# Física ao Vivo

2021

SOCIEDADE BRASILEIRA DE FÍSICA

acesse e participe:
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sugestões ou comentários:
fisicaaovivo@sbfisica.org.br

## Dia 28/04 - 19h


Ado Jorio
Departamento de Física - UFMG


*"O que é um nanoscópio?"*

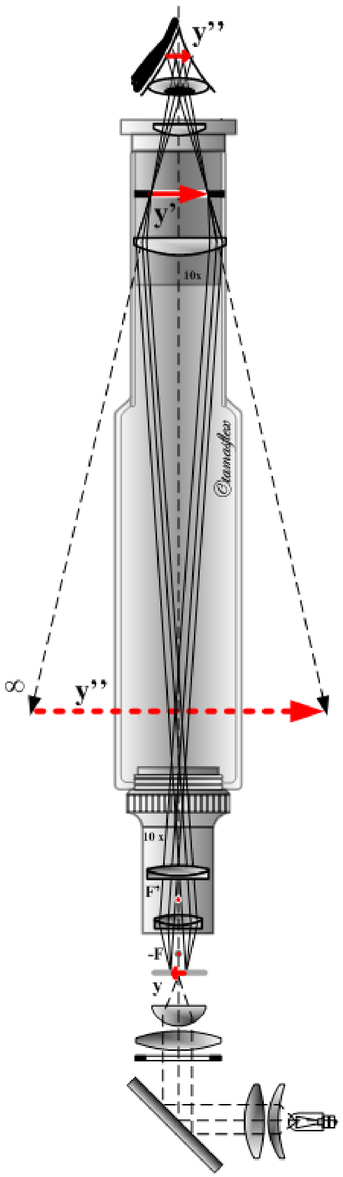
# *O que é um **microscópio**?*

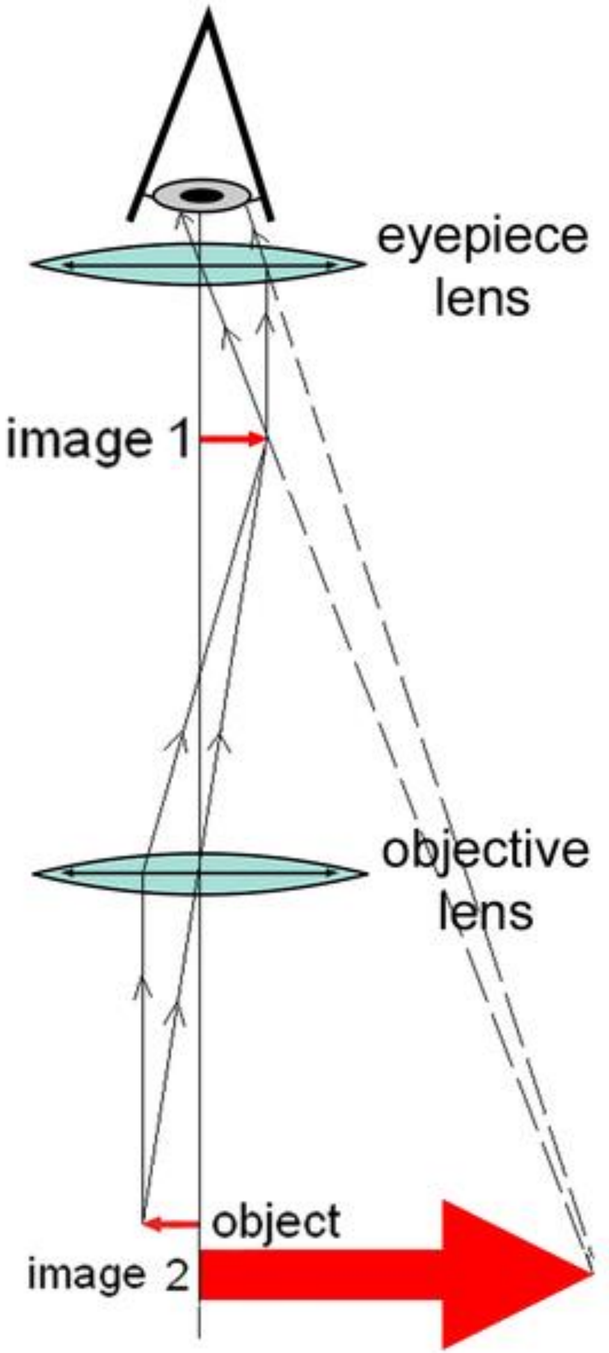
| | | |
|---|---|---|
| $10^{-6}$ | ***micrô**metro* (μm) | ***scópio*** |
| $10^{-3}$ | *milímetro* (mm) | |
| | *metro* (m) | |
| $10^{+3}$ | *kilômetro* (Km) | |
| $10^{+6}$ | *megametro* (Mm) | |

- contemplar
- olhar
- observar
- examinar
- vigiar

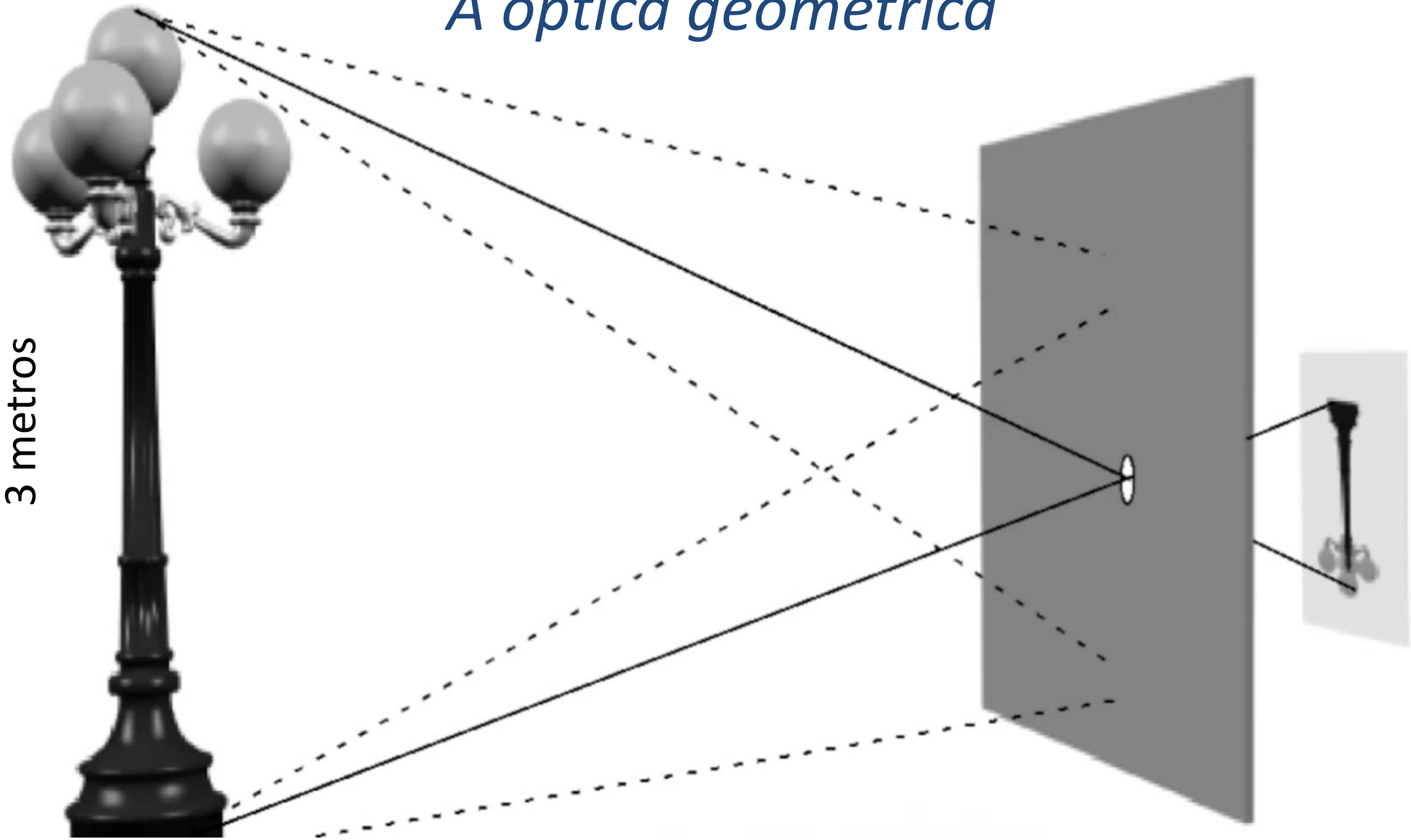
*do grego*

# *O que é um microscópio?*

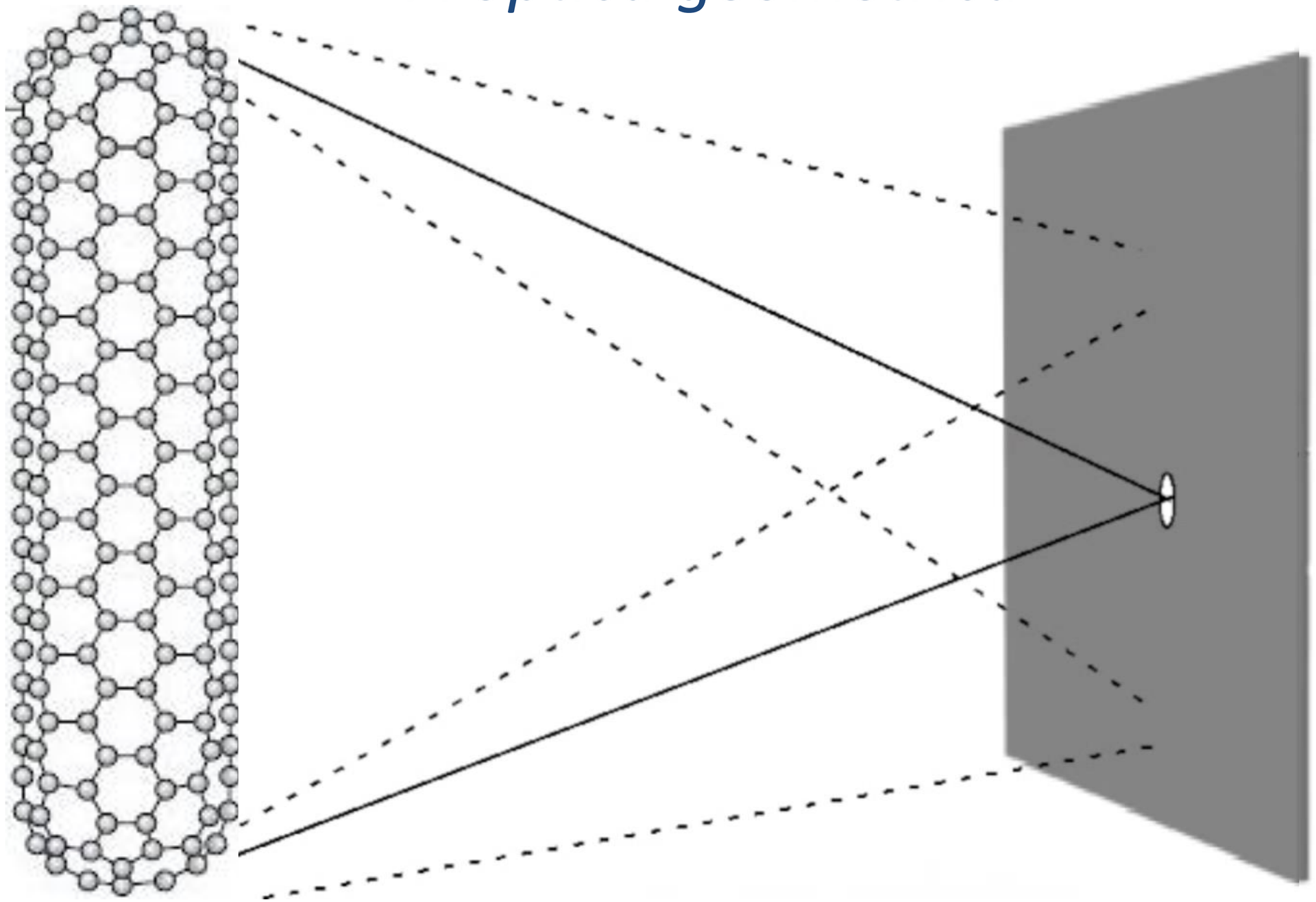



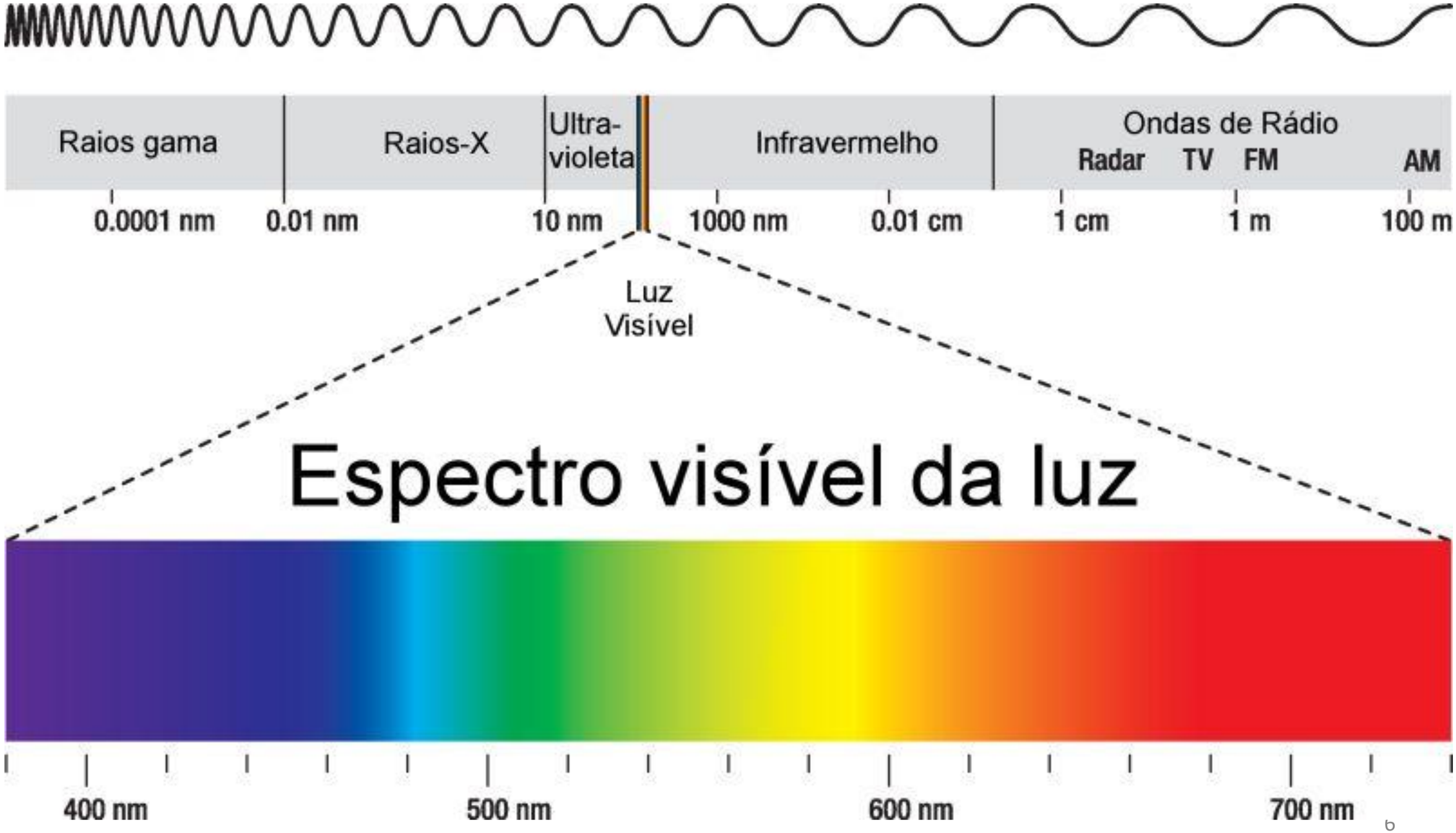
# A óptica geométrica

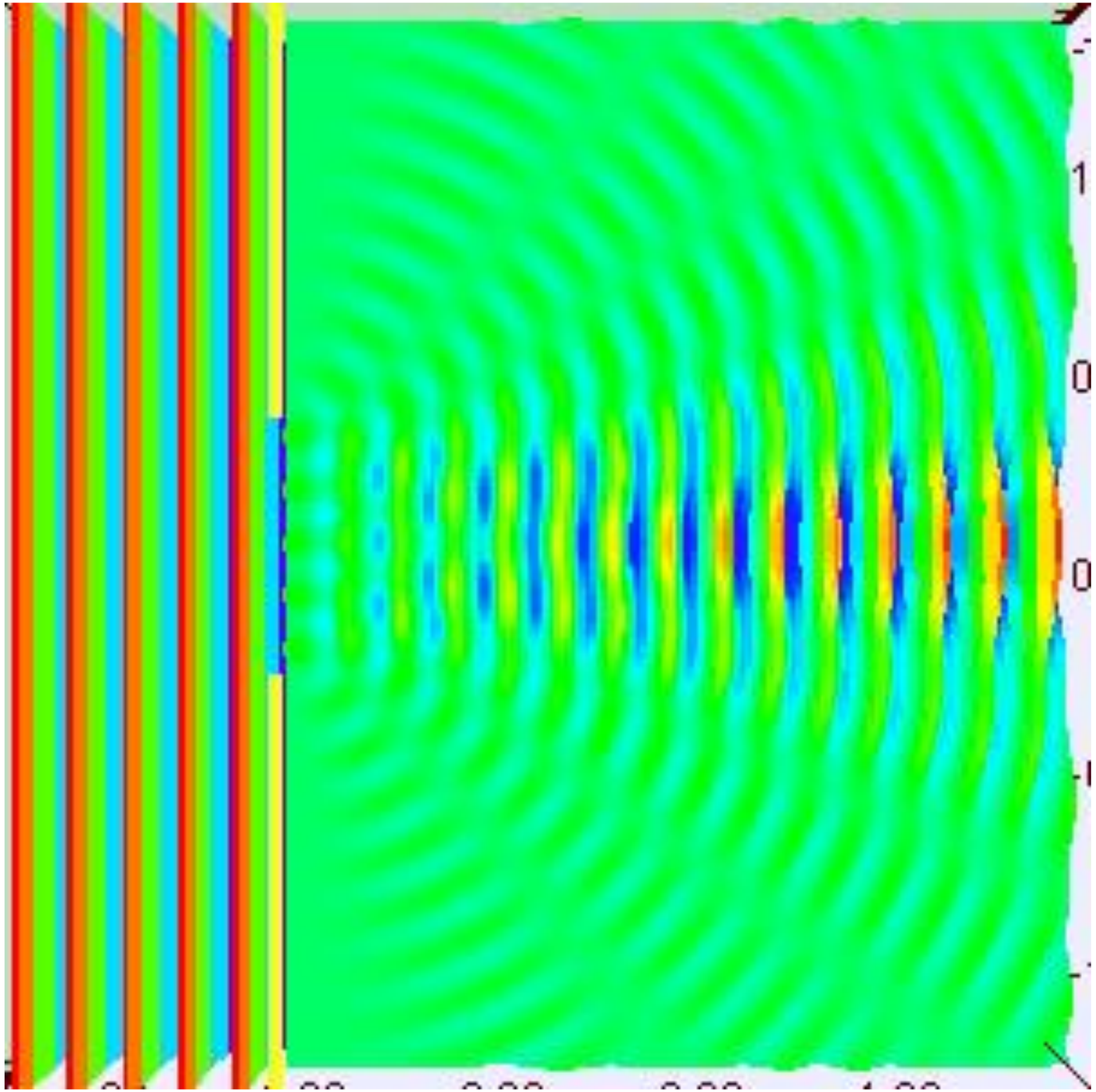


# *A óptica geométrica*

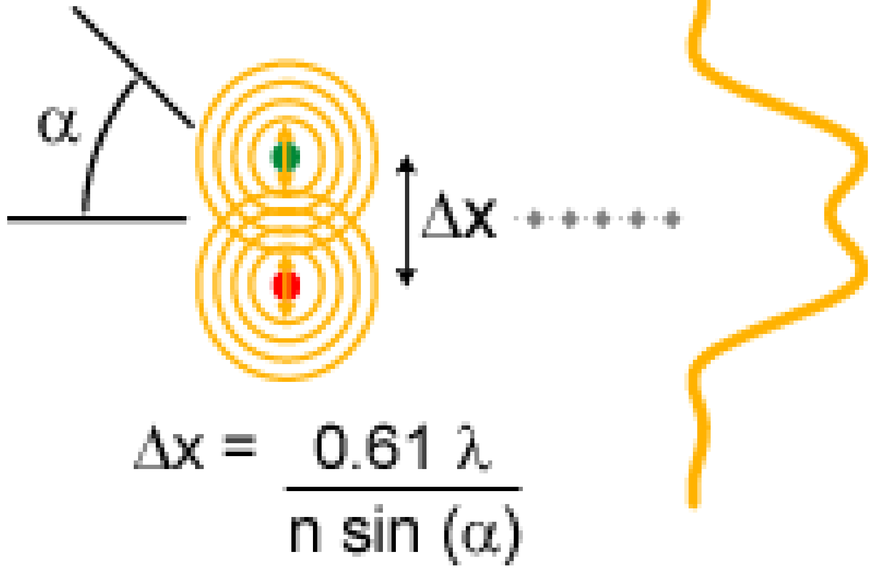



?

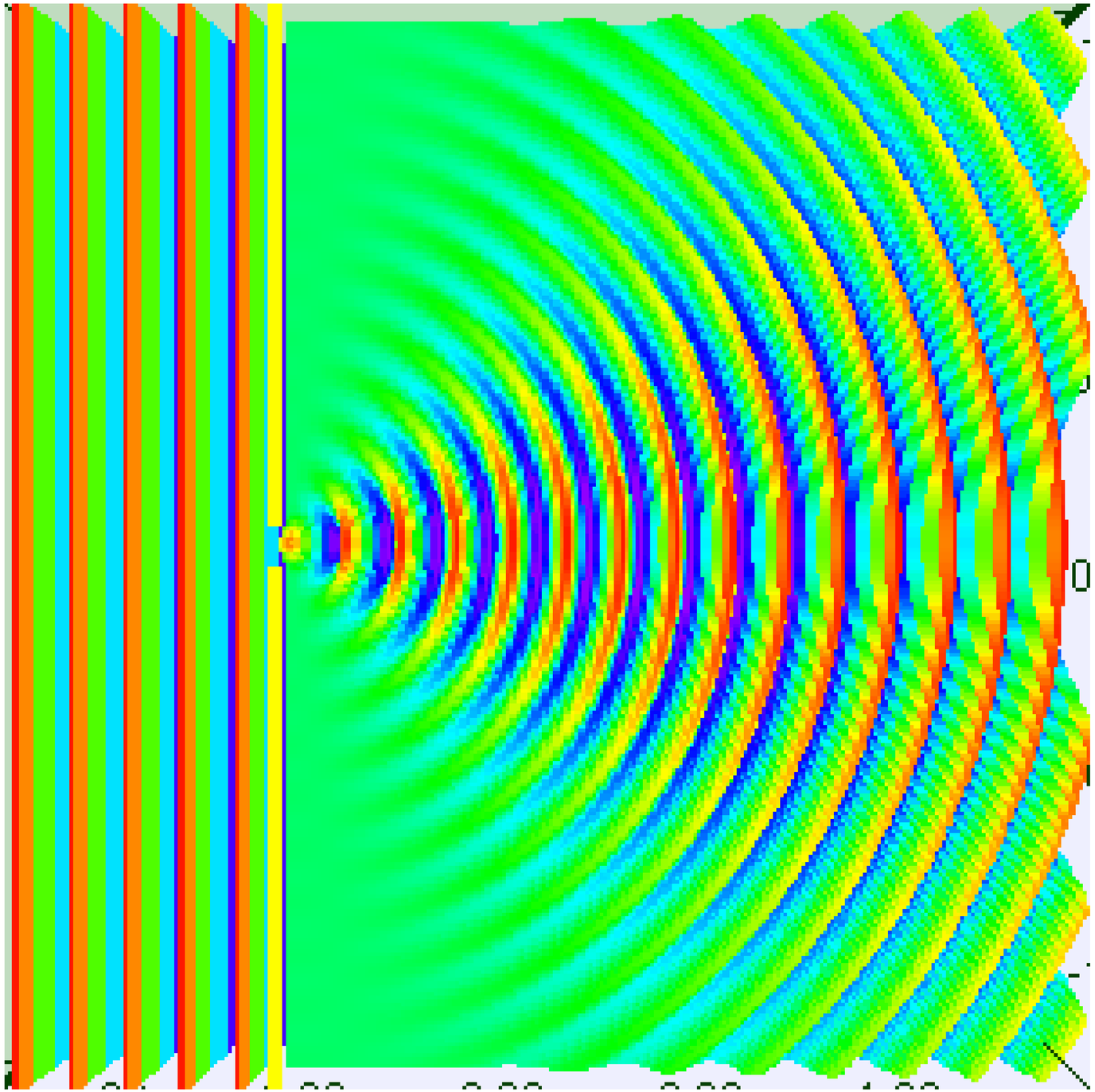

Raios gama
Raios-X
Ultra-violeta
Infravermelho
Ondas de Rádio
Radar
TV
FM
AM
0.0001 nm
0.01 nm
10 nm
1000 nm
0.01 cm
1 cm
1 m
100 m
Luz Visível
Espectro visível da luz
400 nm
500 nm
600 nm
700 nm



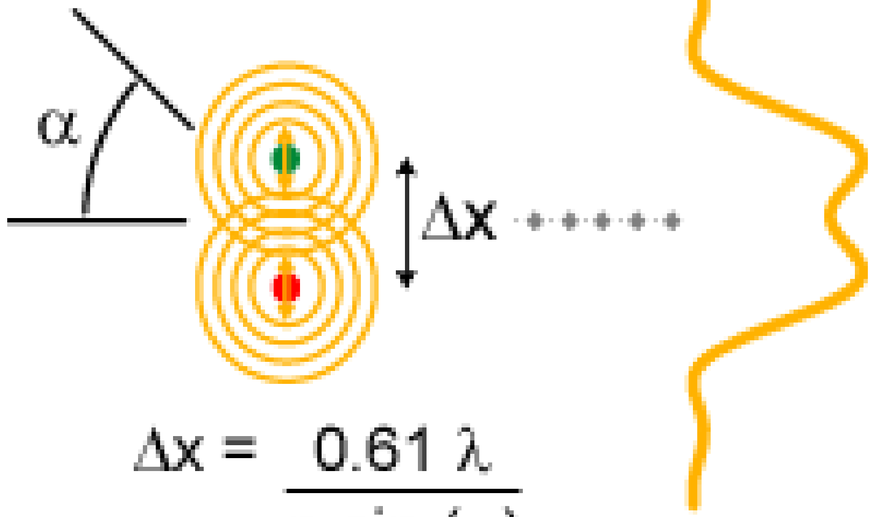
Abertura numérica




$$\Delta x = \frac{0.61\,\lambda}{n \sin(\alpha)}$$



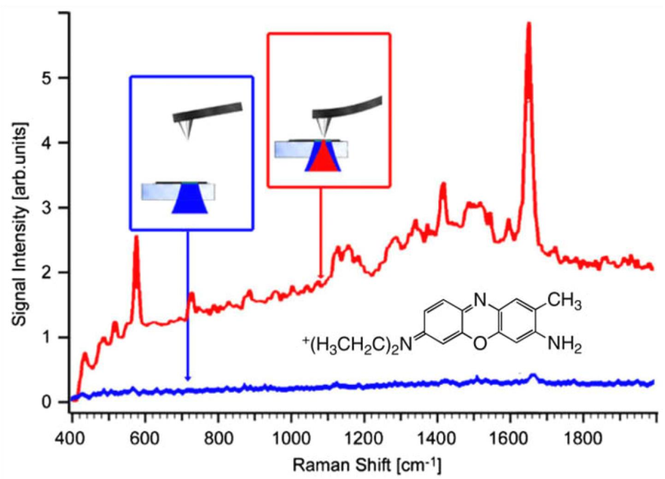
Abertura numérica




$$\Delta x = \frac{0.61\,\lambda}{n \sin(\alpha)}$$

# Um brevíssimo histórico


*Arch Abbé, Mikrosk., Anat. (1873)*




R.M. Stöckle, Y.D. Suh, V. Deckert, R. Zenobi
Chem. Phys. Lett. 318 (2000) 131.

XXXVIII. *A Suggested Method for extending Microscopic Resolution into the Ultra-Microscopic Region. By* E. H. Synge*.

IT is generally accepted as an axiom of microscopy that the only way to extend resolving-power lies in the employment of light of smaller wave-lengths. Practical difficulties, however, rapidly accumulate as light of increasingly small wave-length is brought into service, and probably little hope is entertained of arriving at a resolution much beyond ·1 $\mu$, with, perhaps, ·05 $\mu$ as an extreme limit.

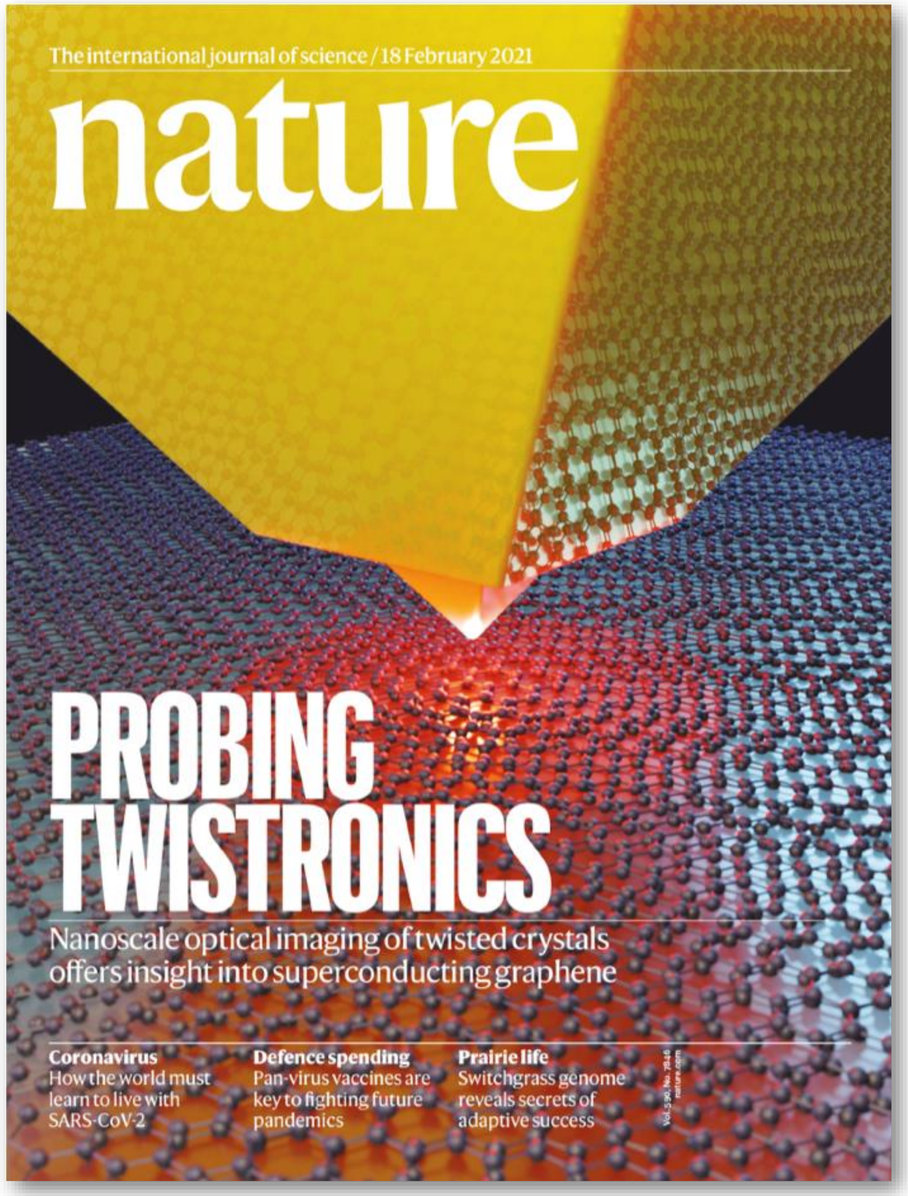
Yet a method offers itself which lies a little outside the beaten track of microscopic work and raises various technical problems of a new kind, but which makes the attainment of a resolution of ·01 $\mu$, and even beyond, dependent upon a

**To cite this article:** E.H. Synge (1928): XXXVIII. A suggested method for extending microscopic resolution into the ultra-microscopic region , Philosophical Magazine Series 7, 6:35, 356-362

**To link to this article:** http://dx.doi.org/10.1080/14786440808564615

**"SONDANDO TWISTRÔNICA"**

*Gadelha et al. Nature 590.7846, 405 (2021)*



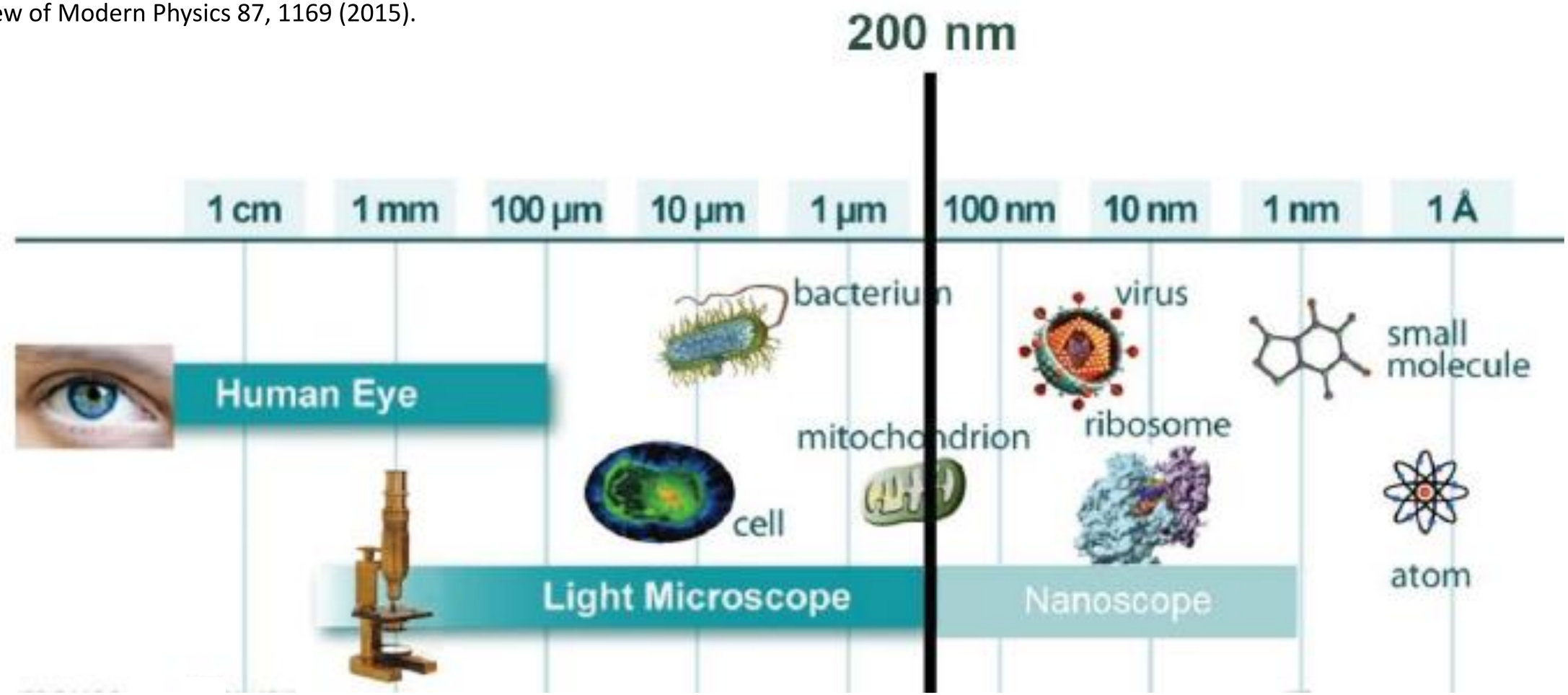
# *O que é um **nanoscópio**?*

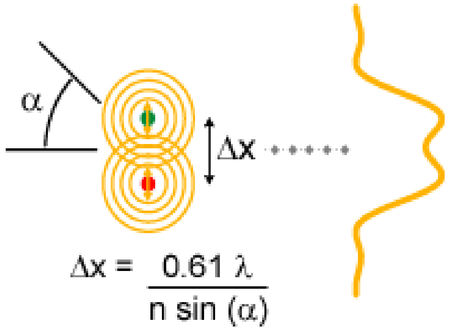
| | | |
|---|---|---|
| $10^{-9}$ | ***nanô**metro* (nm) | ***scópio*** |
| $10^{-6}$ | ***micrô**metro* (μm) | |
| $10^{-3}$ | *milímetro* (mm) | |
| | *metro* (m) | |
| $10^{+3}$ | *kilômetro* (Km) | |
| $10^{+6}$ | *megametro* (Mm) | |
| $10^{+9}$ | *gigametro* (Gm) | |

- contemplar
- olhar
- observar
- examinar
- vigiar

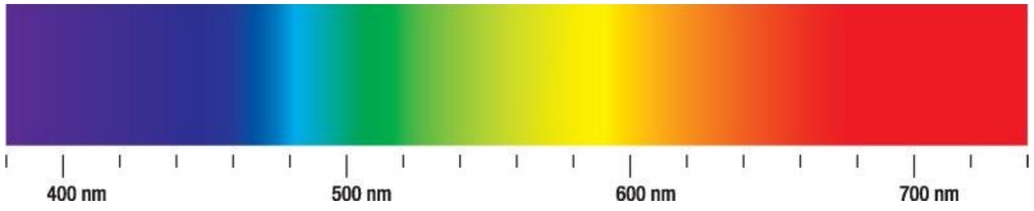
*do grego*

Stefan W. Hell,
Review of Modern Physics 87, 1169 (2015).




$$\Delta x \approx \lambda/2$$

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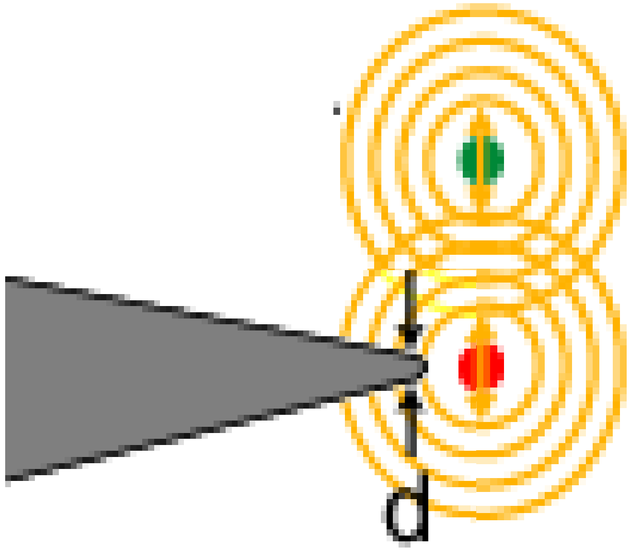
Laboratório de NANO.ESPECTROSCOPIA

# *A nanoóptica*

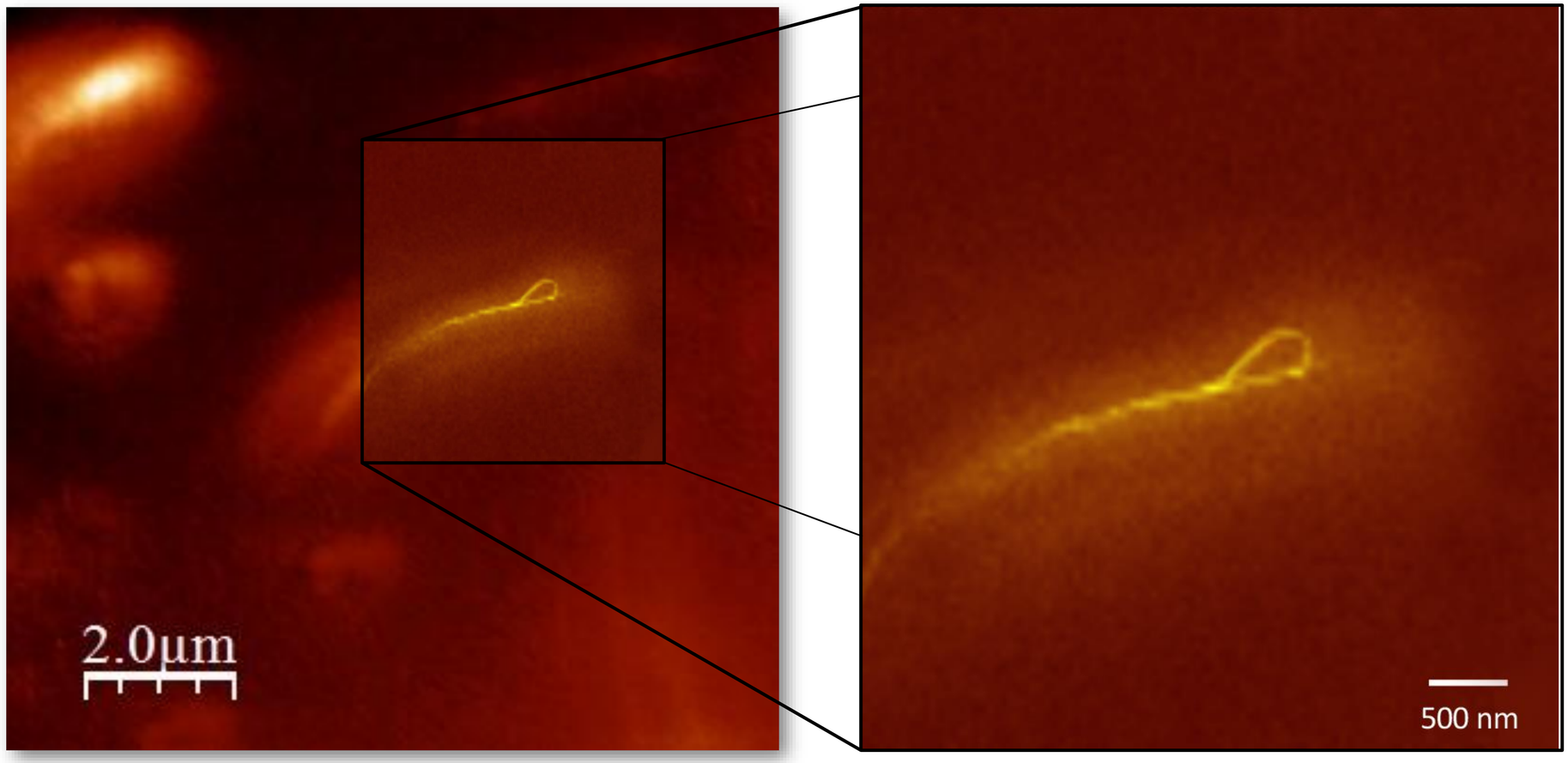
## Vencendo o limite da difração com uma nanoantena




*Wessel, JOSA B, (1985).*

*ıy et al., Ultramicroscopy, (1998).*

# Resolução especial nanométrica




*Jorio & Cancado PCCP **14**, 15246 (2012)*

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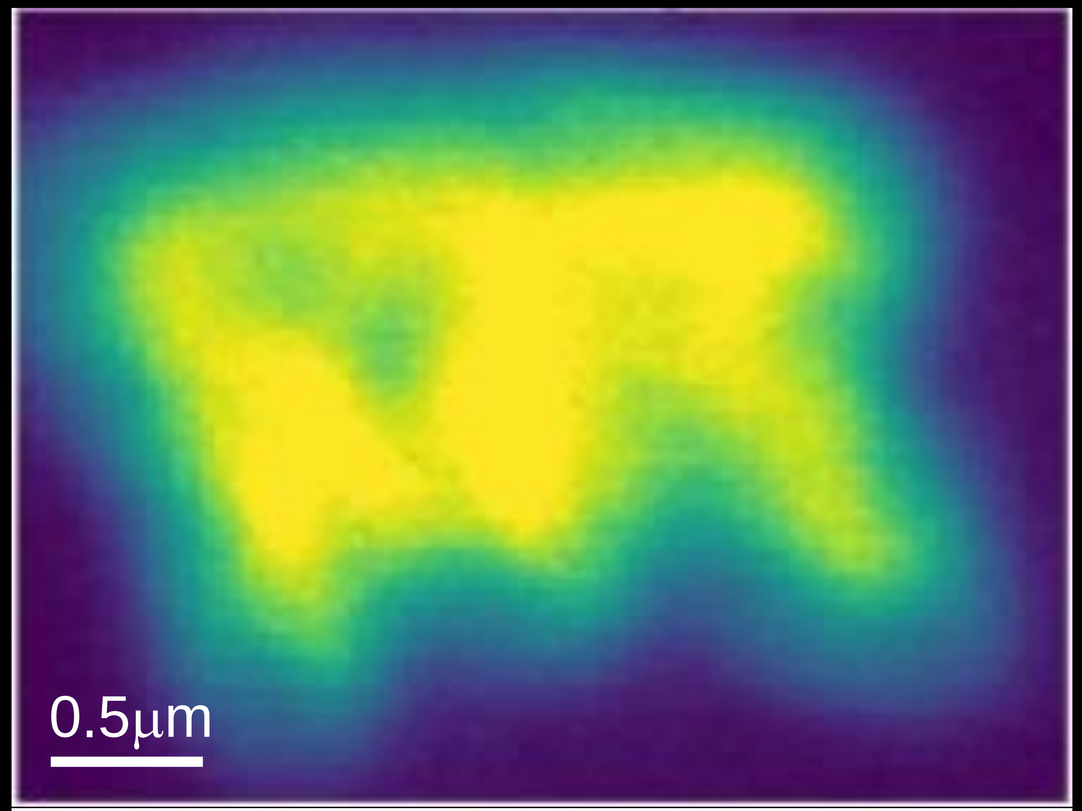
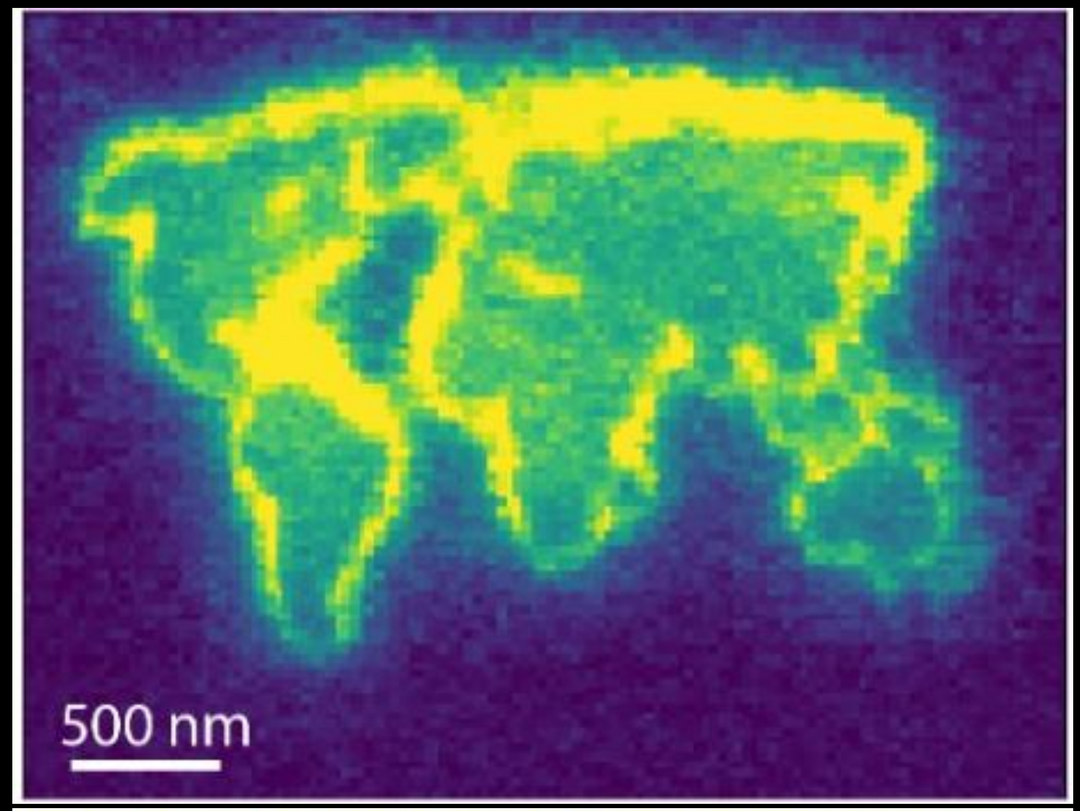
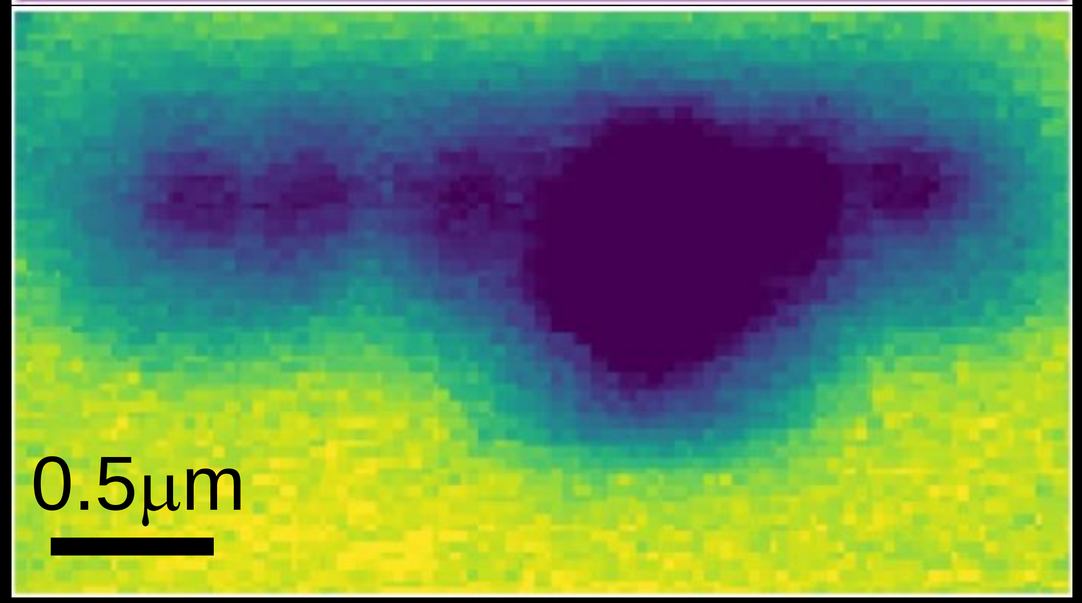
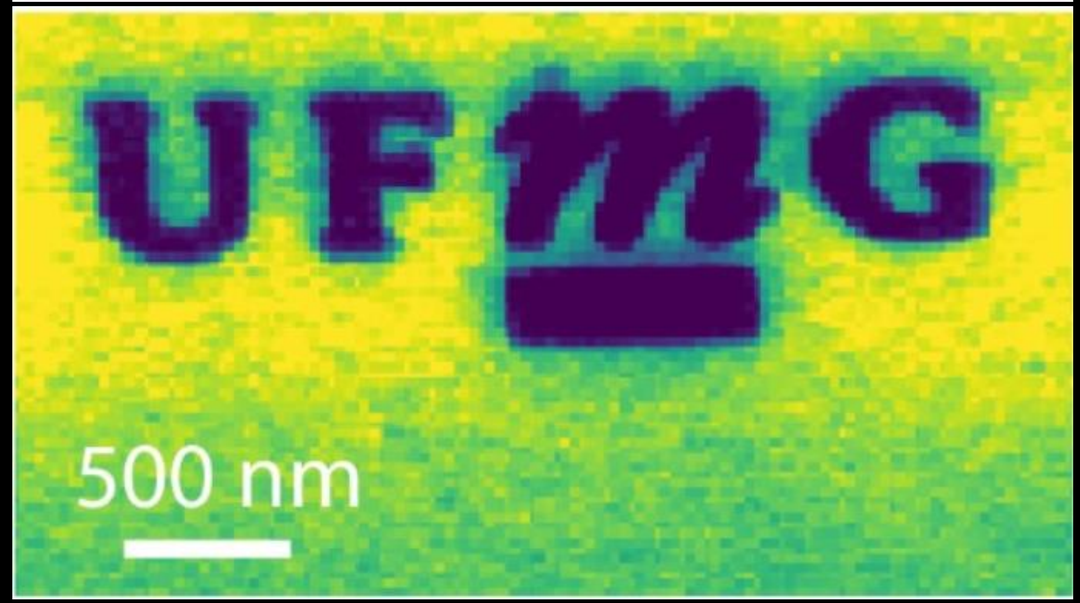
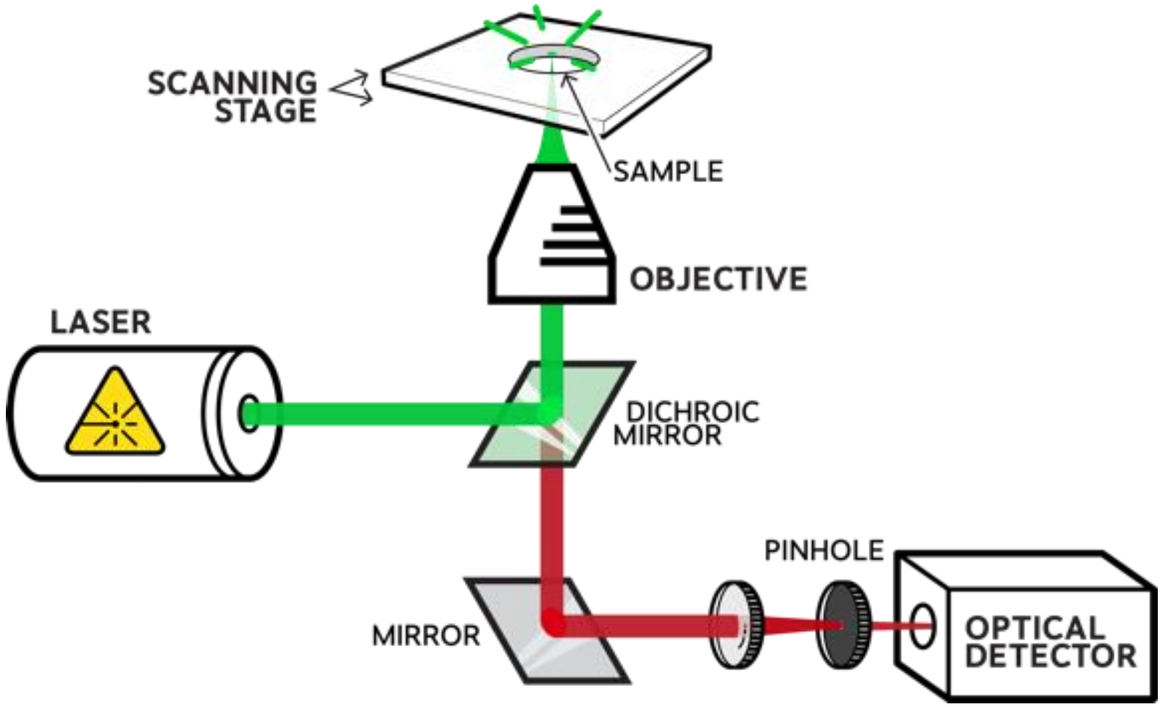


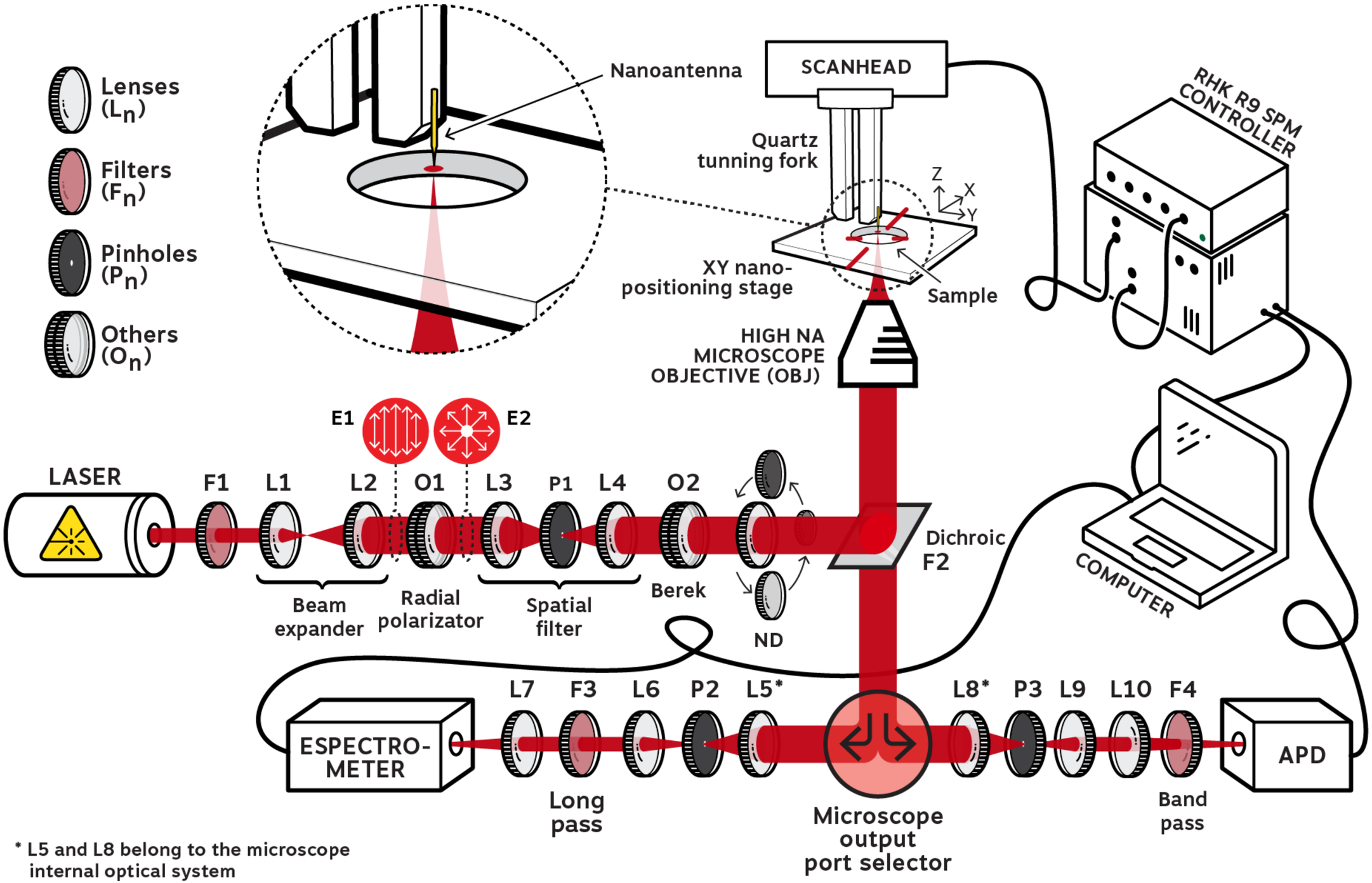




Laboratório de NANO.ESPECTROSCOPIA


SCANNING STAGE
SAMPLE
OBJECTIVE
LASER
DICHROIC MIRROR
PINHOLE
MIRROR
OPTICAL DETECTOR

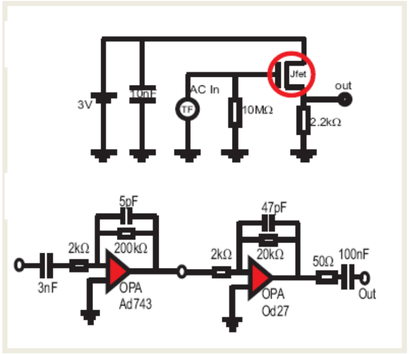



* L5 and L8 belong to the microscope internal optical system

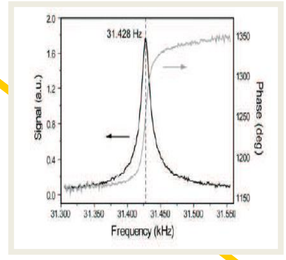
# Spectroscopy and Imaging of Nano-systems


DF converted into voltage


Amplification



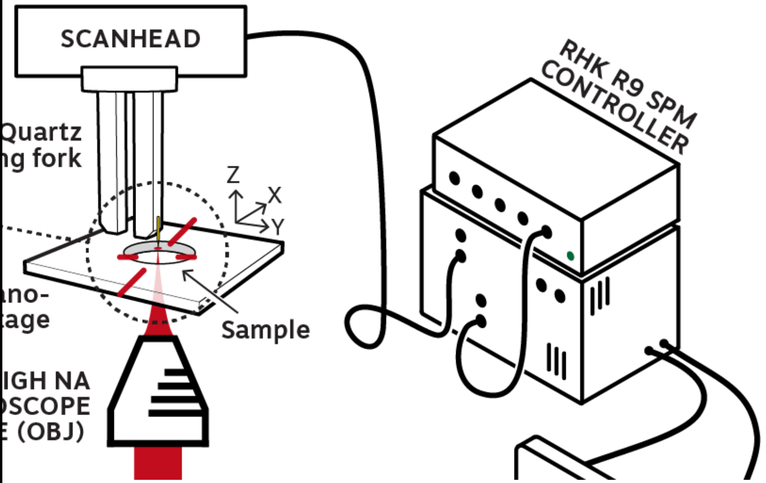

Dither




DF signal

piezoelectric

X,Y,Z piezo sensitively controlled




tip has to be very close to the sample: ~ 1-5nm

X,Y stage controller


*K. Karrai et al., APL 66, 1842 (1995)*

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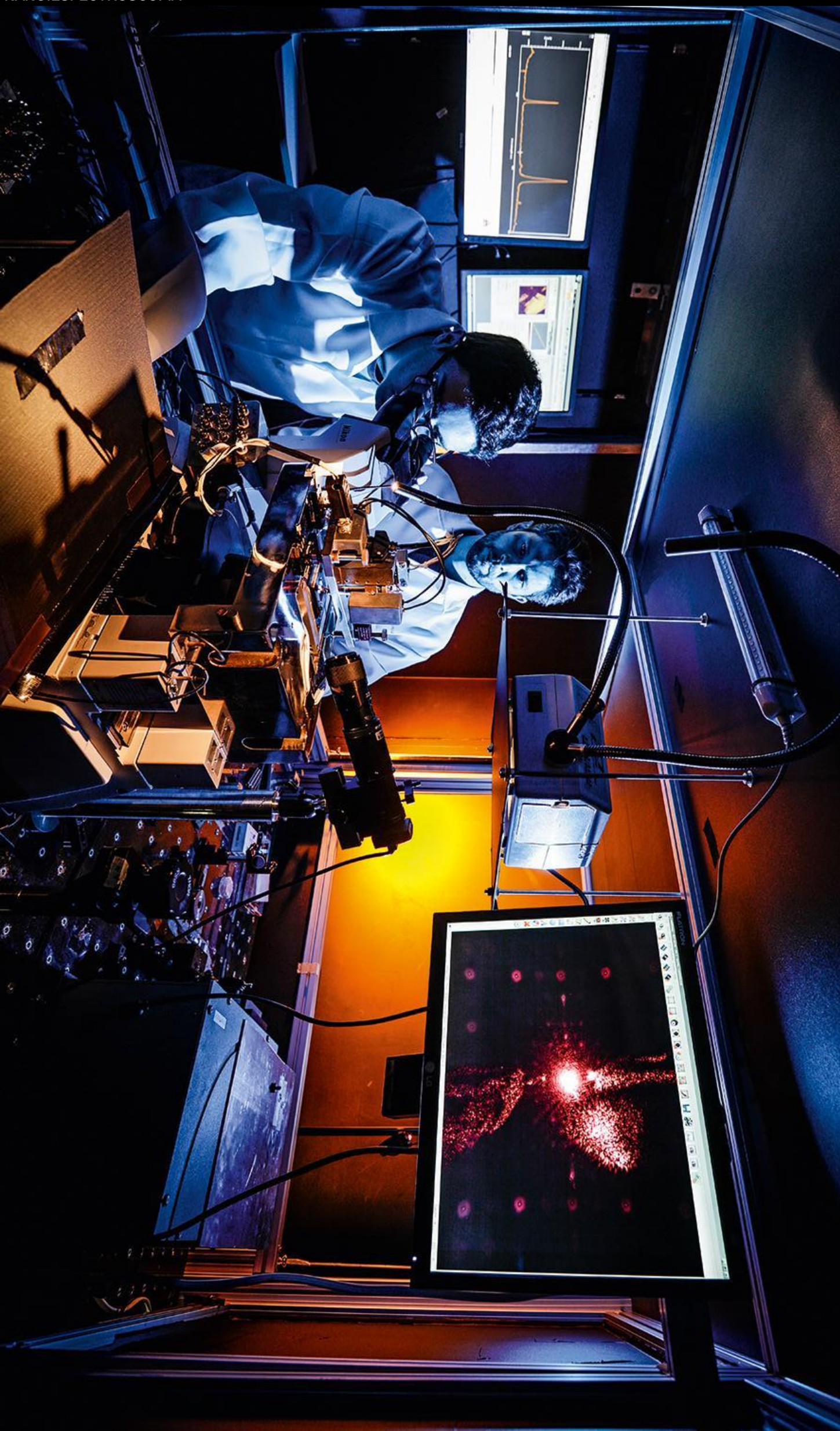
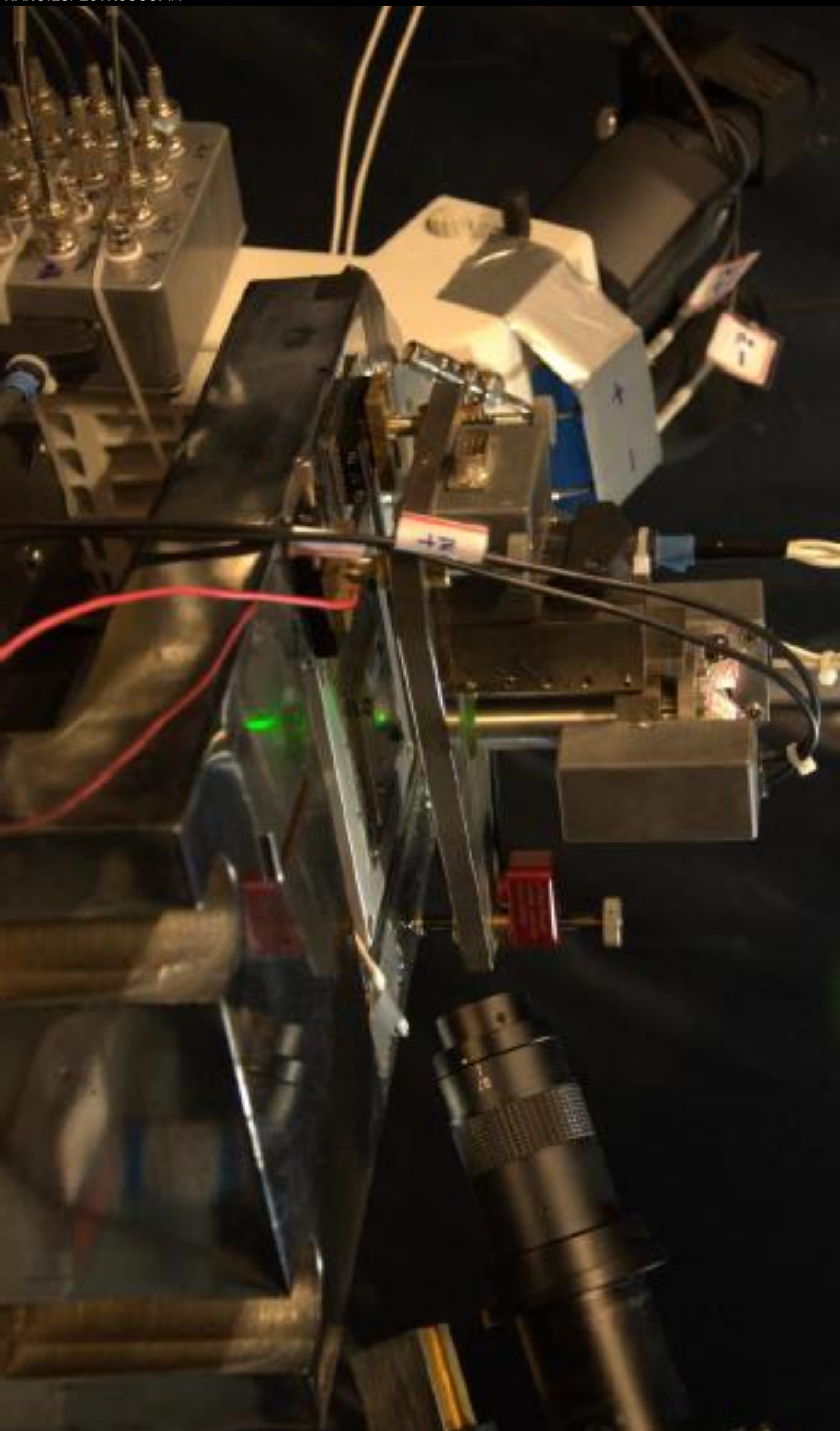
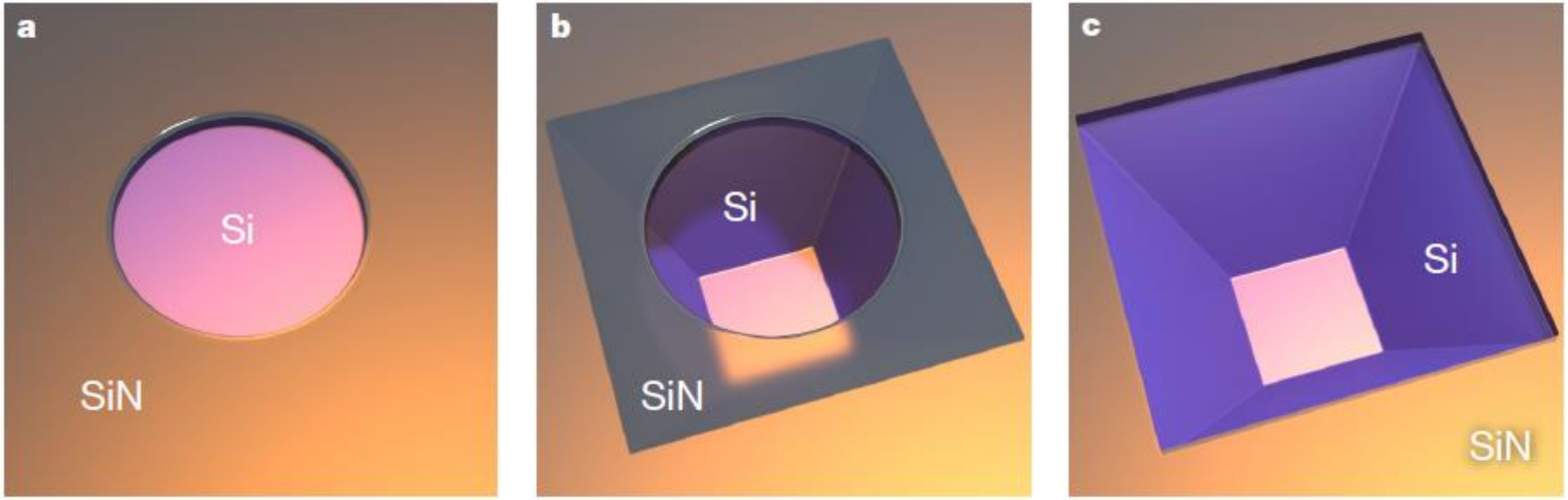
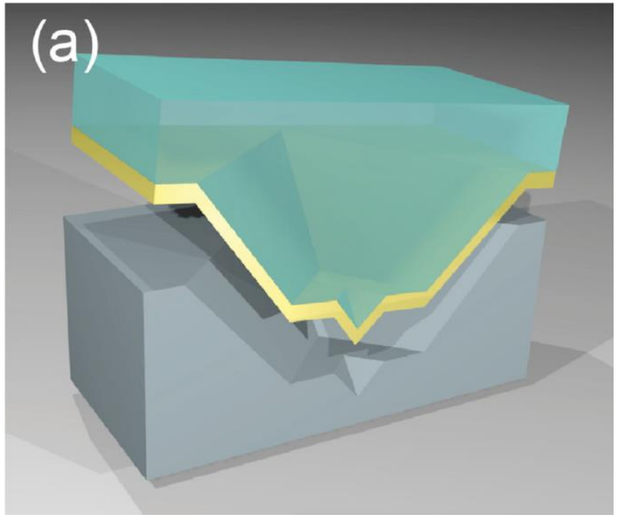




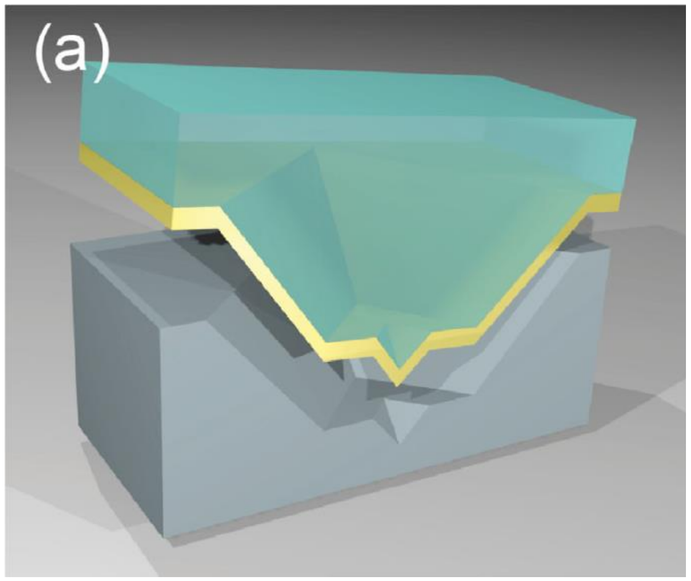


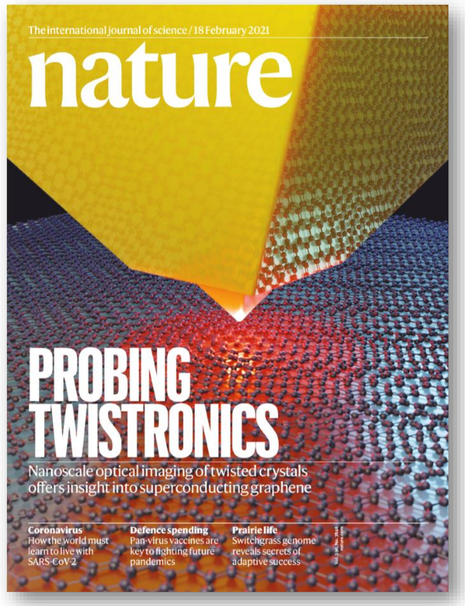


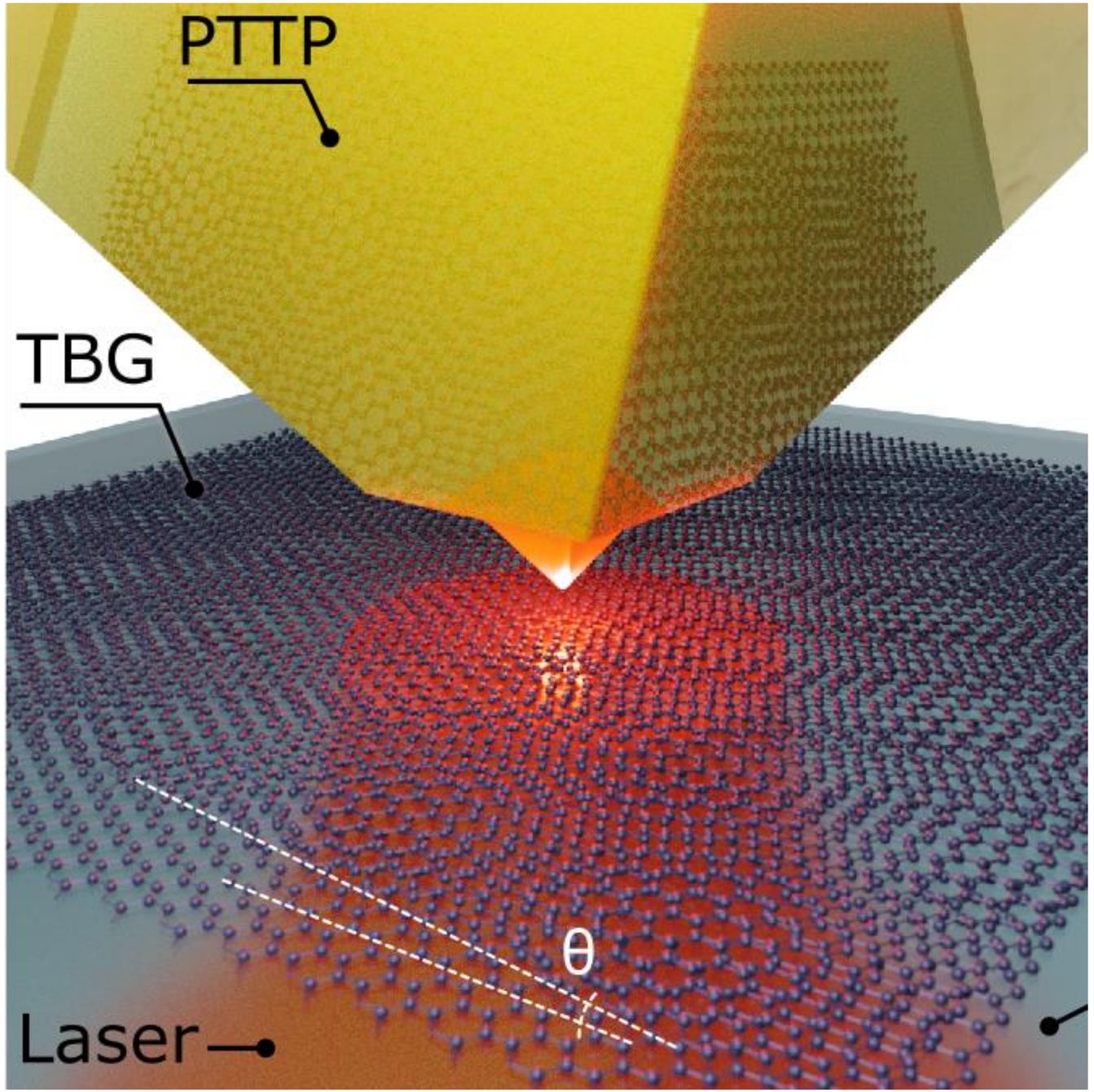


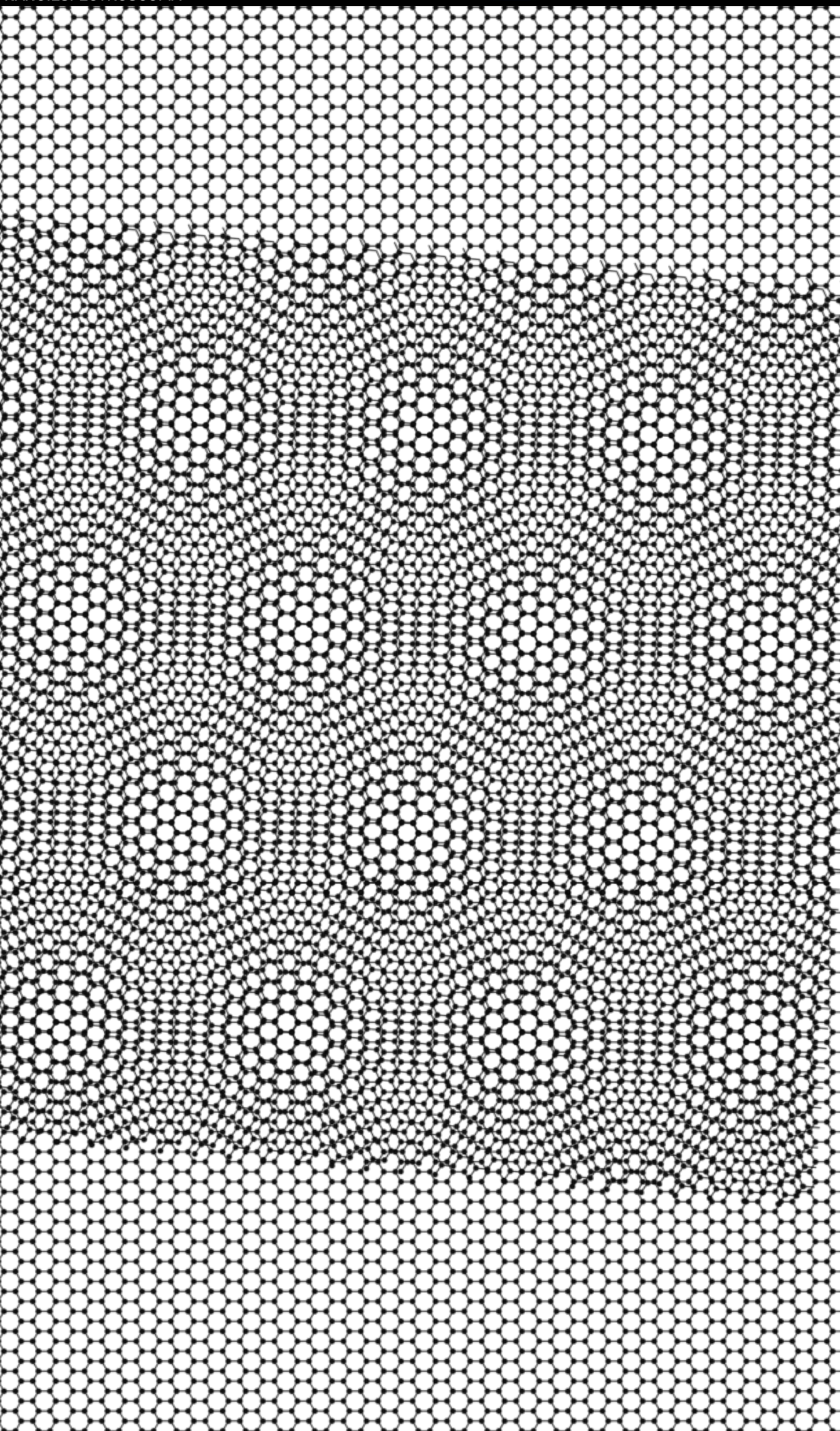

*Gadelha et al. Nature 590.7846, 405 (2021)*

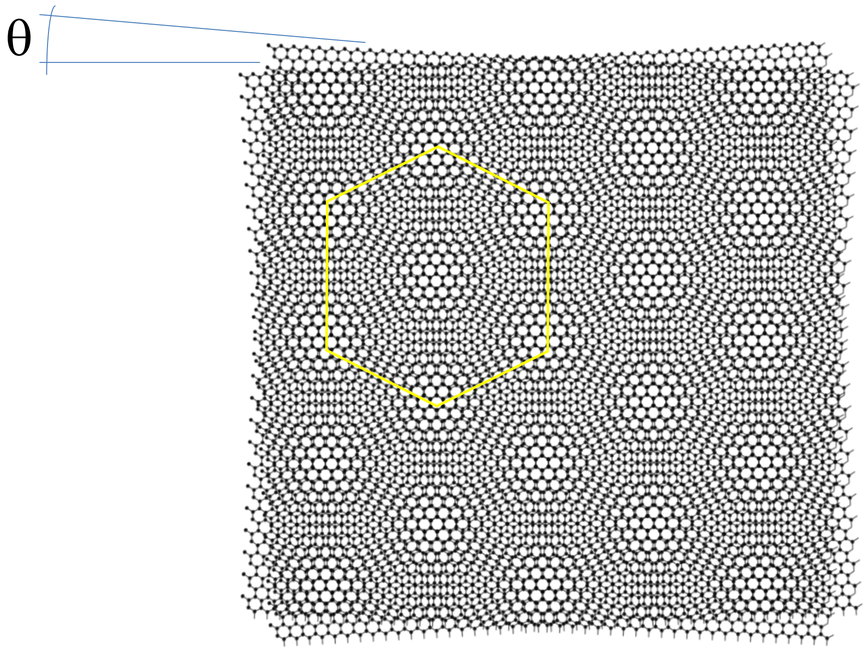
*Vasconcelos et al. IEEE JSTQE (2020)*

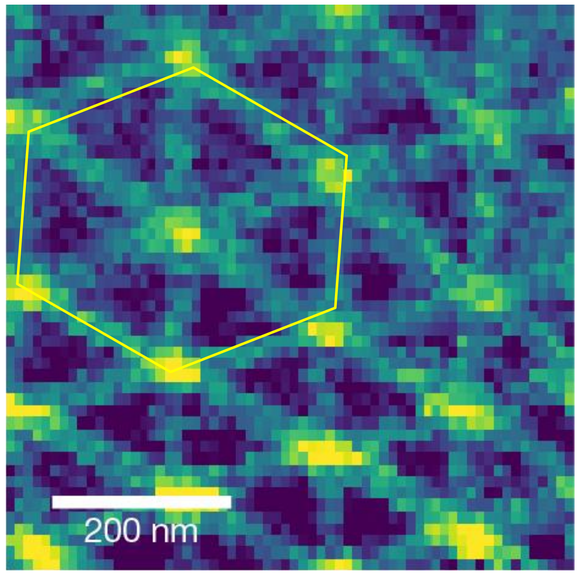


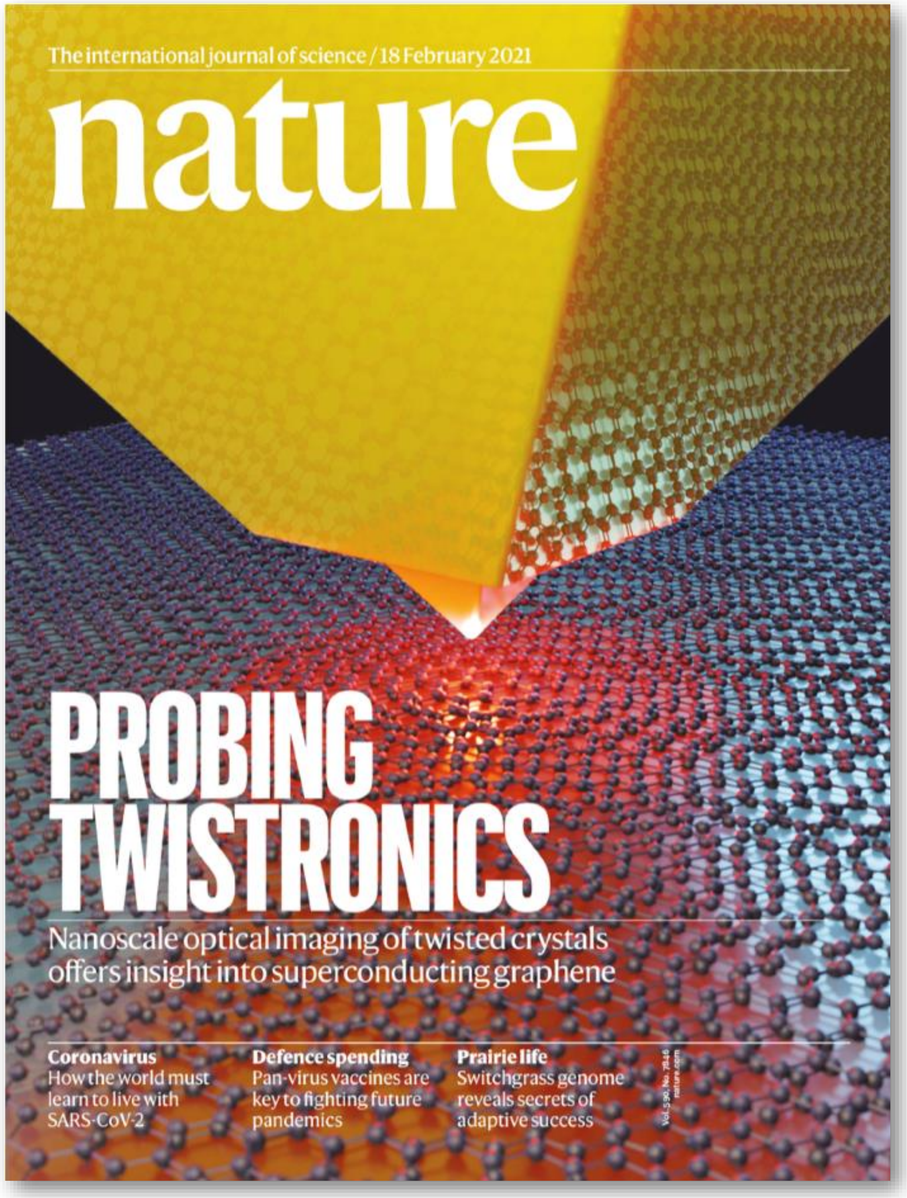



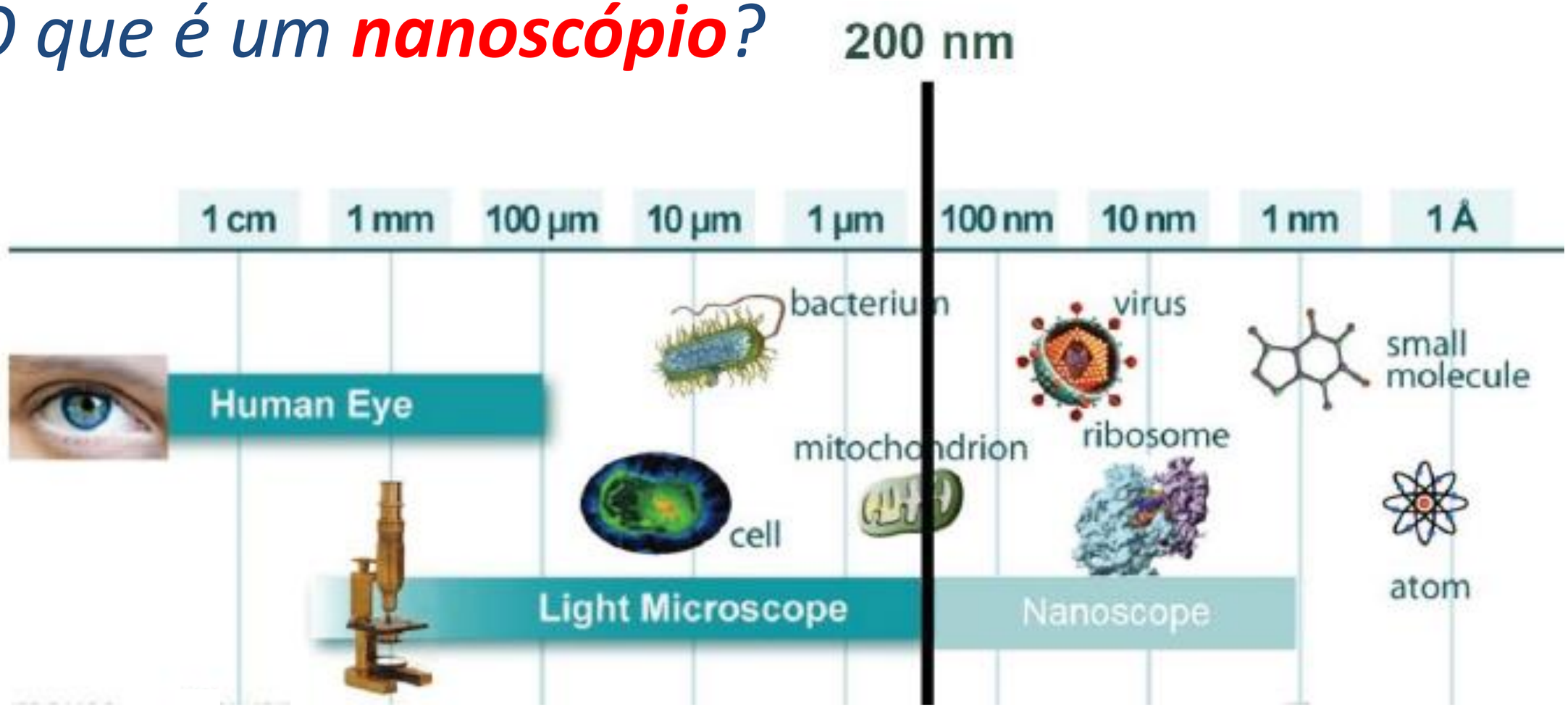


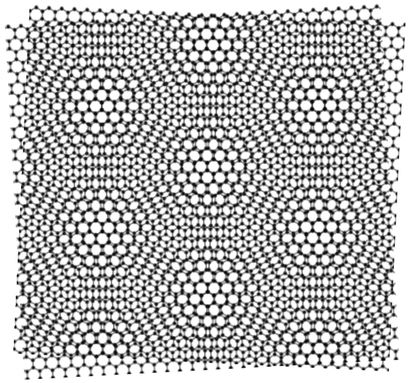


# *O que é um **nanoscópio**?*

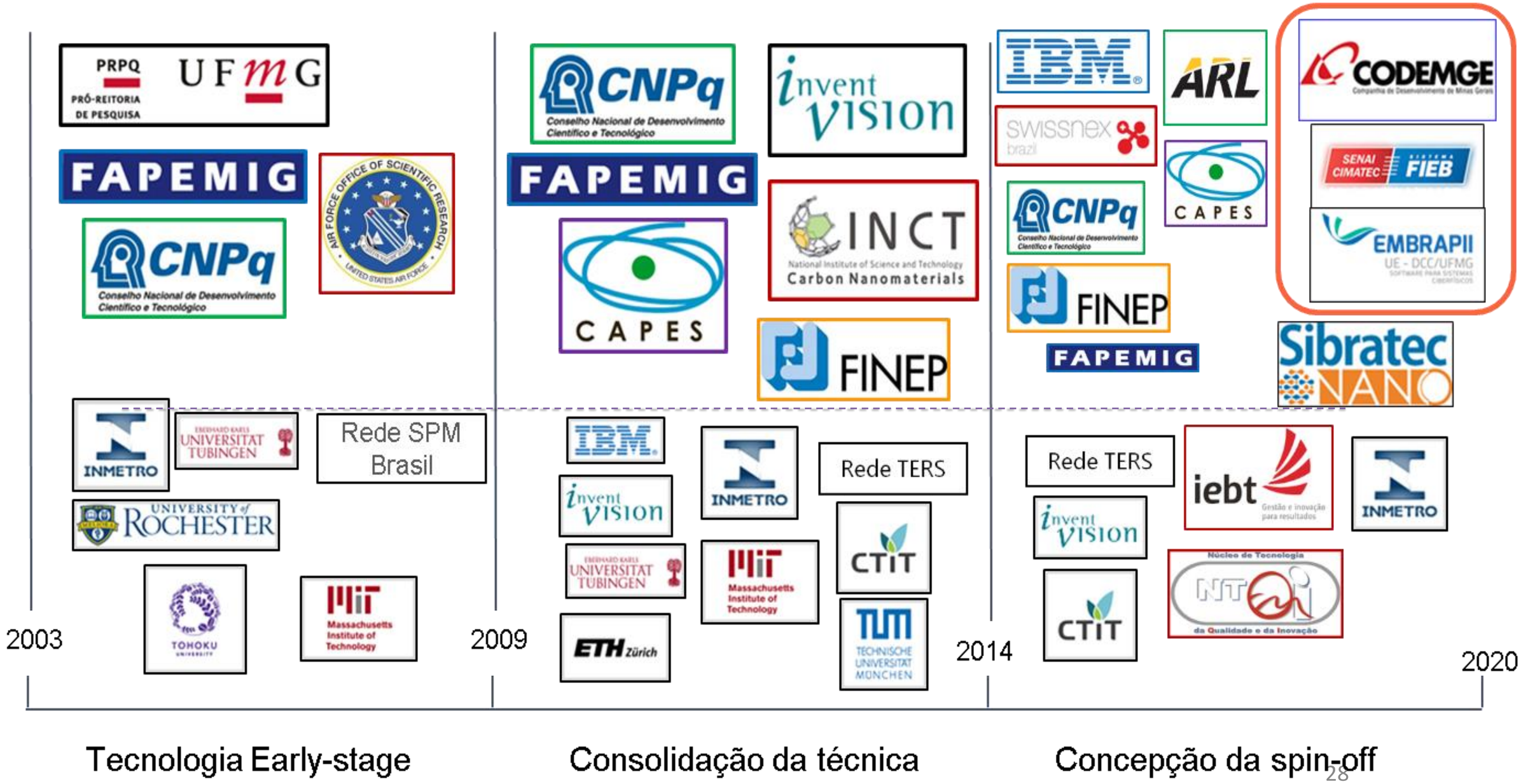


“In 1937 Harvard mark I was made which was first computer and financed by IBM”

*http://www.azhblog.com/2015/08/facts-and-history-about-computer.html*

# FINANCIAMENTO E PARCERIAS



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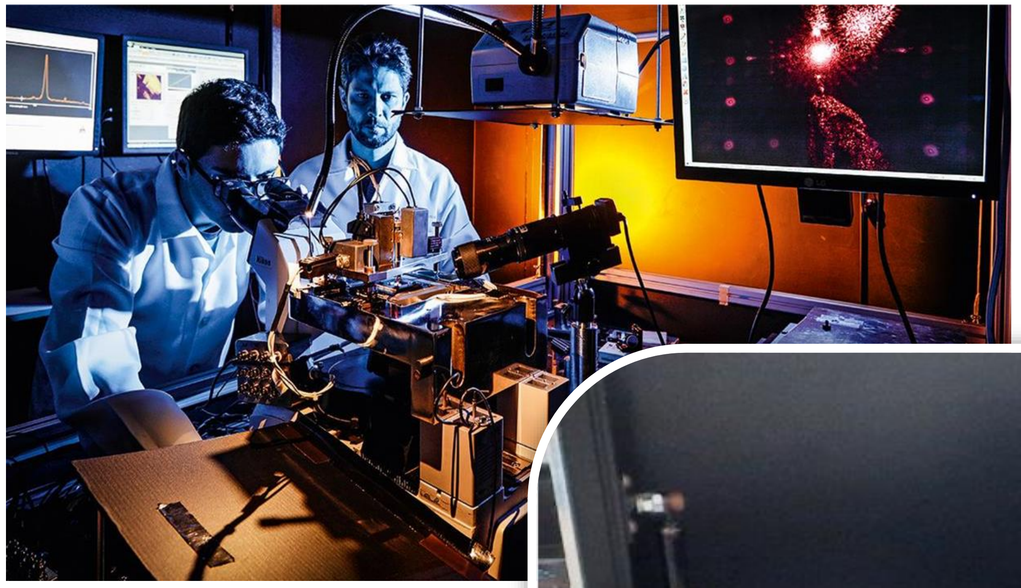
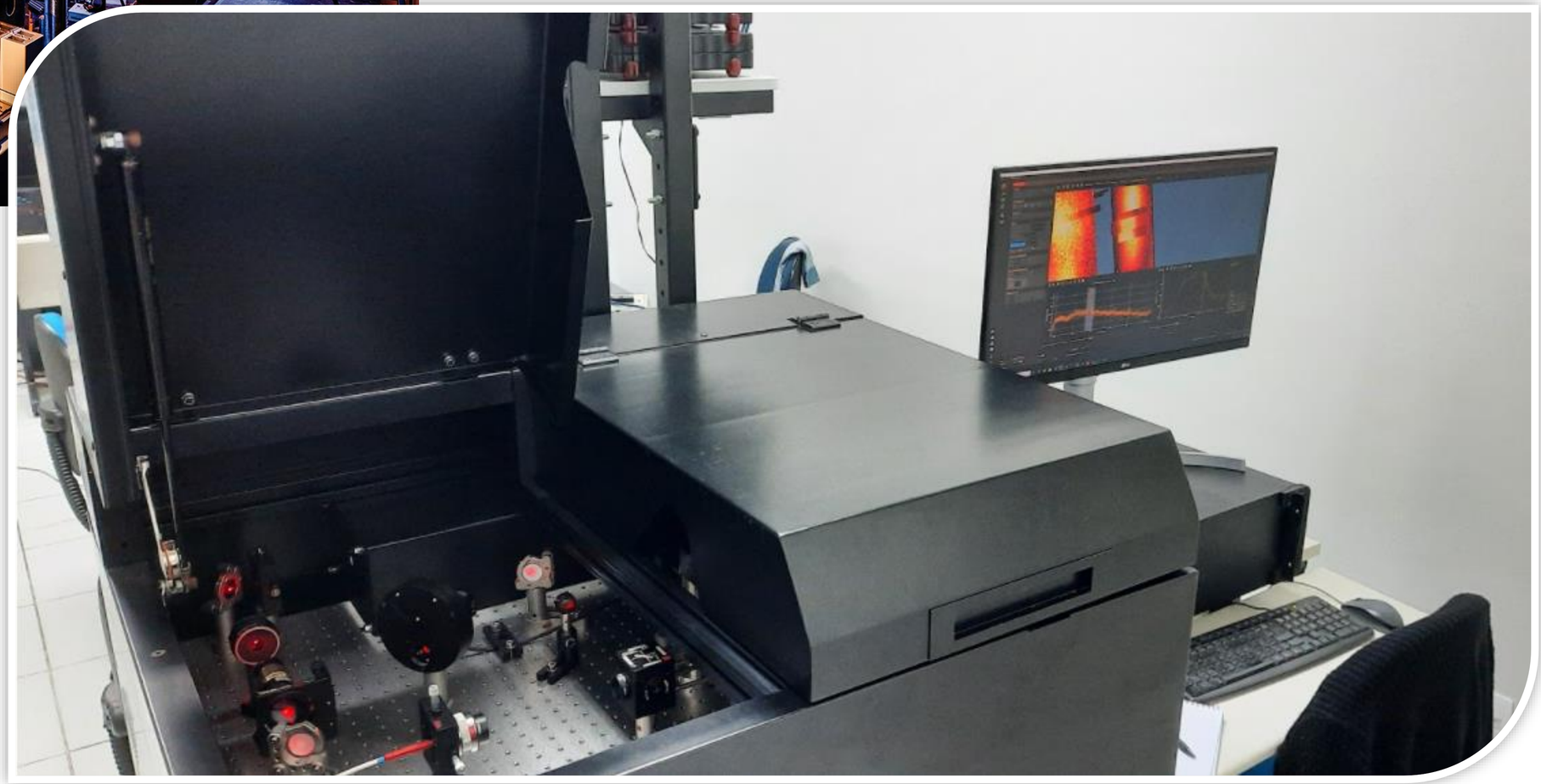


Protótipo laboratorial

LabNS



Protótipo comercial

FabNS

*Protagonismo no desenvolvimento da nanotecnologia*