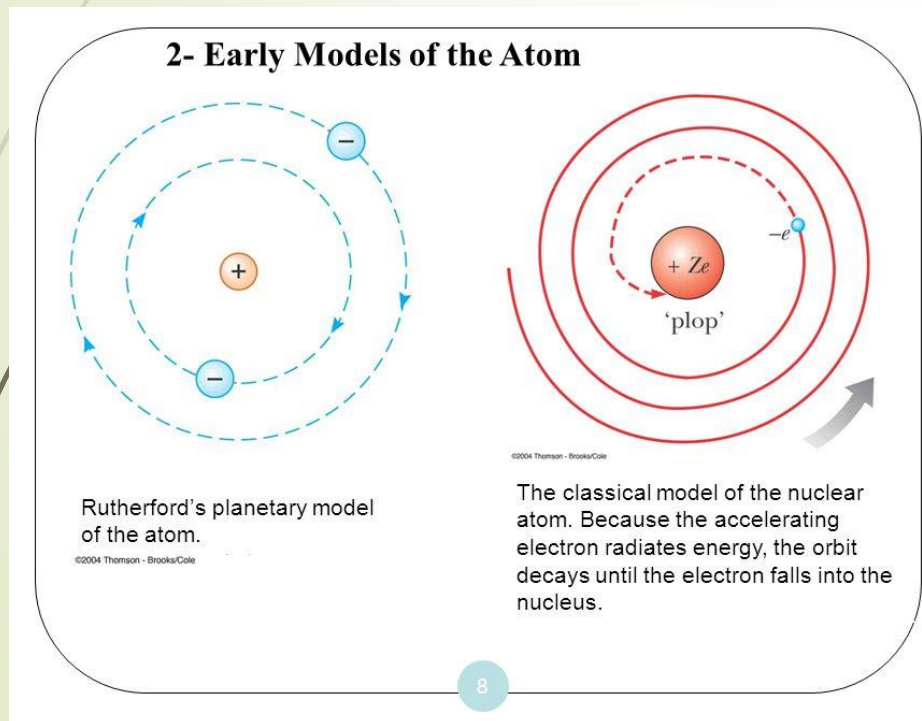
Maravilhas do mundo moderno...



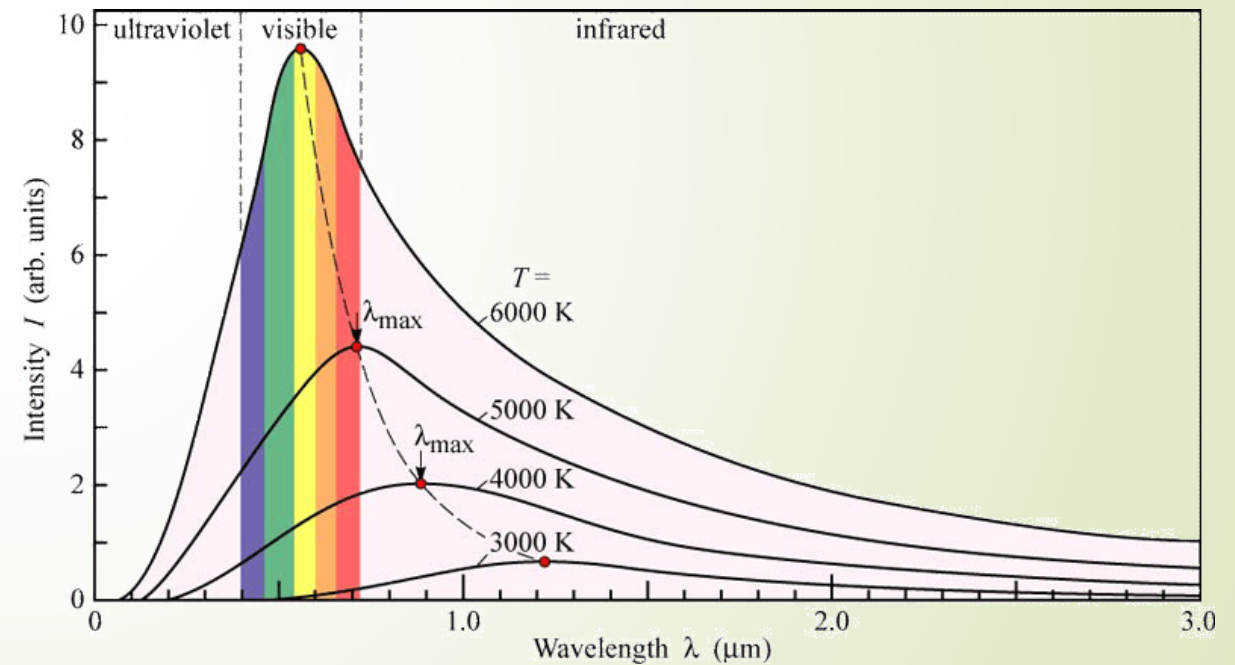
Maravilhas do mundo realmente moderno...

# Eletrromagnetismo Quântico

- Como explicar a estabilidade de certas órbitas atômicas?
- Como explicar o espectro de emissão de certos corpos?



<http://slideplayer.com/slide/257194/>



<https://www.skepticalscience.com/empirical-evidence-for-co2-enhanced-greenhouse-effect-advanced.htm>

# Eletromagnetismo Quântico



+



$$\langle \vec{E} \rangle = 0 \quad \text{mas} \quad \langle E^2 \rangle \neq 0!!$$

# Forças Dispersivas

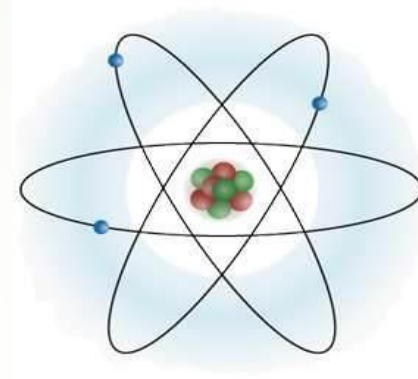
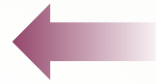
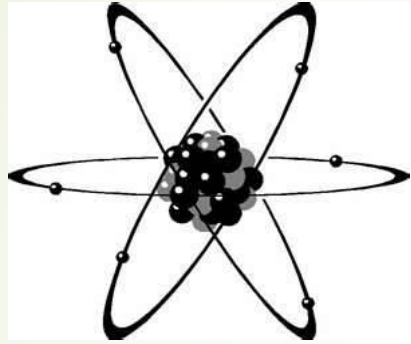
**Forças** entre objetos sem densidade de carga permanente.



A **condensação** sugere a existência de tal força.

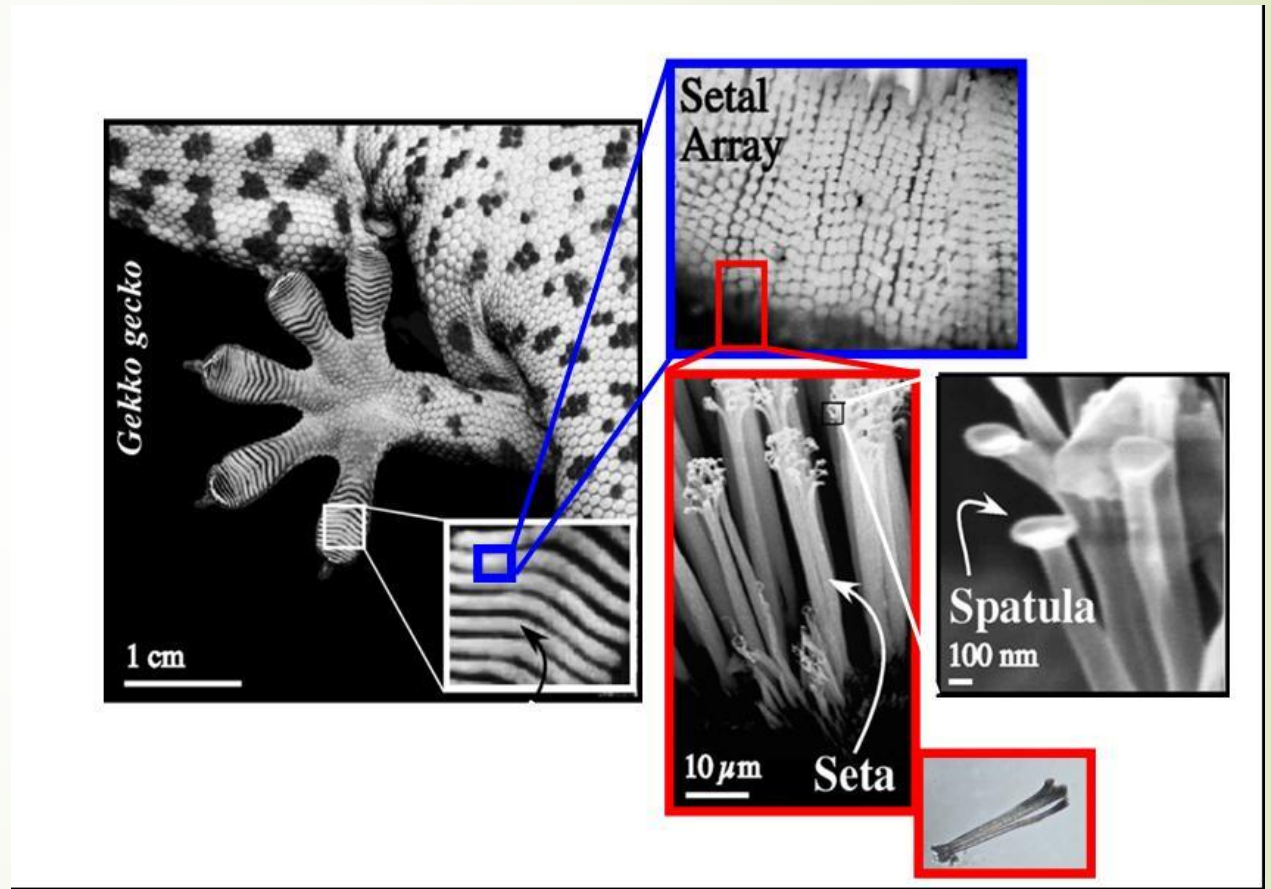


## Forças Dispersivas – van der Waals



$$U_{vdW} = -\frac{C}{r^6} \quad K \approx \frac{3}{2}k_B T$$

## Forças Dispersivas - Lagartixas



<https://ouchmath.wordpress.com/2011/04/26/gecko-adhesion-and-nanotechnology/>

## Forças Dispersivas – Aranhas(!)



<http://www.theamazingspidermangame.com/>



Universidade de Kiel, Kiel, Alemanha

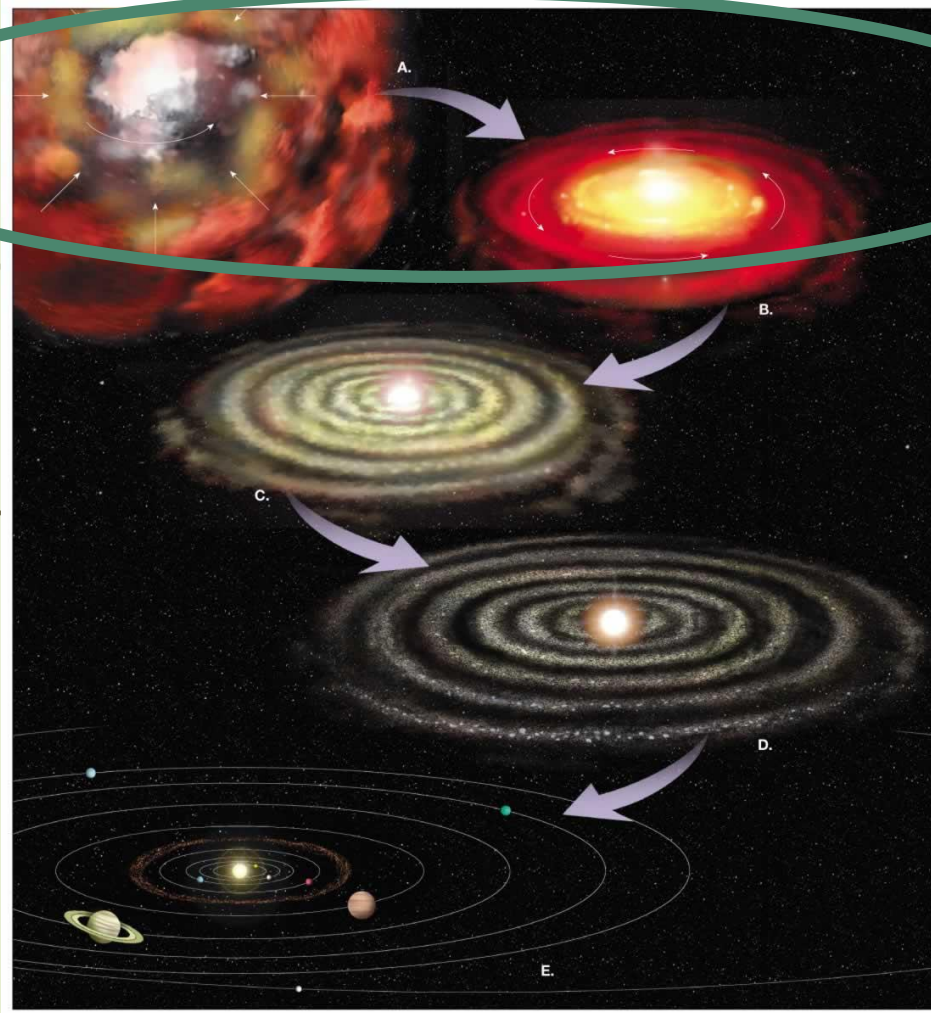
## Forças Dispersivas – Tormentas



<http://ohsinsider.com/insider-top-stories/lightning-safety-take-shelter-storm>



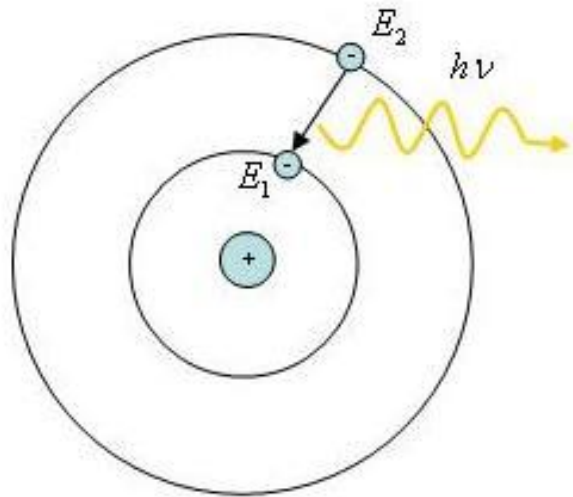
## Forças Dispersivas – Acreção de corpos celestes



**Início da acreção:  
forças dispersivas**

[http://jupiter.plymouth.edu/~sci\\_ed/Turski/Courses/Earth\\_Science/Intro.html](http://jupiter.plymouth.edu/~sci_ed/Turski/Courses/Earth_Science/Intro.html)

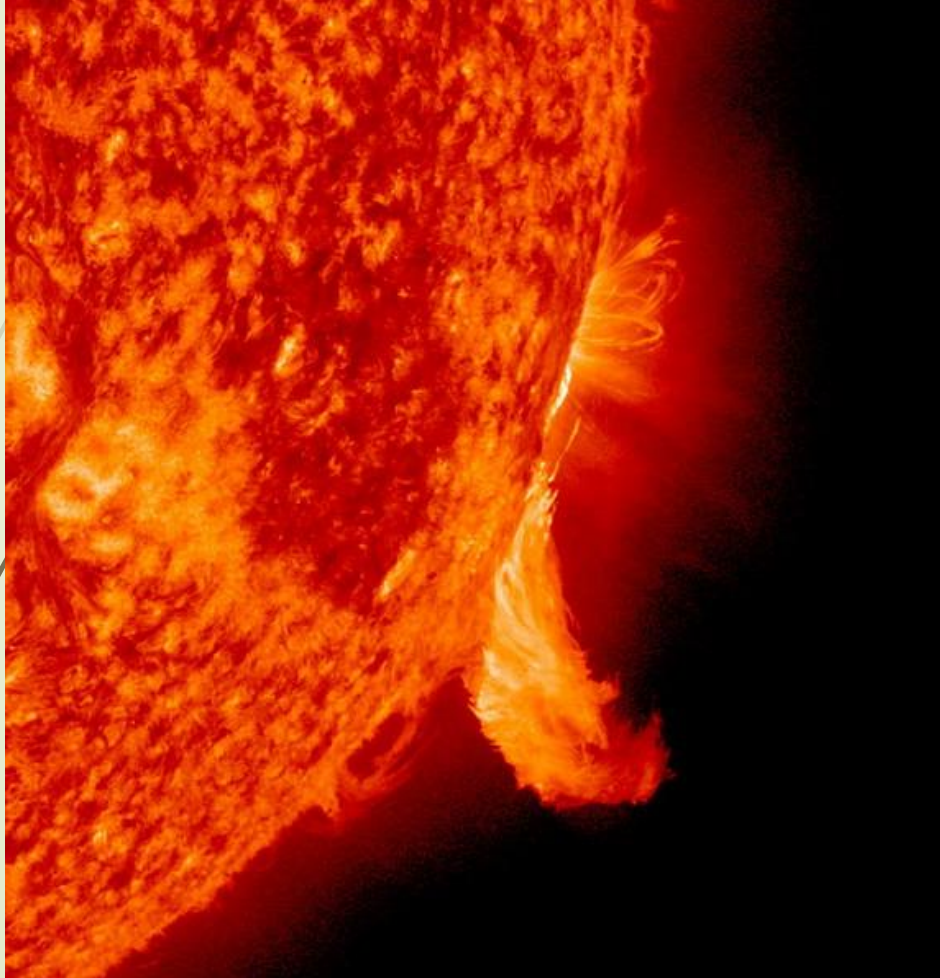
# Emissão Espontânea



O campo eletromagnético quantizado, mesmo em seu **estado fundamental** (**vácuo**), afeta os entes nele imersos!

[http://www.thespectroscopy.net/?Physical\\_Background:Atomic\\_Emission:Transition\\_Moments](http://www.thespectroscopy.net/?Physical_Background:Atomic_Emission:Transition_Moments)

## Emissão espontânea – muito comum



Mesmo a **T = 5500 K**, a EE é de longe a maior responsável pela emissão de luz solar!

# Emissão espontânea – muitos exemplos



**Luminescência**



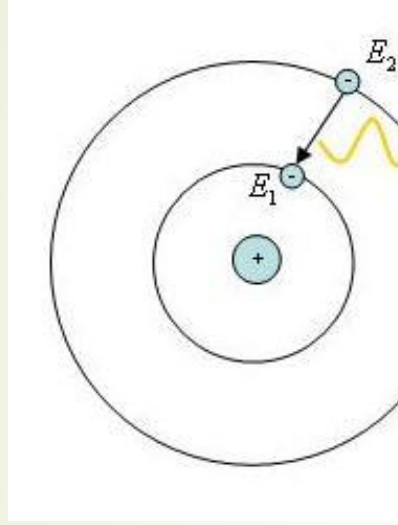
**Fosforescência**



**Fluorescência**



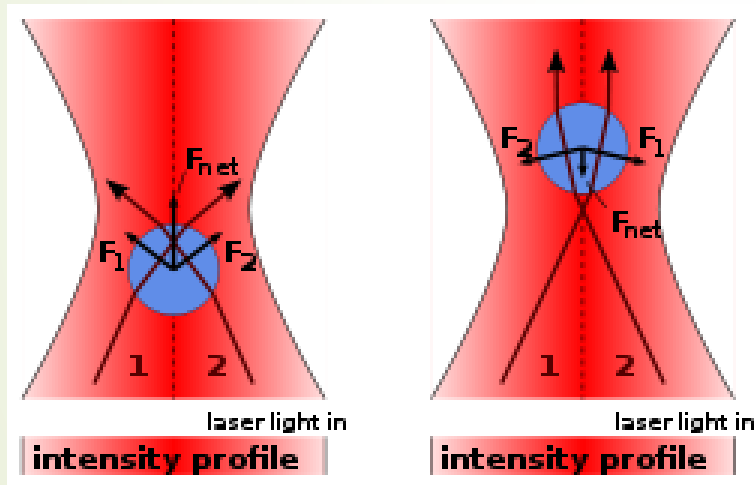
# The Purcell Effect



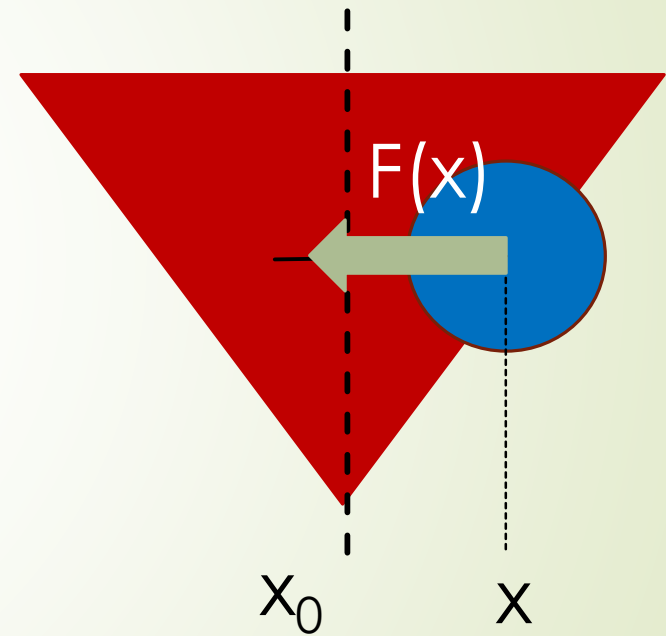
Alteration of SE by placing the emitter near macroscopic bodies!

# Atividade do grupo – Experimento

Interação com o **laboratório de pinças óticas**

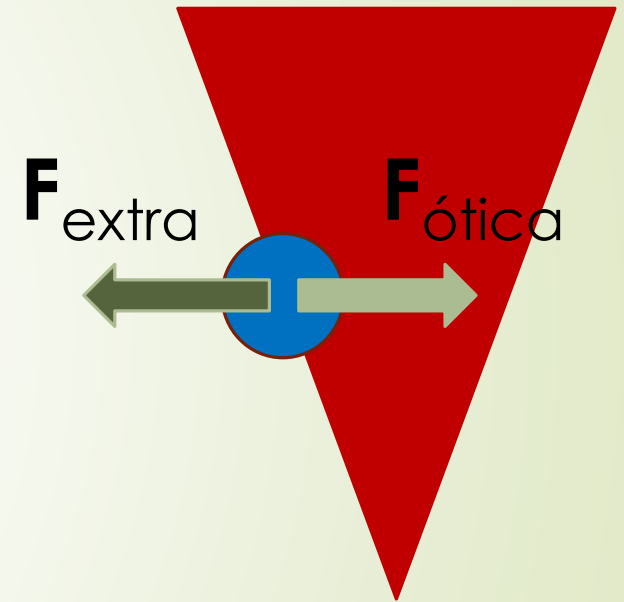
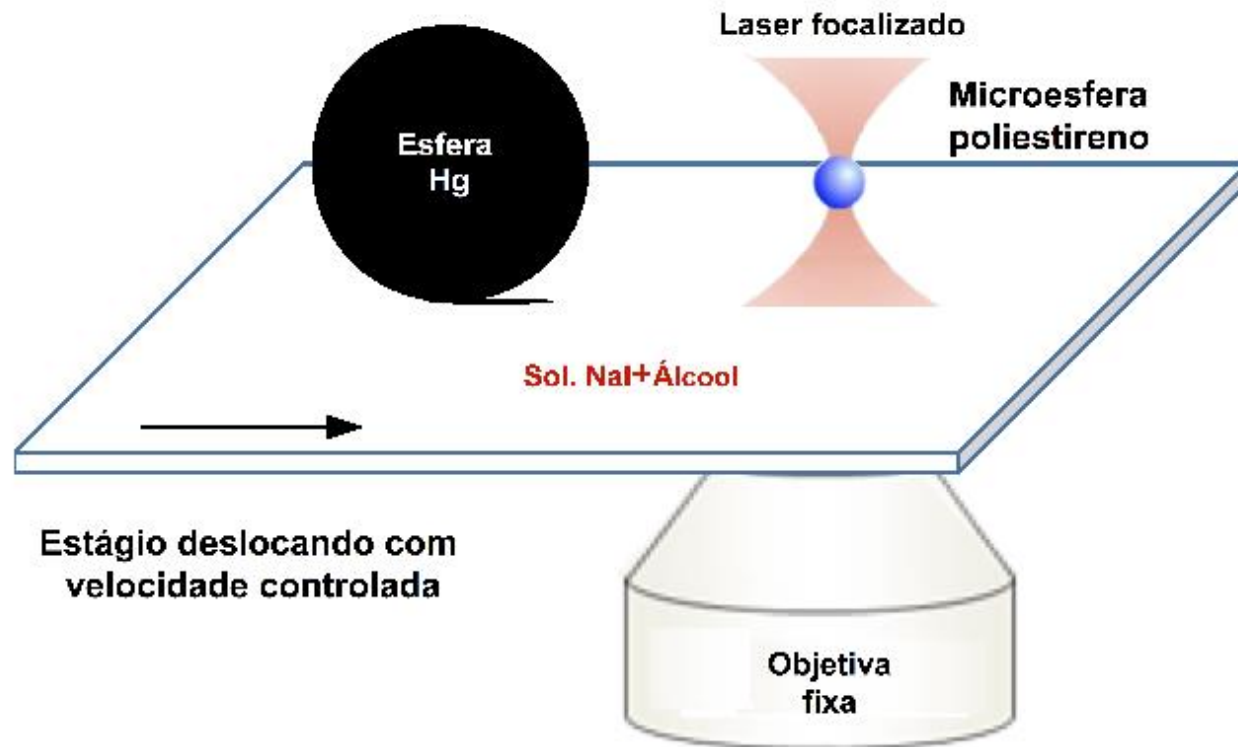


<http://en.academic.ru/dic.nsf/enwiki/180823>

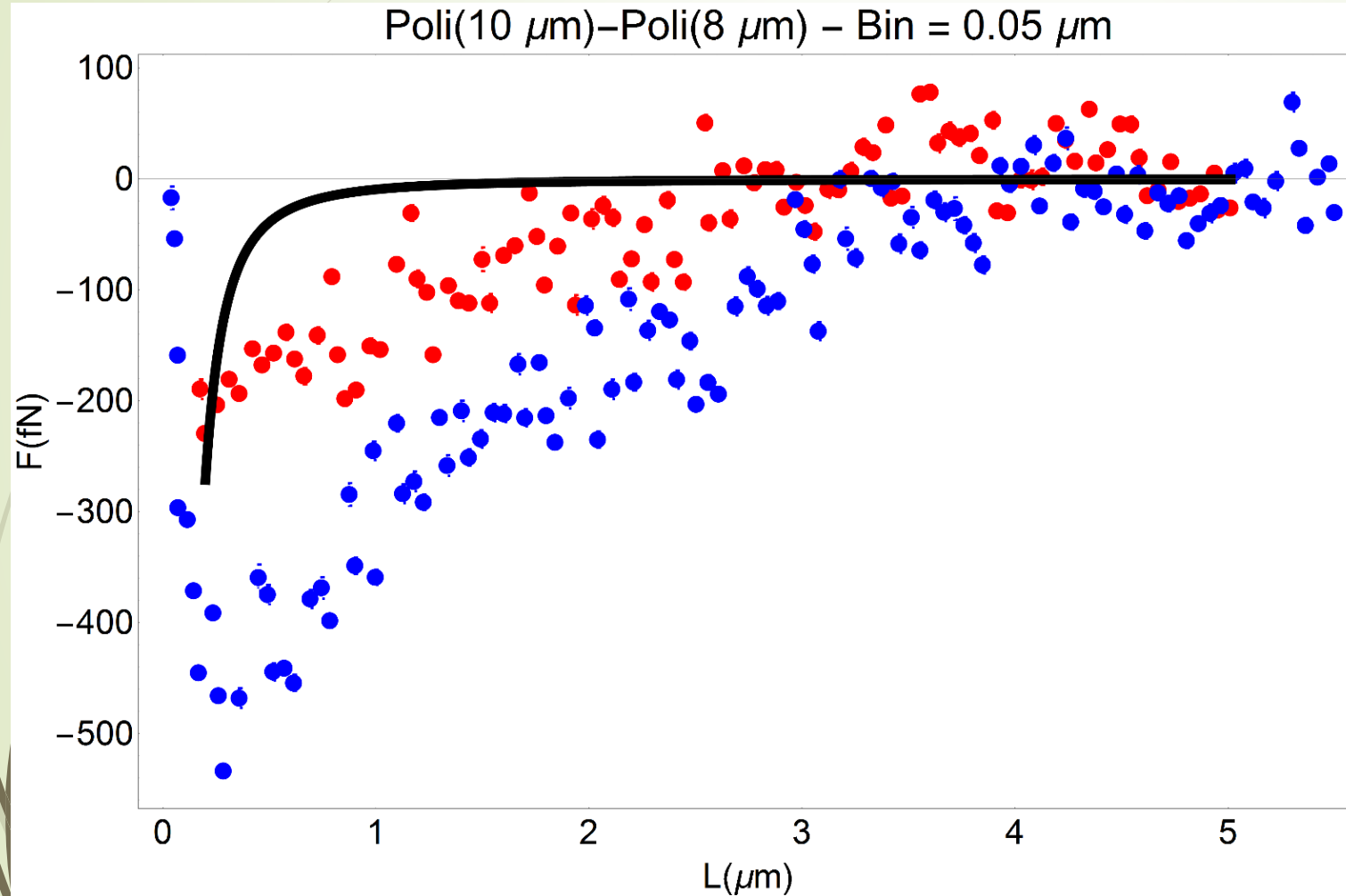


Aprisionamento de partículas com um único laser!

## Atividade grupo - Experimento



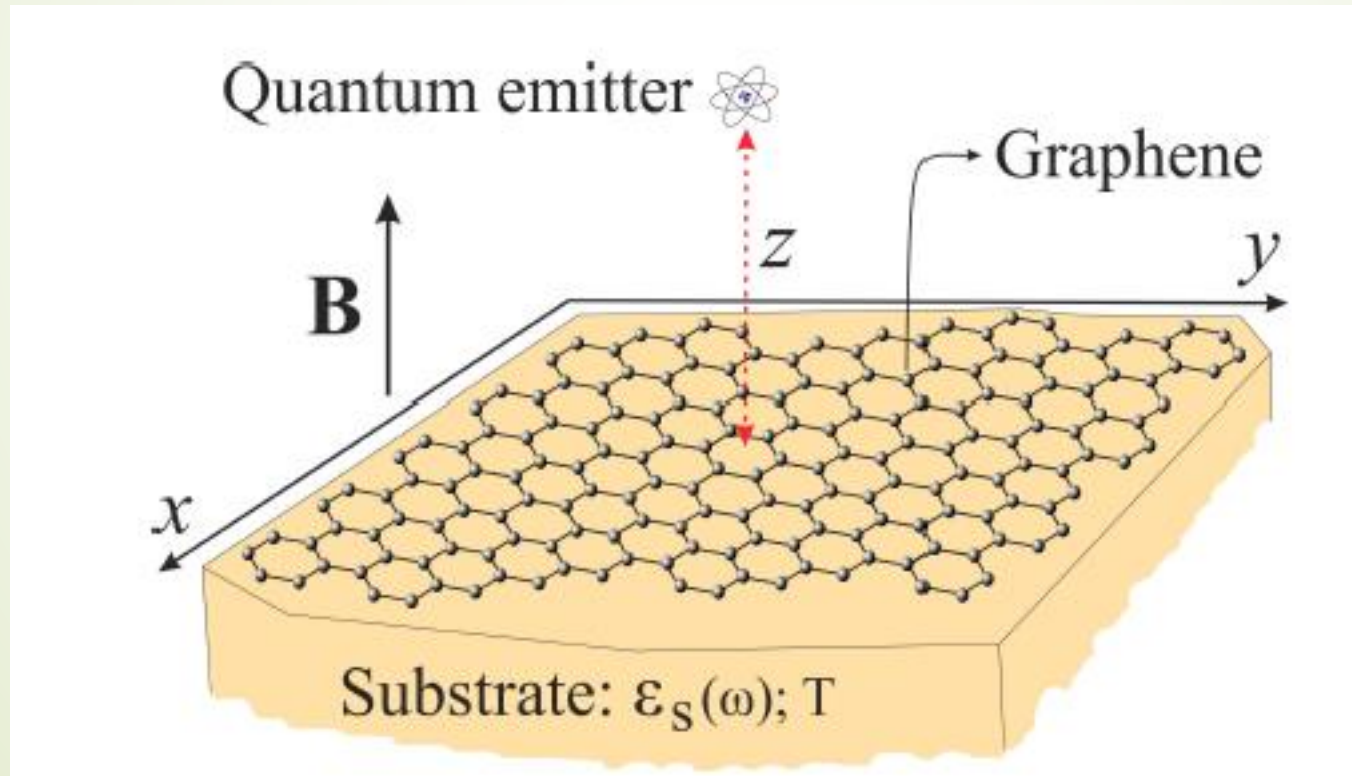
## Atividade grupo – Experimento - Resultados



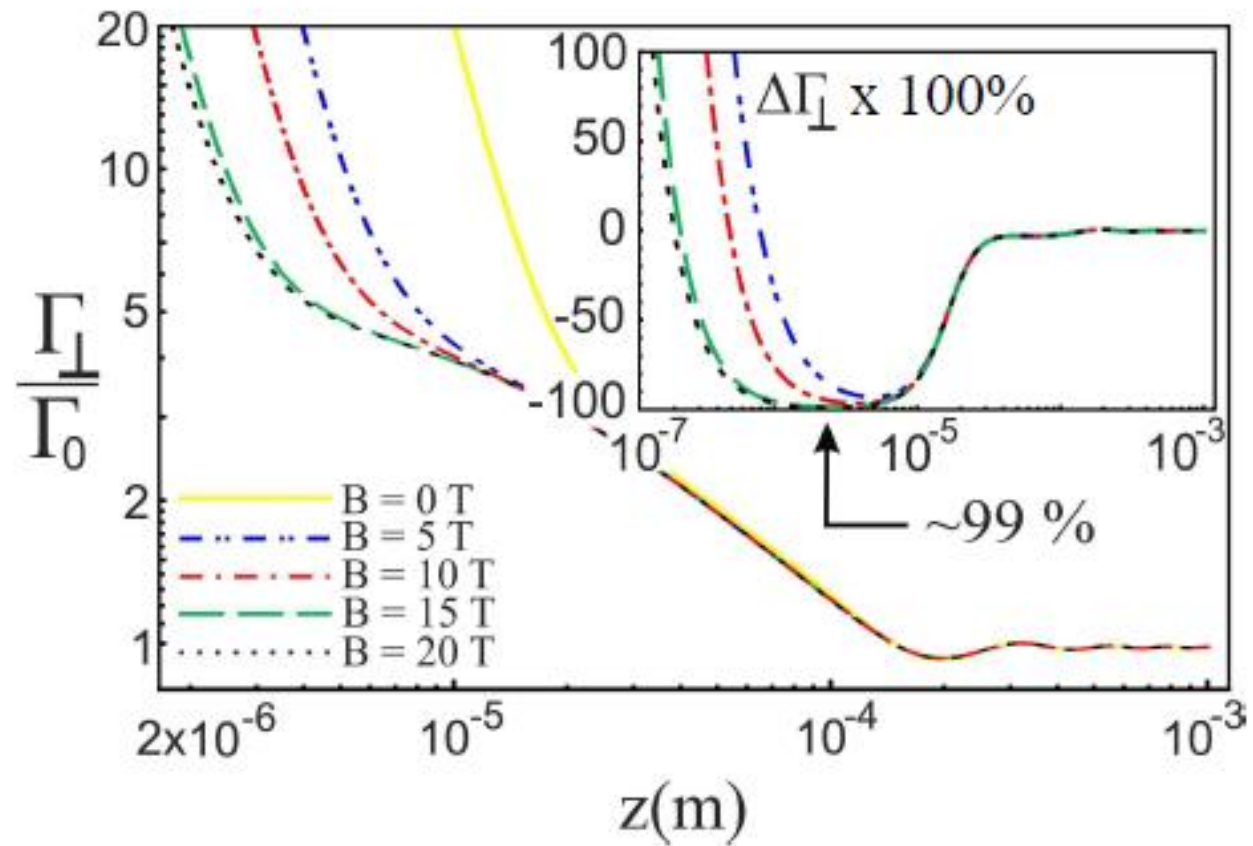
É sempre assim...

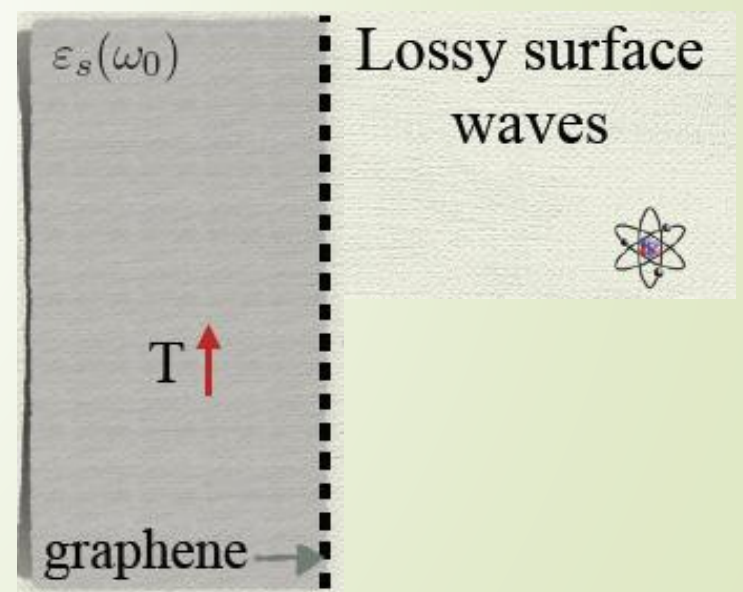
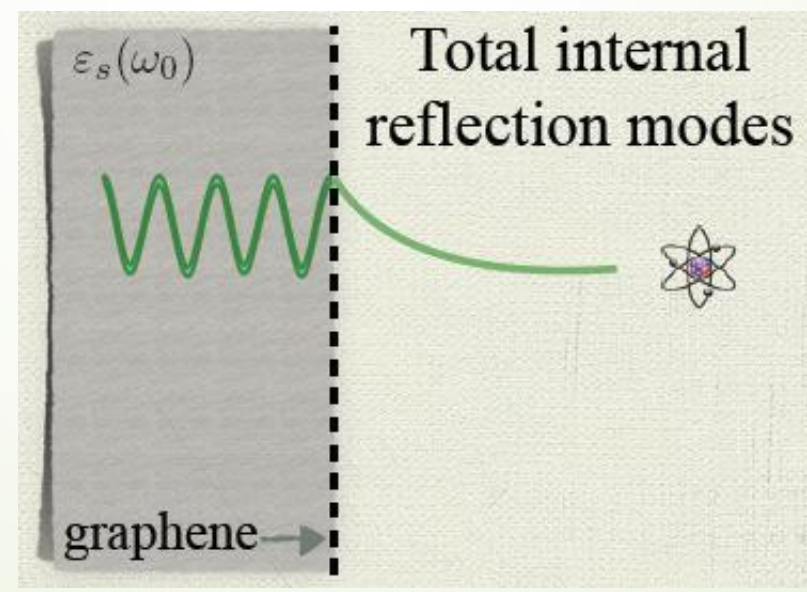
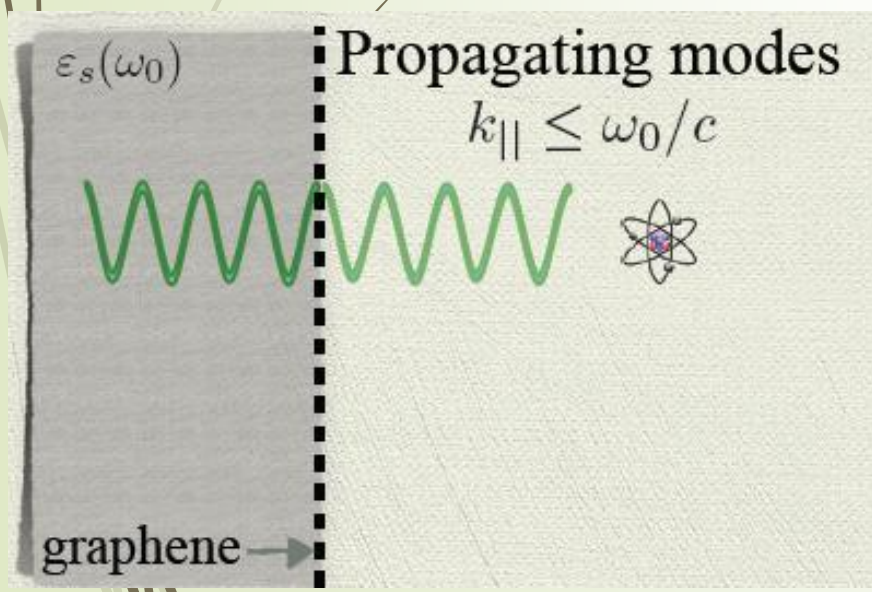
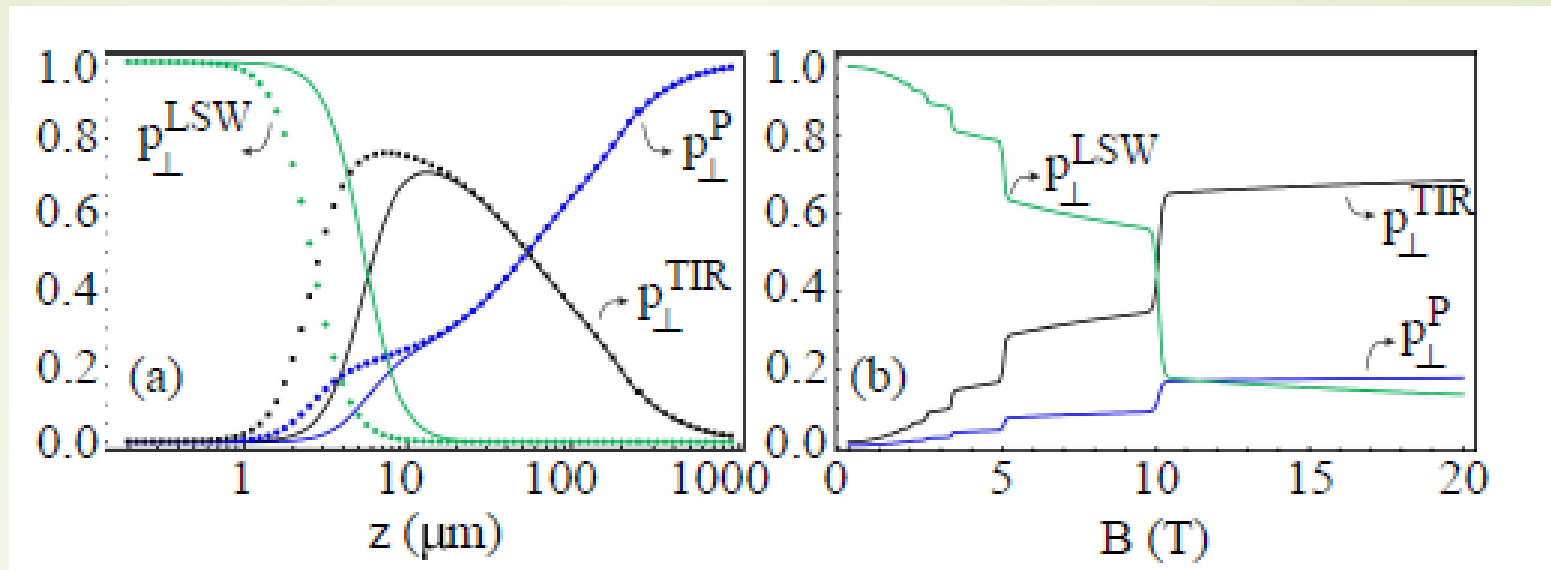
# Atividade grupo - Teoria

Controle da emissão espontânea com grafeno e campos magnéticos



# Atividade grupo





# O Grupo de Flutuações Quânticas (GFQ)



Prof. Carlos Farina



Prof. Paulo Américo



Prof. Marcus Venícius

- + Prof. Felipe Pinheiro
- + Prof. Nathan Viana (LPO)
- + Prof. François Impens
- + Prof. Moysés Nussenzveig (LPO)
- + Prof. Reinaldo Souza (IF-UFF)

+ Diney Ether (LPO), Mateus Lima, Daniela Szilard, Luis Pires (LPO), Vinicius Henning, Renan Nunes, Anna Batista, Marcius Vinicius, Rfaqat Ali, Patricia Abrantes, Yuri Muniz, Diego Oliver, Tarik Cysne...

+ Prof. Felipe Rosa

