JUGANDO CON FOTONES

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Grupo de Procesado Láser

Instituto de Ciencia de Materiales de Barcelona, ICMAB - CSIC

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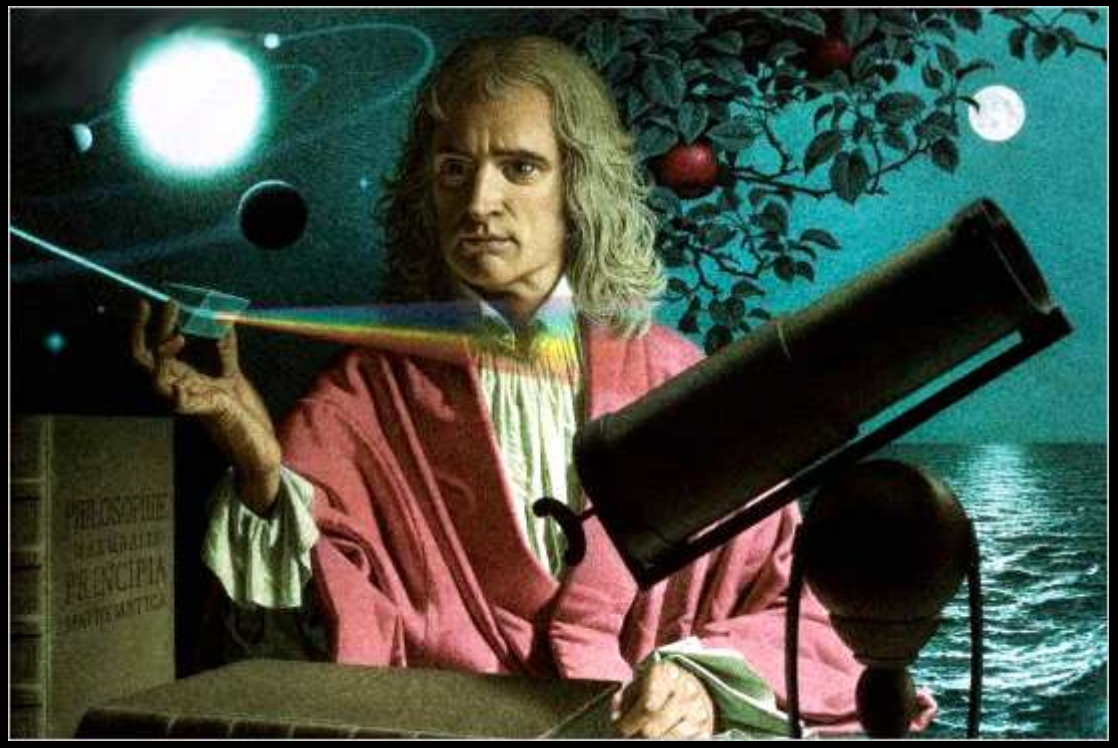
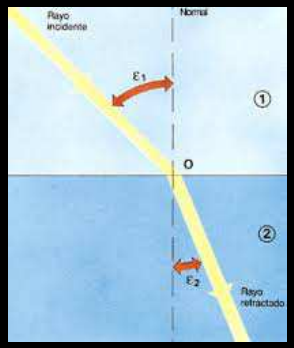
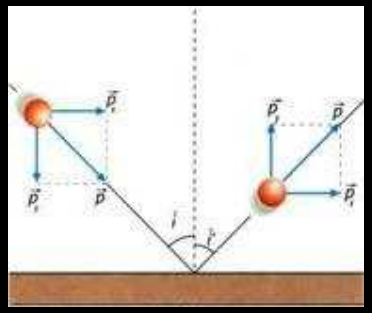
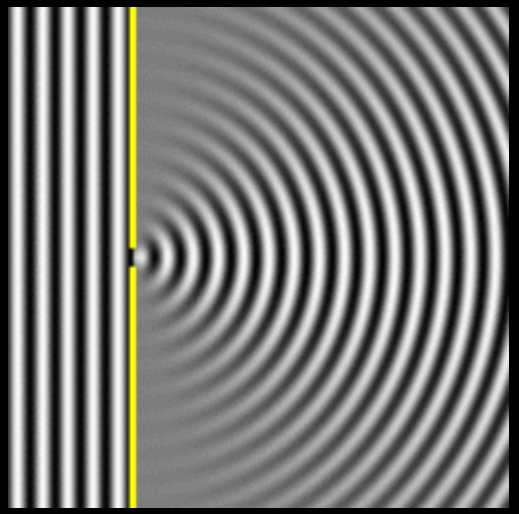
NATURALEZA DE LA LUZ



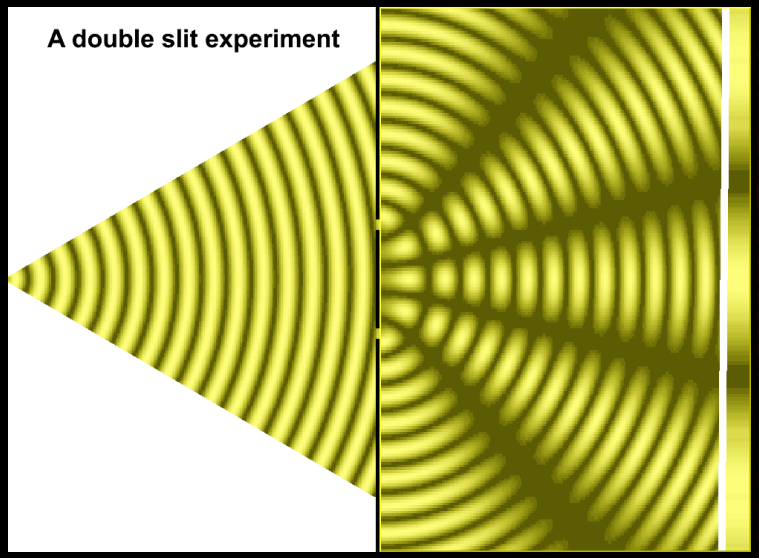


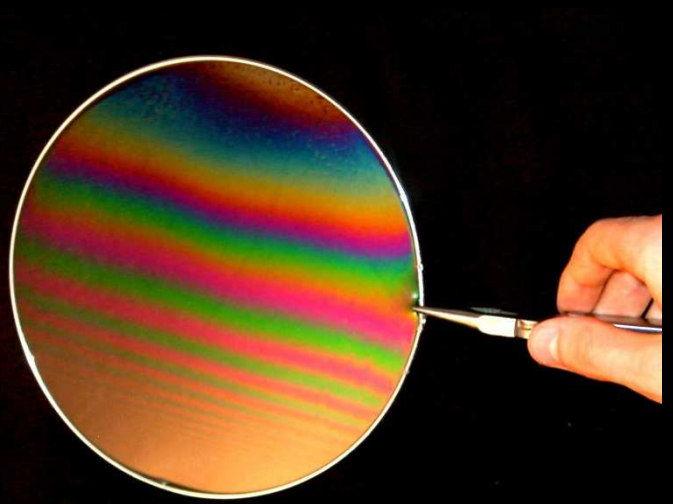


Refracción / Reflexión



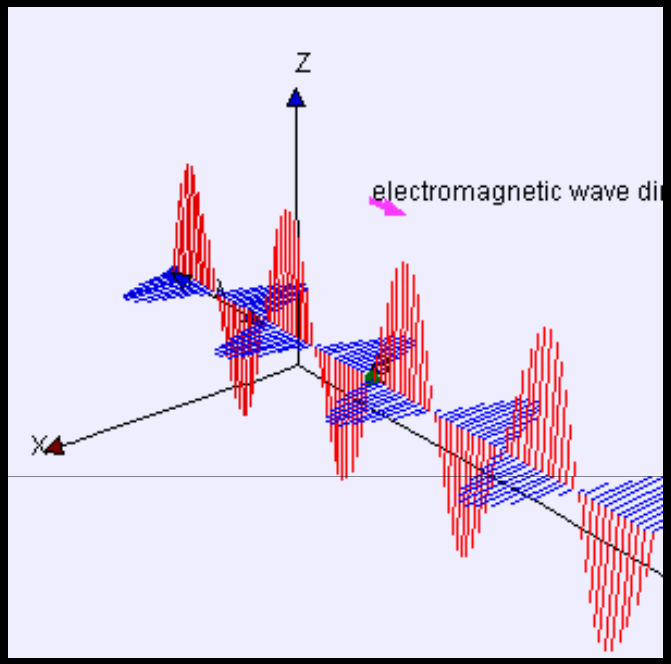
Difracción

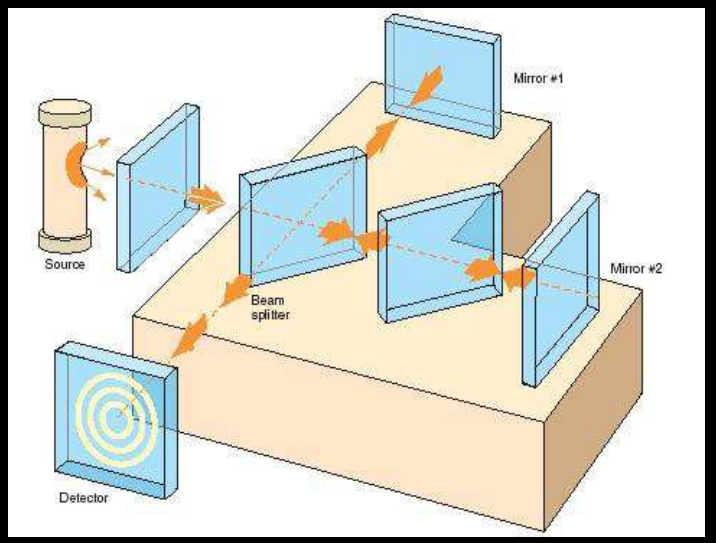




Interferencia

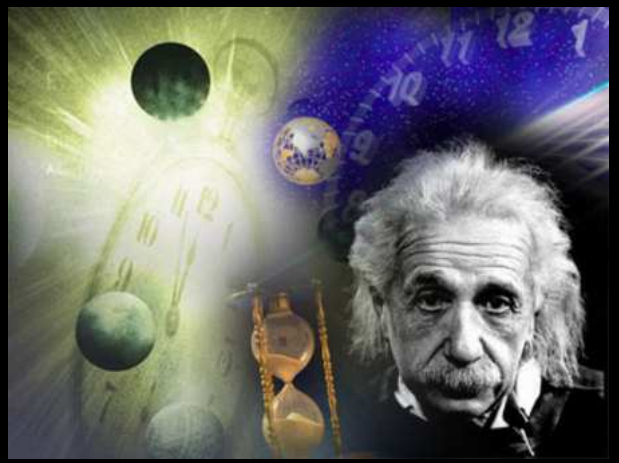
ONDA ELECTROMAGNÉTICA

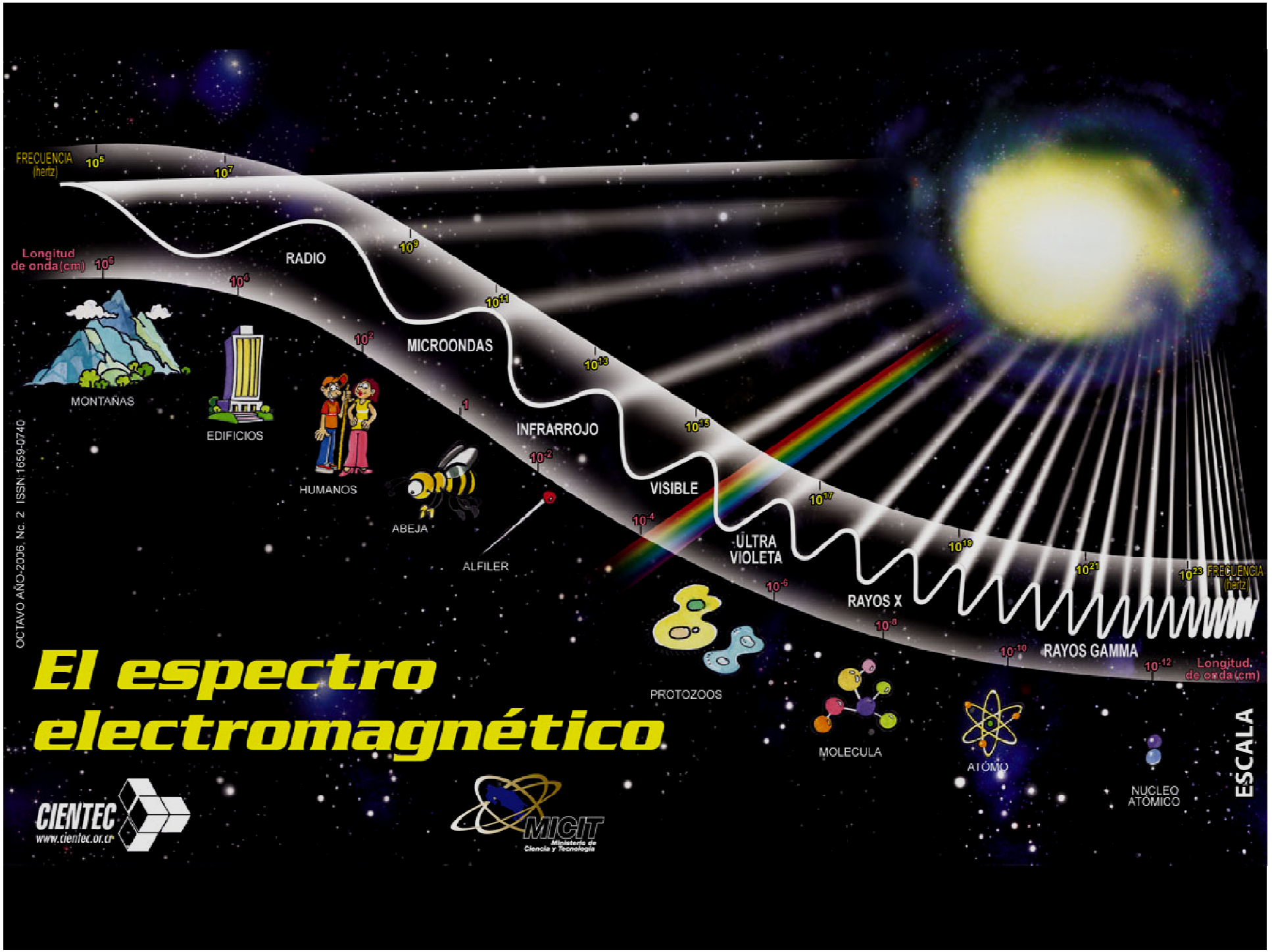




Experimento de Michelson – Morley (1887)

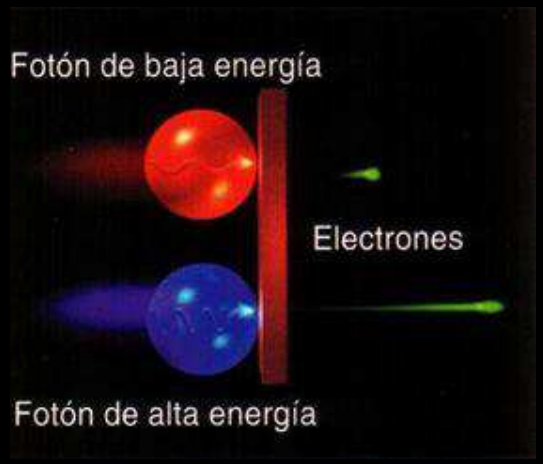
- Velocidad:
  c = 299.792.458 m/s
- Límite absoluto
- Relatividad Especial - Einstein

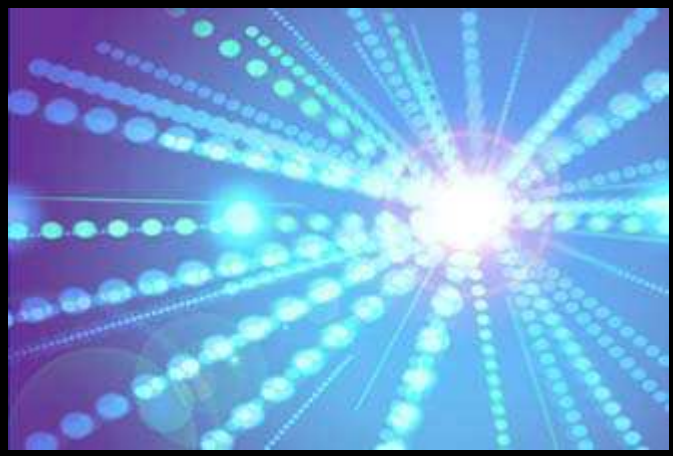


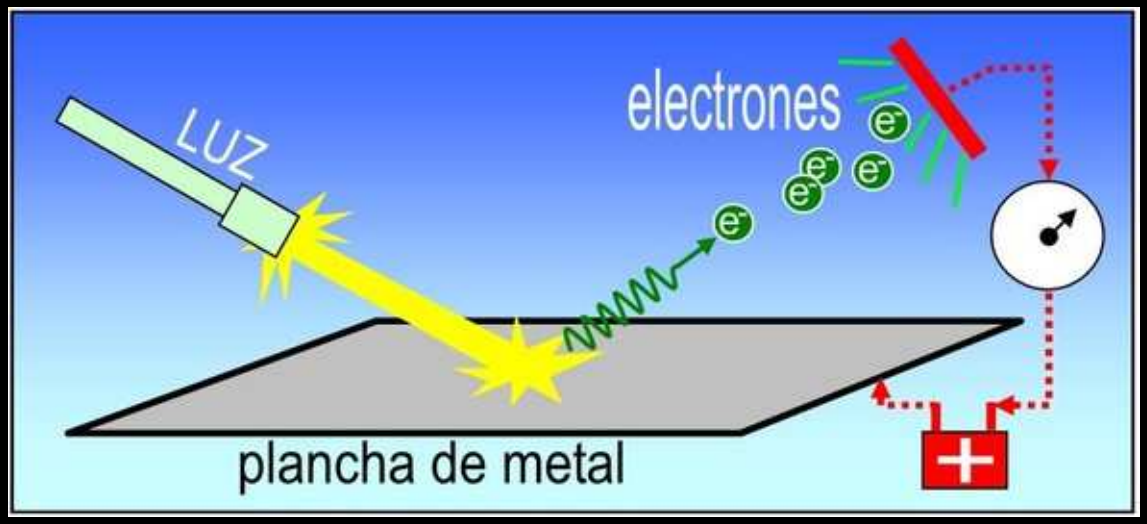

FRECUENCIA (hertz)
10^{5}
10^{7}
10^{9}
10^{11}
10^{13}
10^{15}
10^{17}
10^{19}
10^{21}
10^{23}
FRECUENCIA (hertz)
Longitud de onda(cm)
10^{6}
10^{4}
10^{2}
1
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
Longitud. de onda(cm)
RADIO
MICROONDAS
INFRARROJO
VISIBLE
ULTRA VIOLETA
RAYOS X
RAYOS GAMMA
MONTAÑAS
EDIFICIOS
HUMANOS
ABEJA
ALFILER
PROTOZOOS
MOLECULA
ATÓMO
NUCLEO ATÓMICO
ESCALA
El espectro electromagnético
CIENTEC
www.cientec.or.cr
MICIT
Ministerio de Ciencia y Tecnología
OCTAVO AÑO-2006. Nc. 2 ISSN 1659-0740

PARTÍCULA: FOTÓN

Einstein: cuantos de energía– Fotón





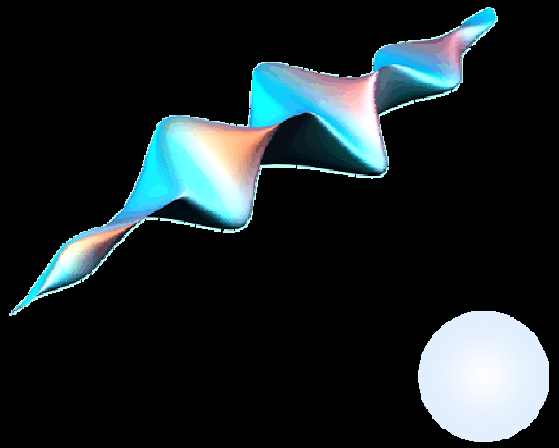


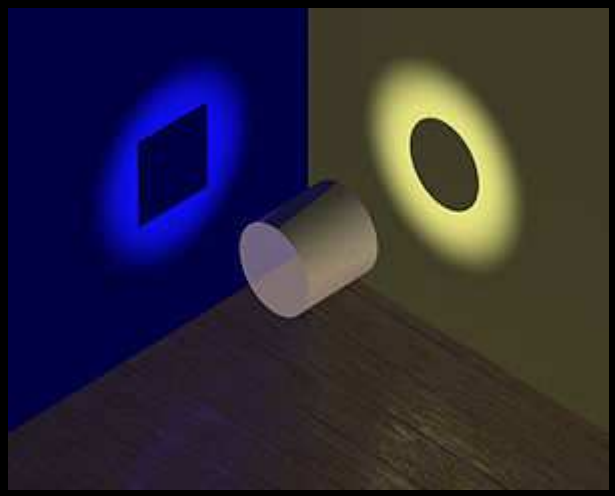
Efecto fotoeléctrico (Hertz – 1887, Einstein – 1905)

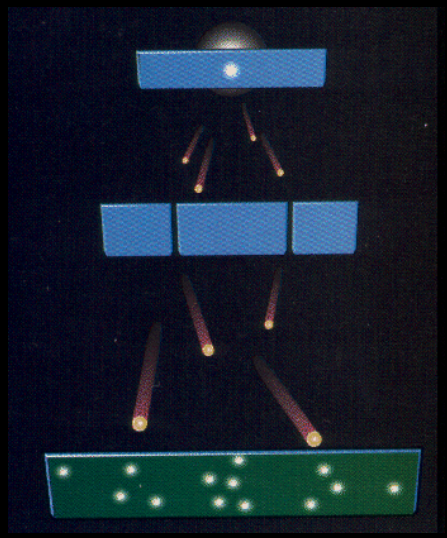
$E_{fotón} = h\nu = hc/\lambda$

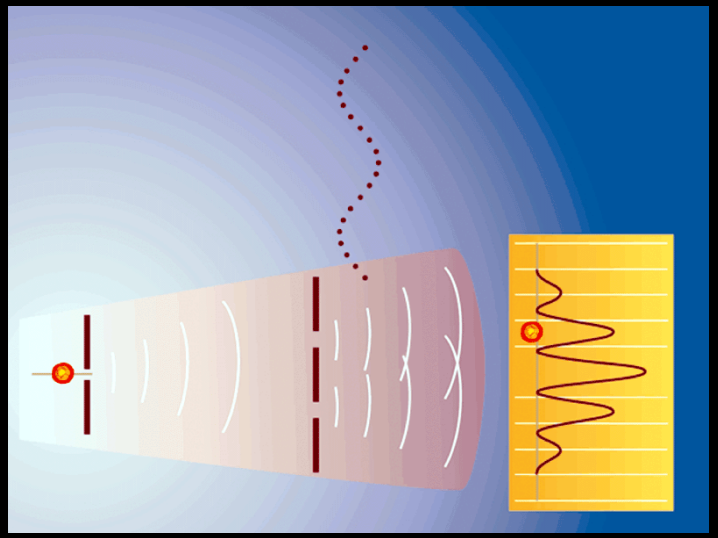
$h = 6{,}62 \times 10^{-34}$ J·s

DUALIDAD ONDA-CORPÚSCULO: PROPIEDAD CUÁNTICA



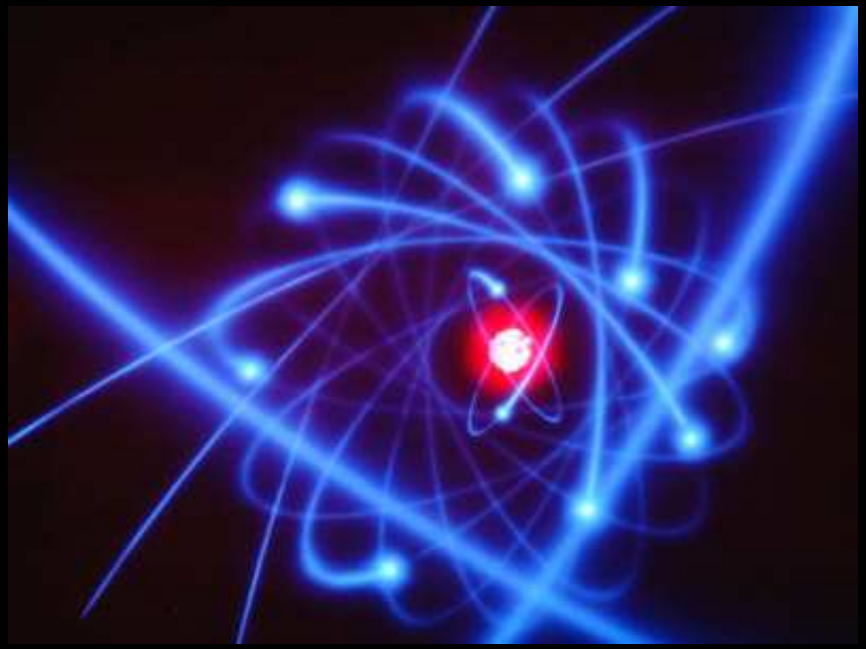


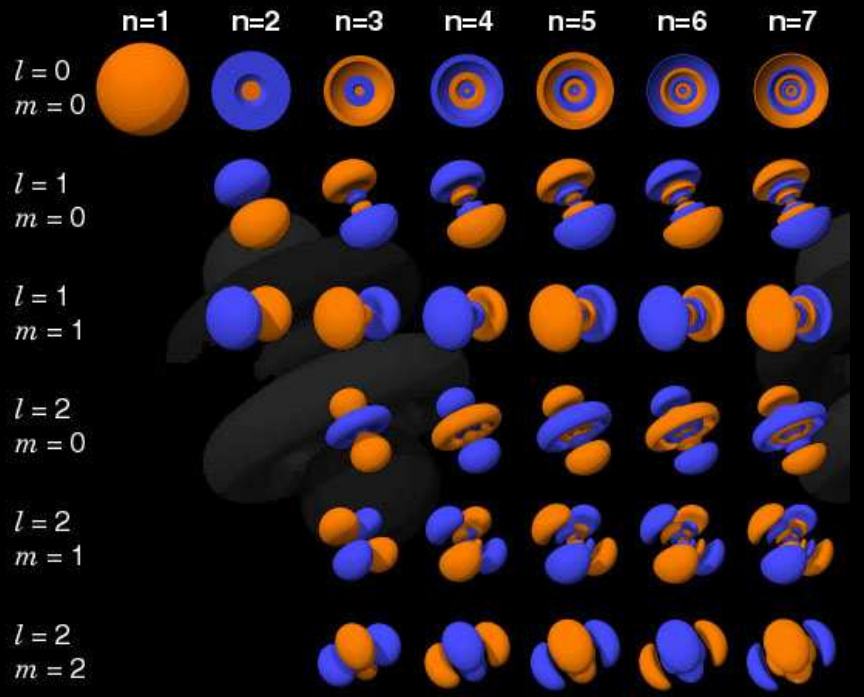




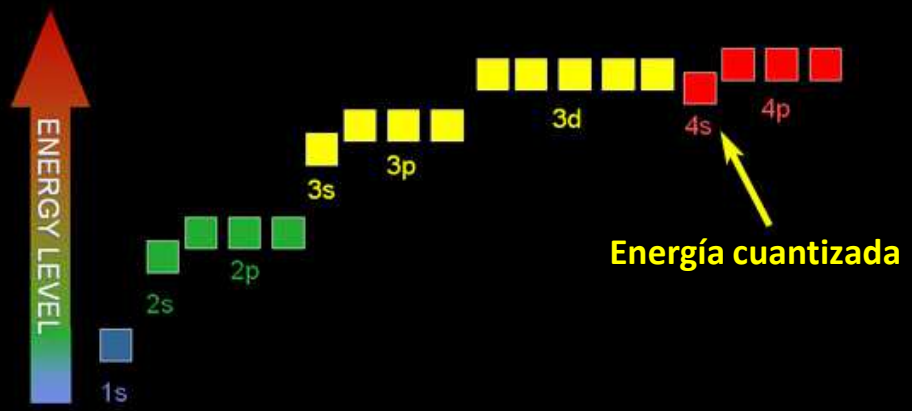

INTERACCIÓN LUZ - MATERIA

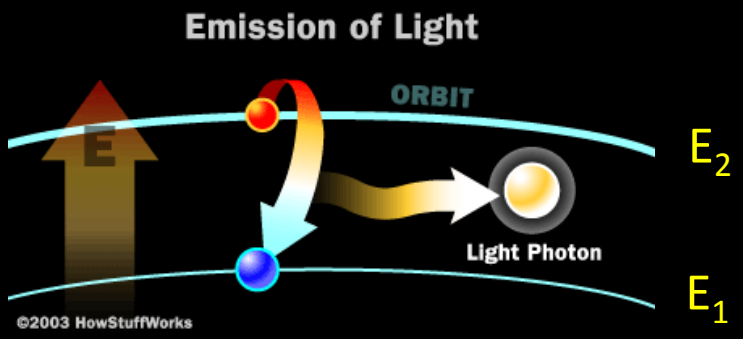
ÁTOMO




n=1
n=2
n=3
n=4
n=5
n=6
n=7
l = 0
m = 0
l = 1
m = 0
l = 1
m = 1
l = 2
m = 0
l = 2
m = 1
l = 2
m = 2


Neutrones
Protones

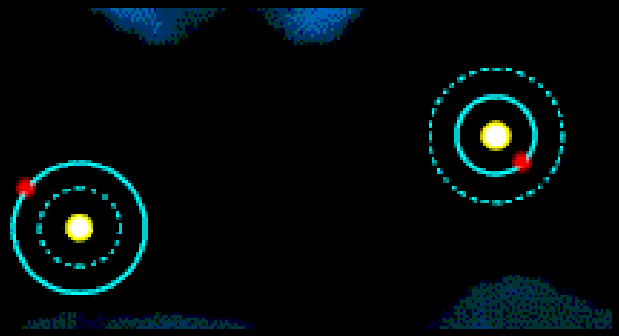

ENERGY LEVEL
1s
2s
2p
3s
3p
3d
4s
4p
Energía cuantizada

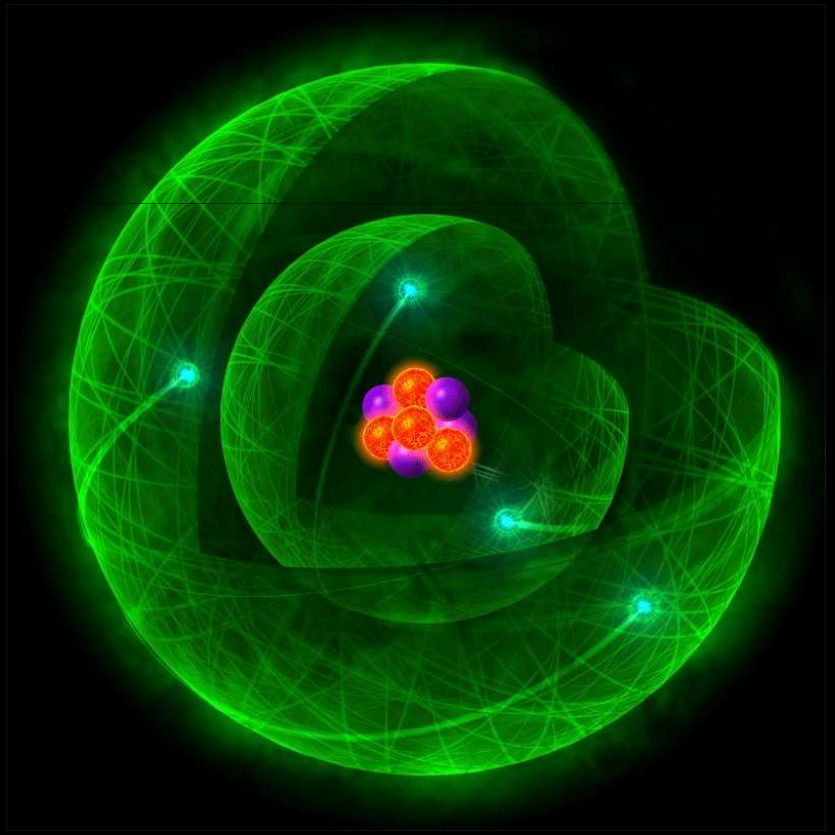


E_2

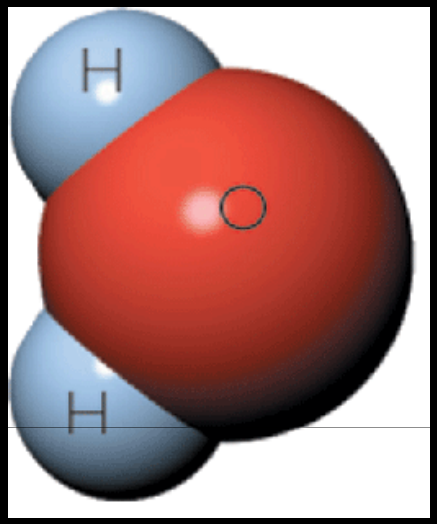
E_1

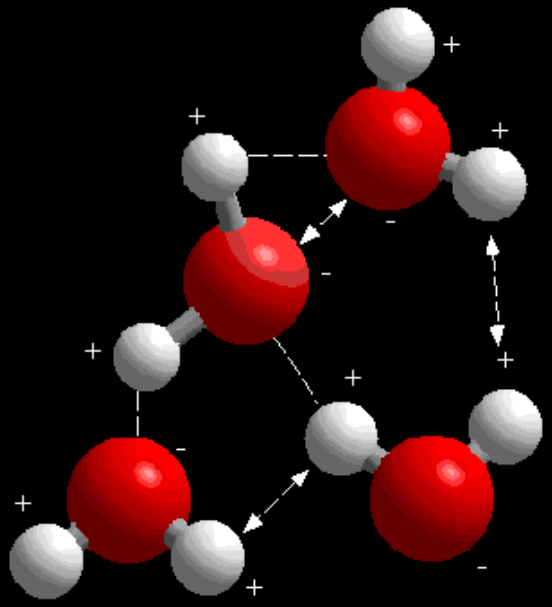
$$E_{fotón} = h\nu = E_2 - E_1$$

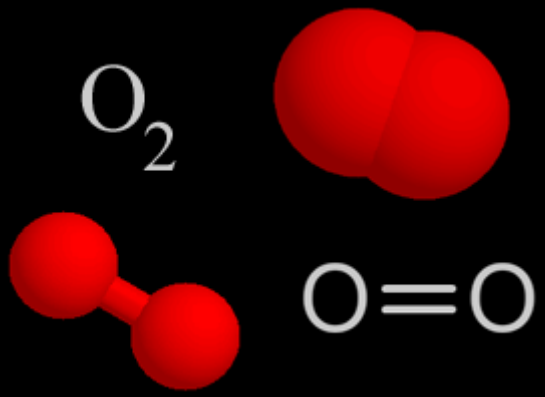


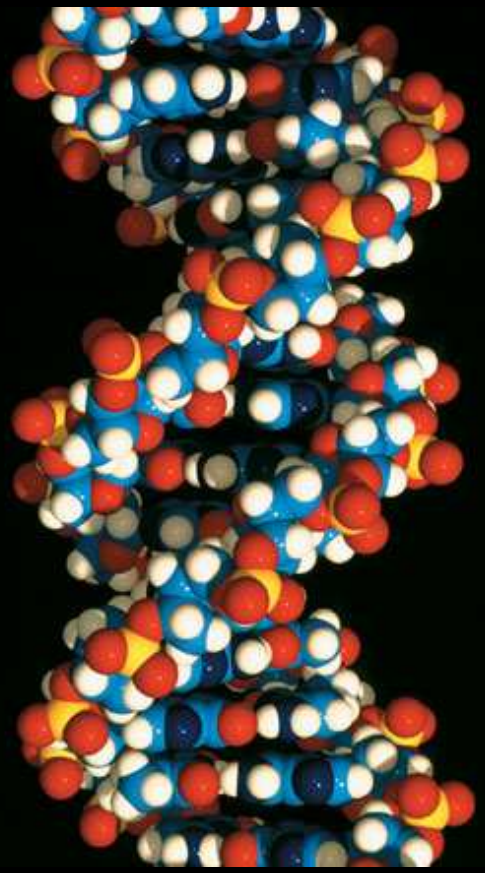


MOLÉCULA

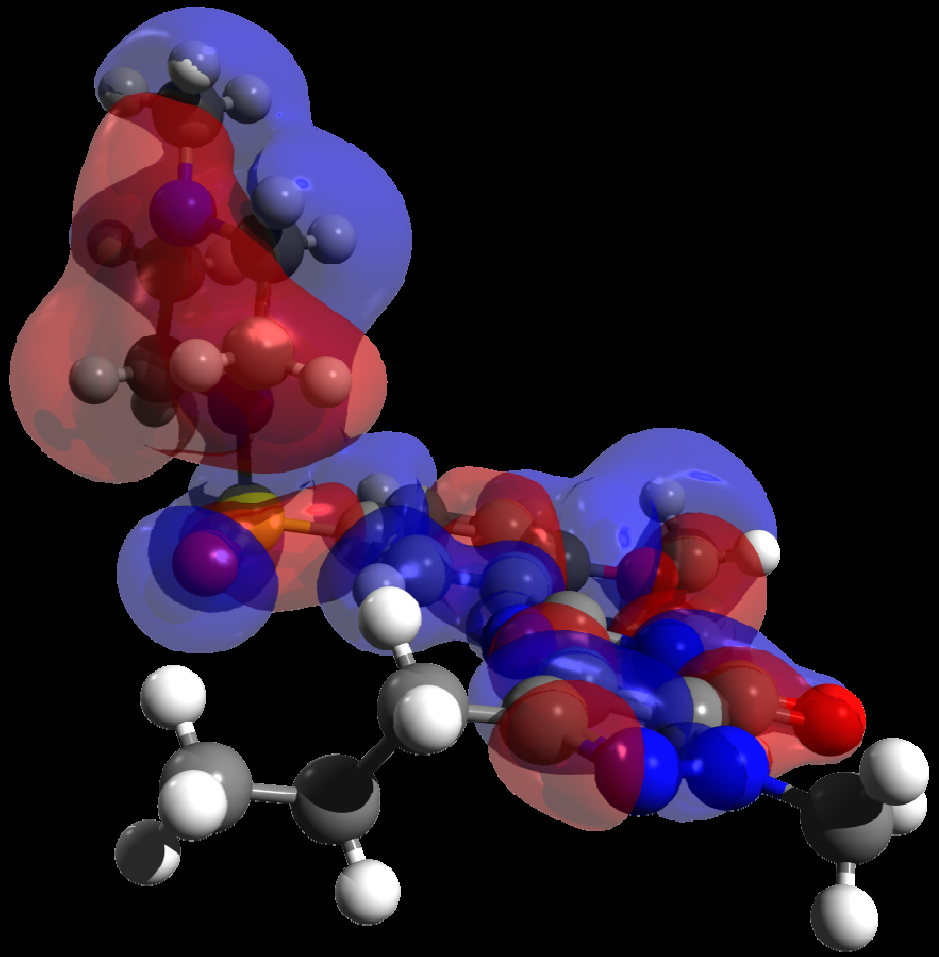


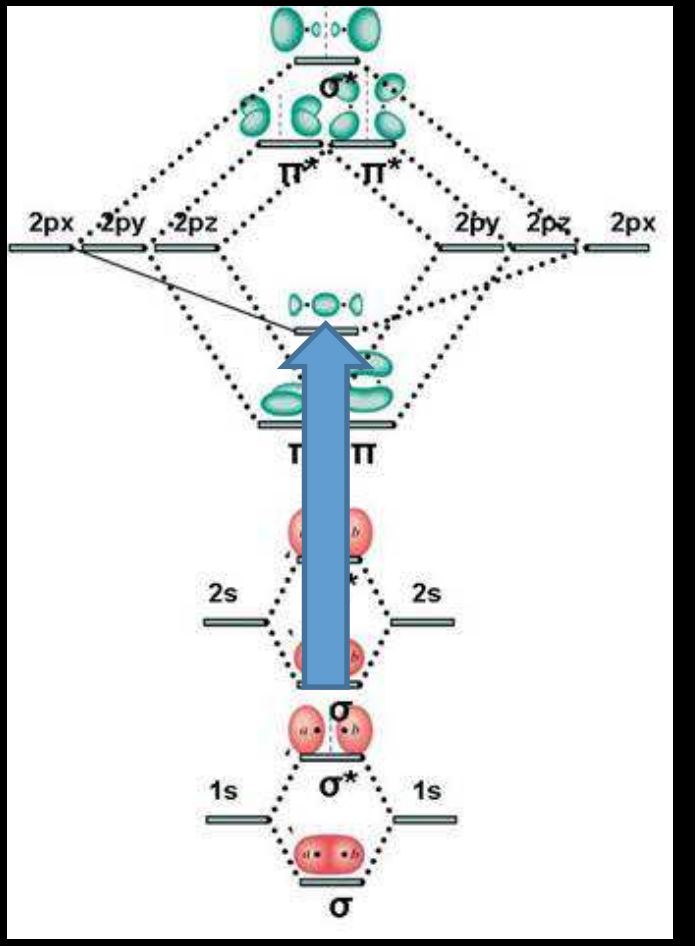






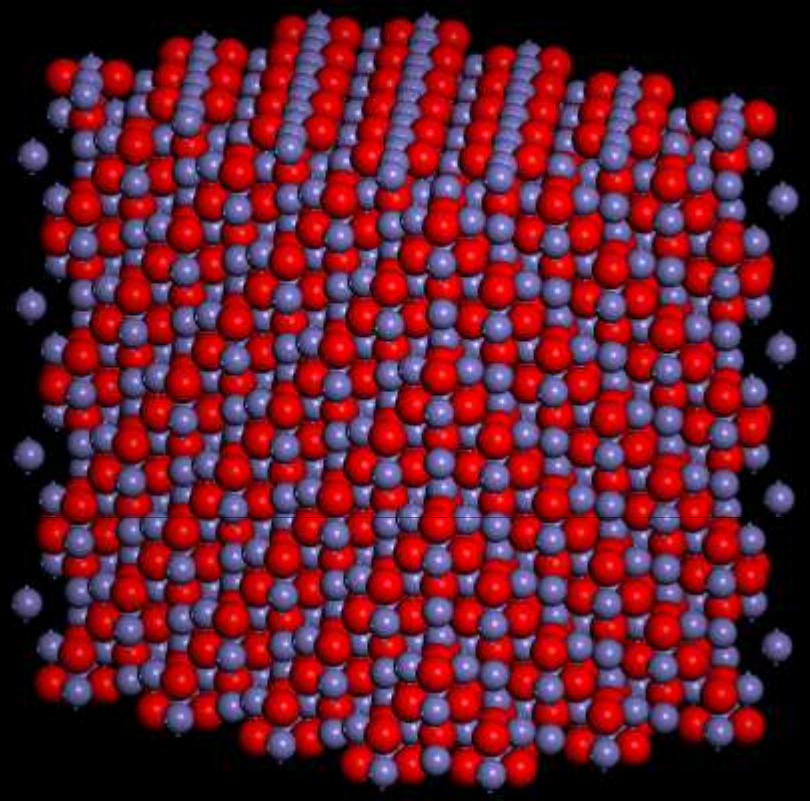
ORBITALES MOLECULARES

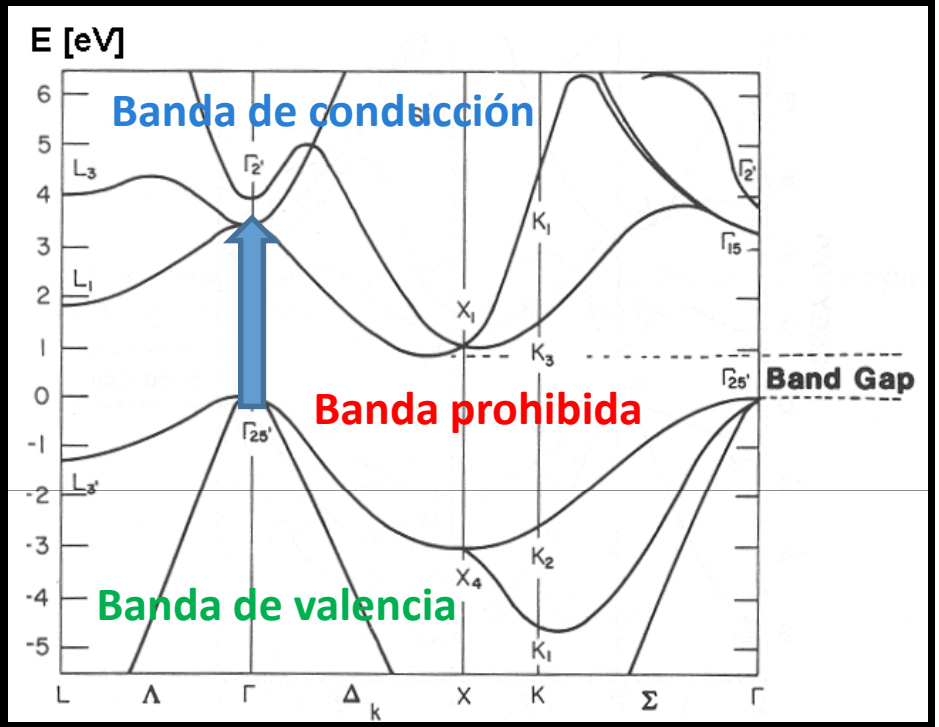




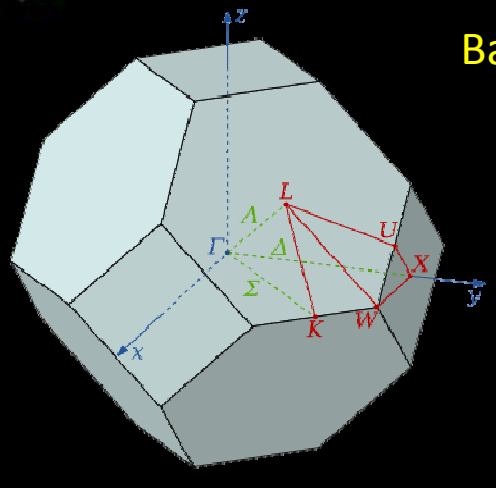
Estados energéticos

SÓLIDOS





Bandas de energía

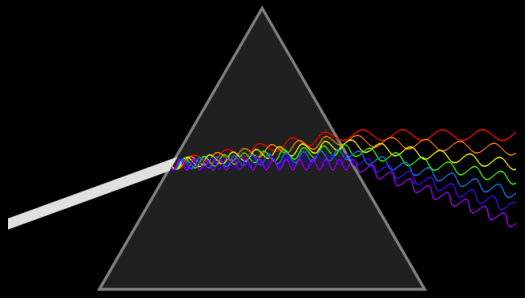


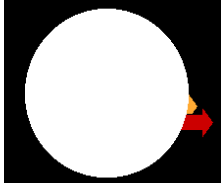
APLICACIONES DE LA LUZ

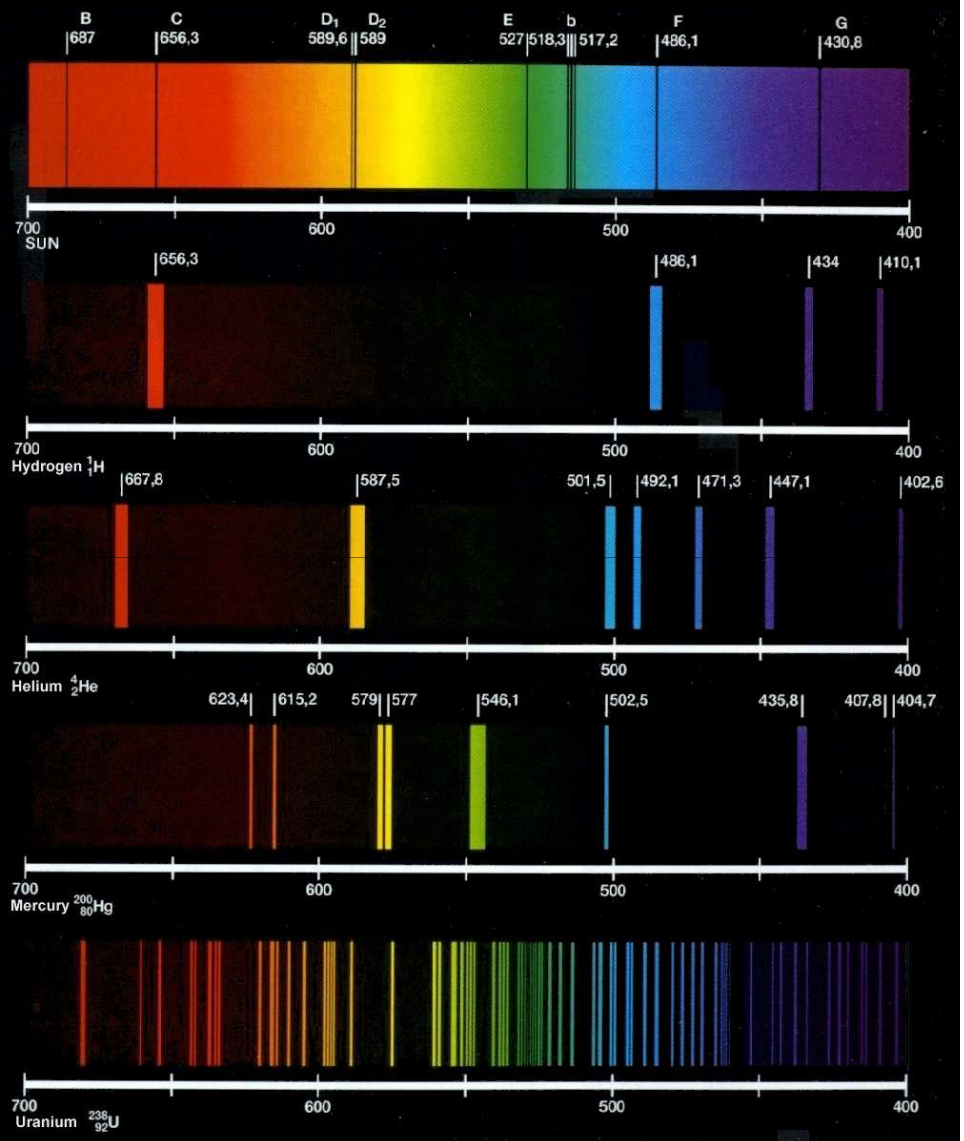
ESTUDIO DE MATERIALES

ESPECTROSCOPIAS

Espectroscopia atómica

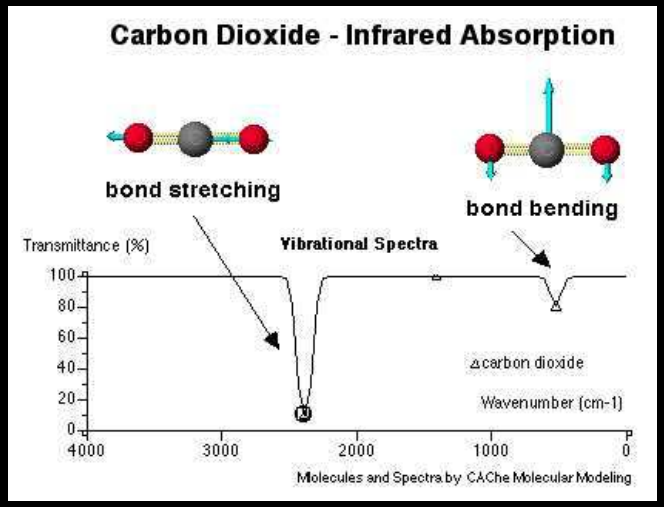


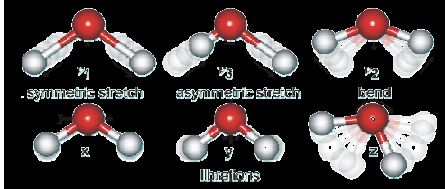


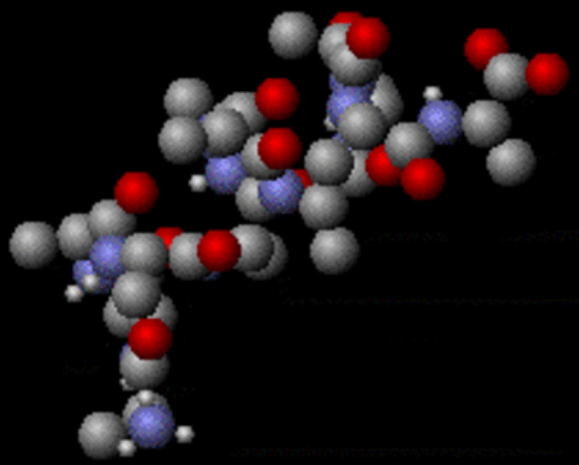


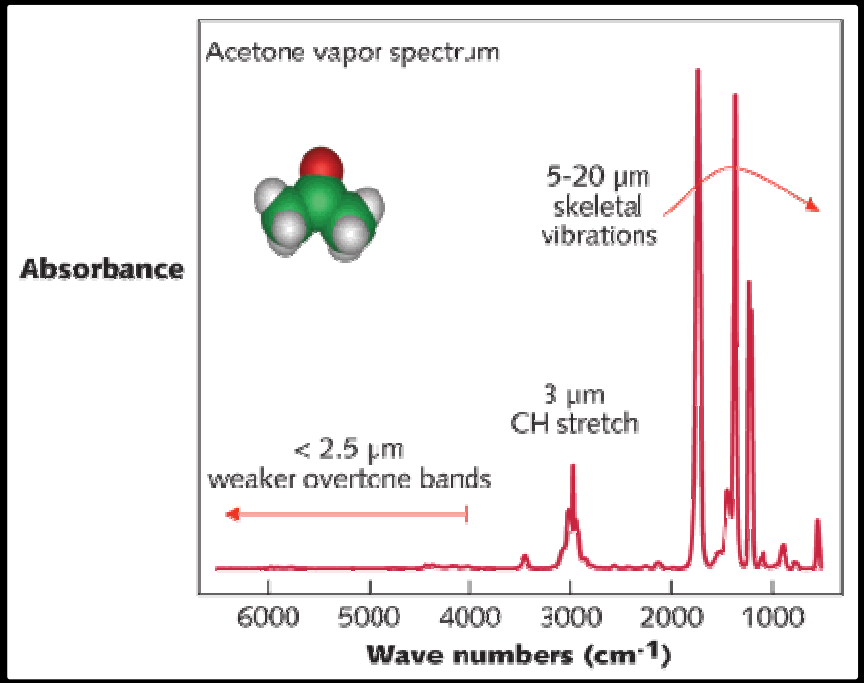
Espectro atómico

Espectroscopia molecular

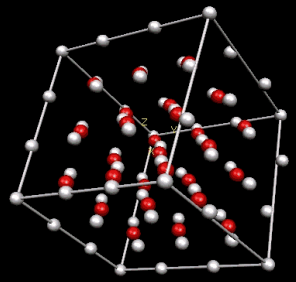


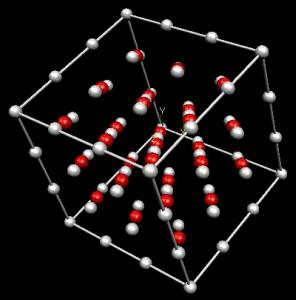


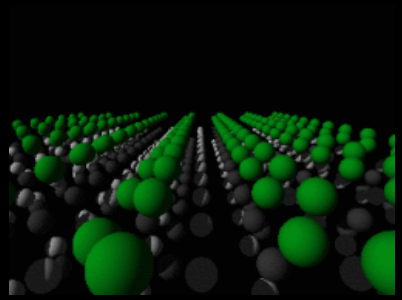




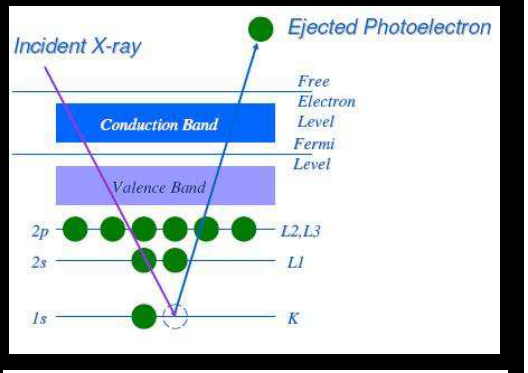
Espectroscopias en sólidos



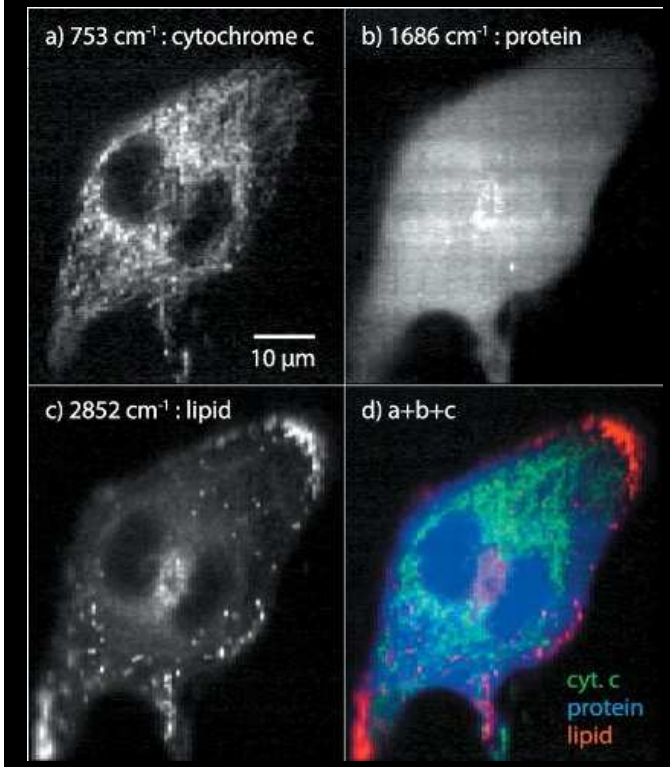


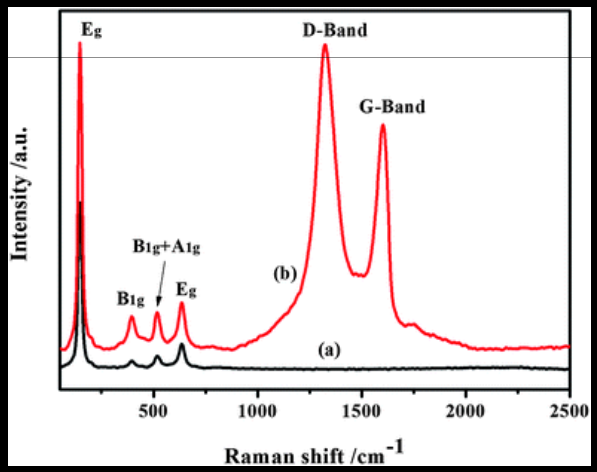


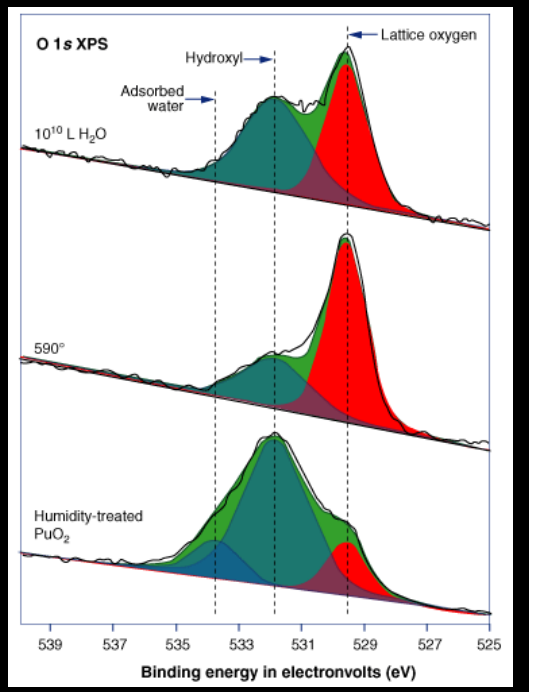
XPS: espectroscopia de fotoelectrones



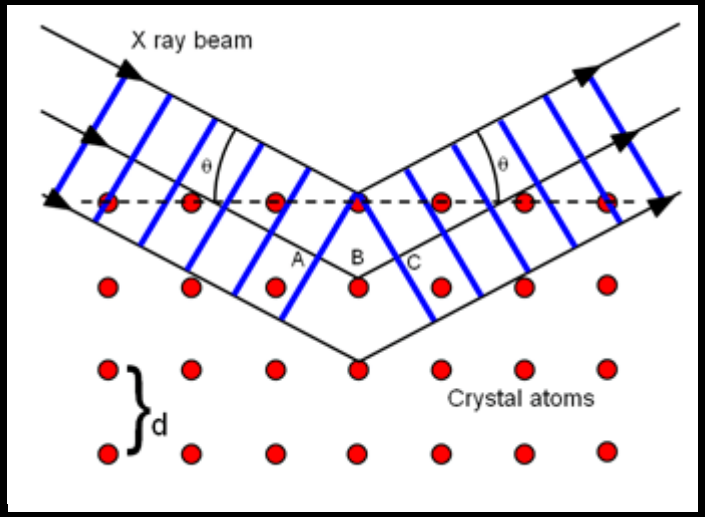
Espectroscopia Raman





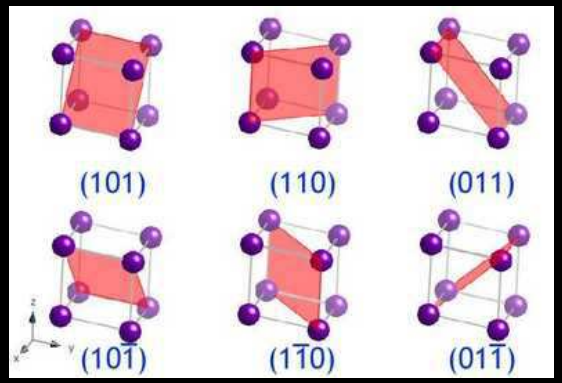


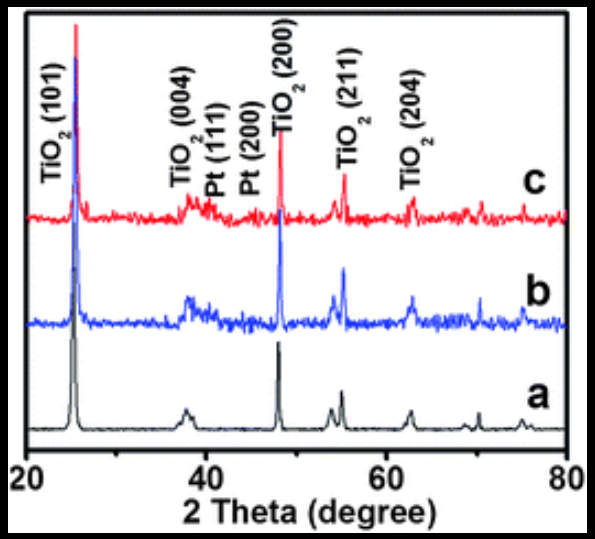
DIFRACCIÓN DE RAYOS X

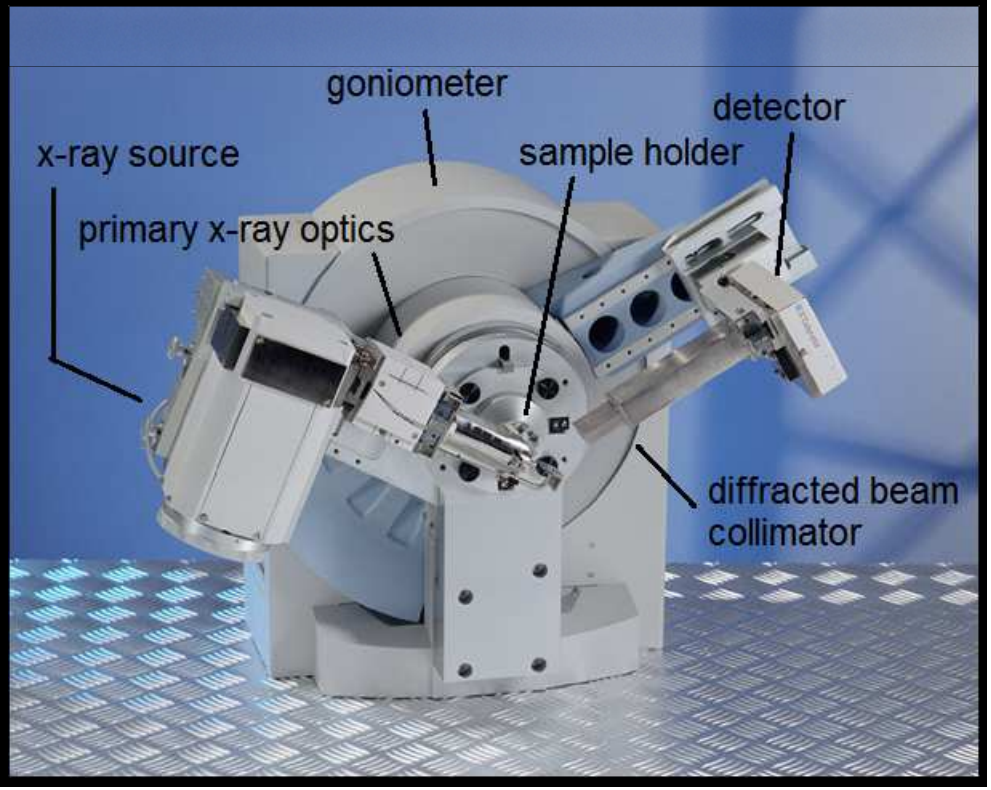


Ley de Bragg

$$2d \operatorname{Sen} \theta = n\lambda$$

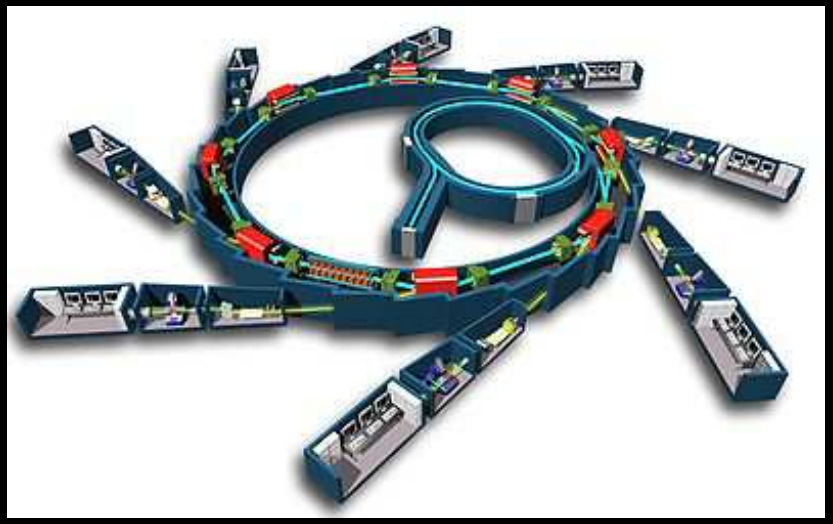




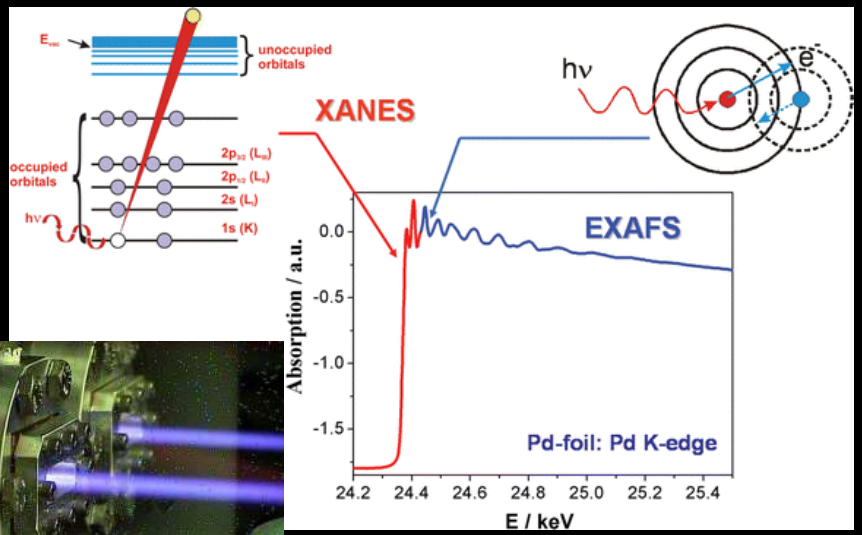


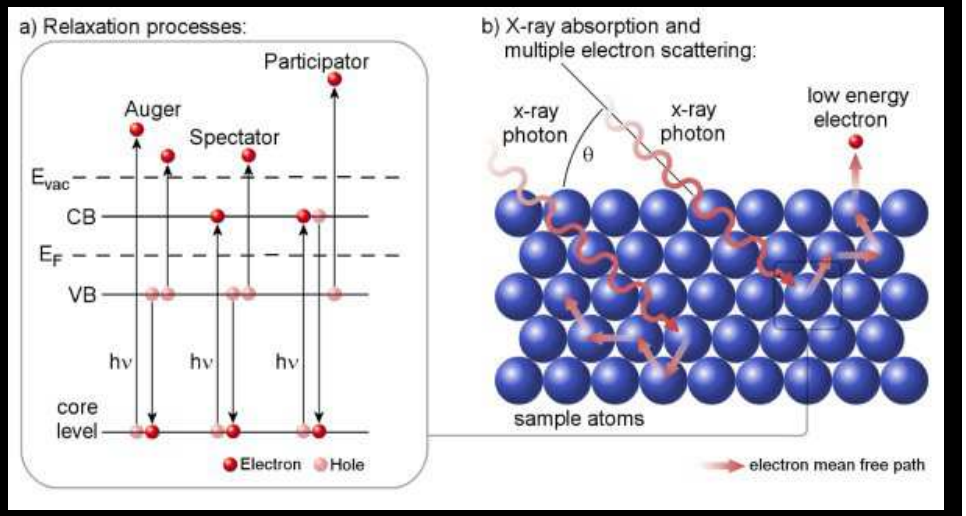
TÉCNICAS CON LUZ SINCROTRÓN

Sincrotrón ALBA



Haces intensos de luz IR- RX

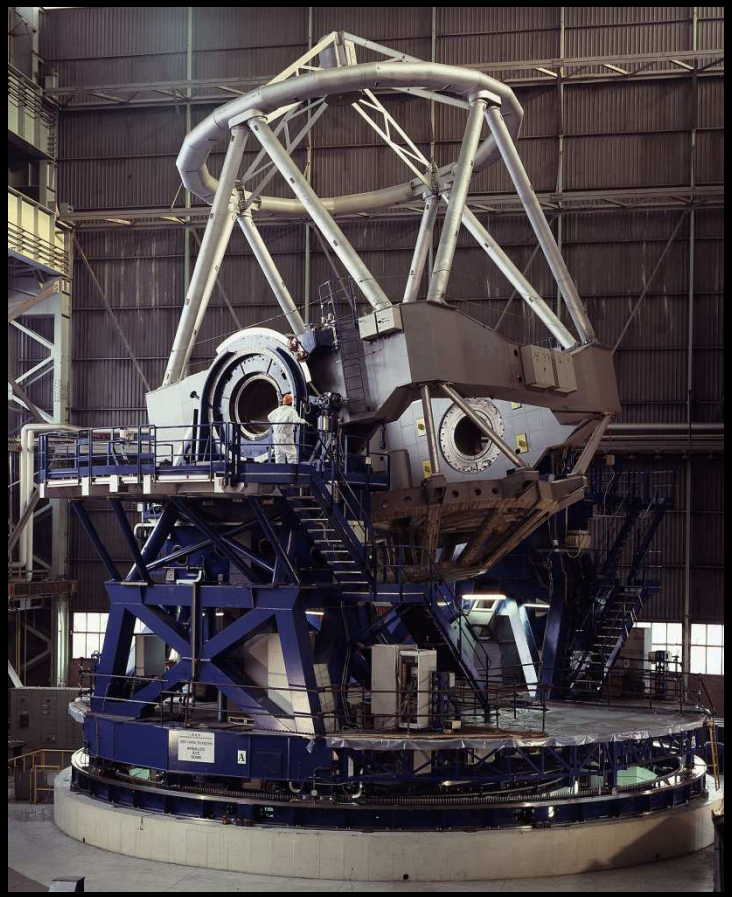




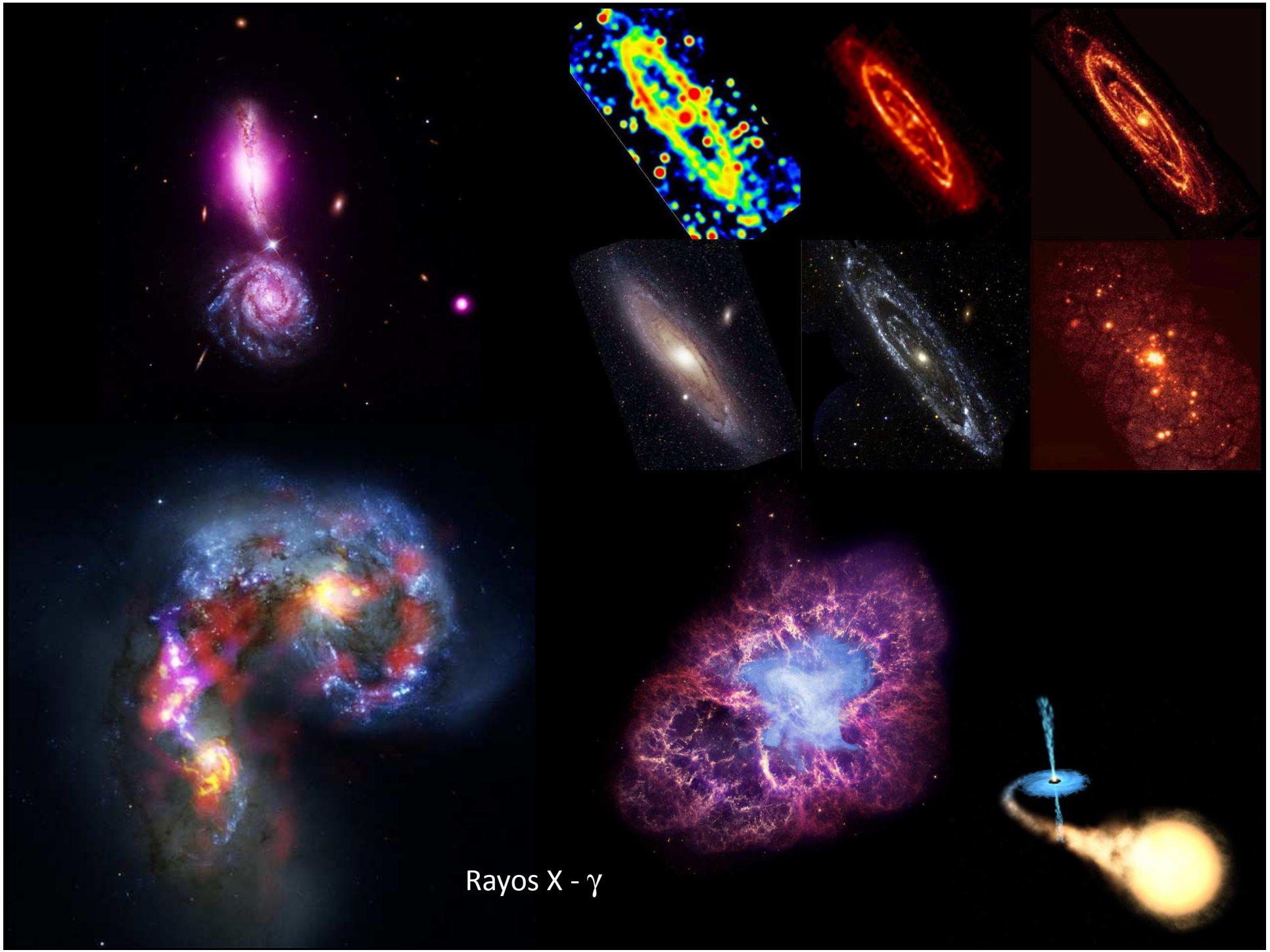

ASTRONOMIA

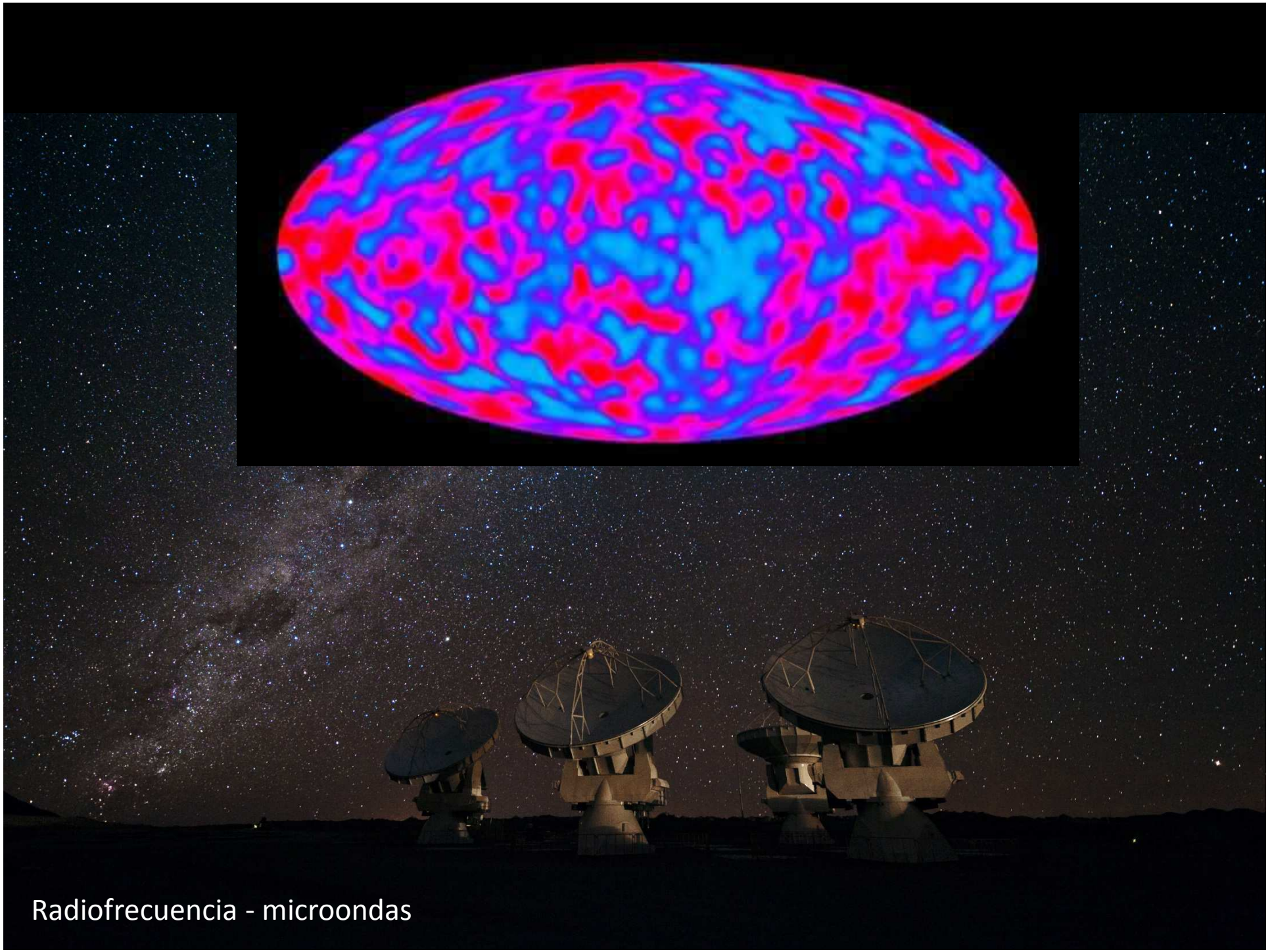
TELESCOPIOS

Observación desde ondas de radio a rayos γ



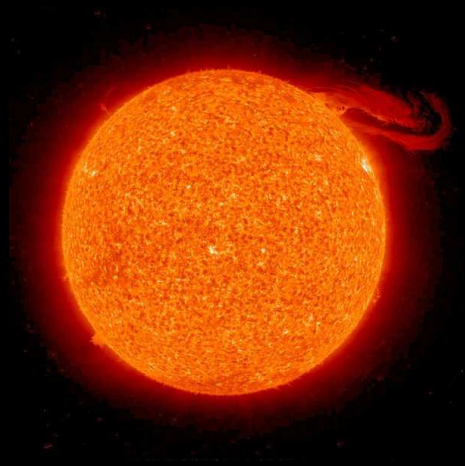

Espectro visible

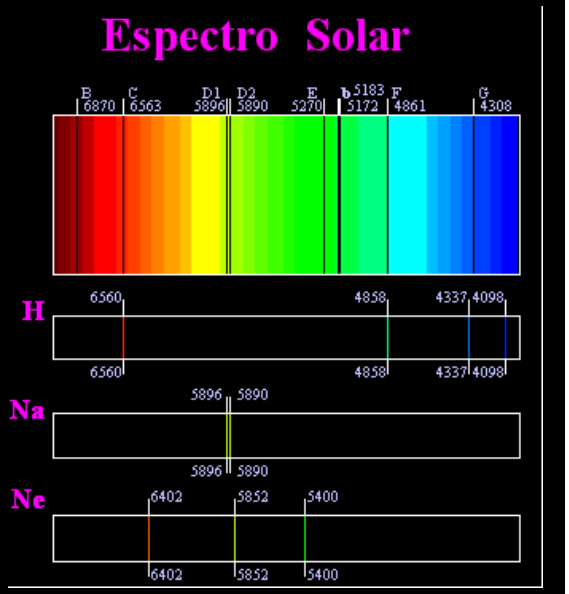

Rayos X - γ



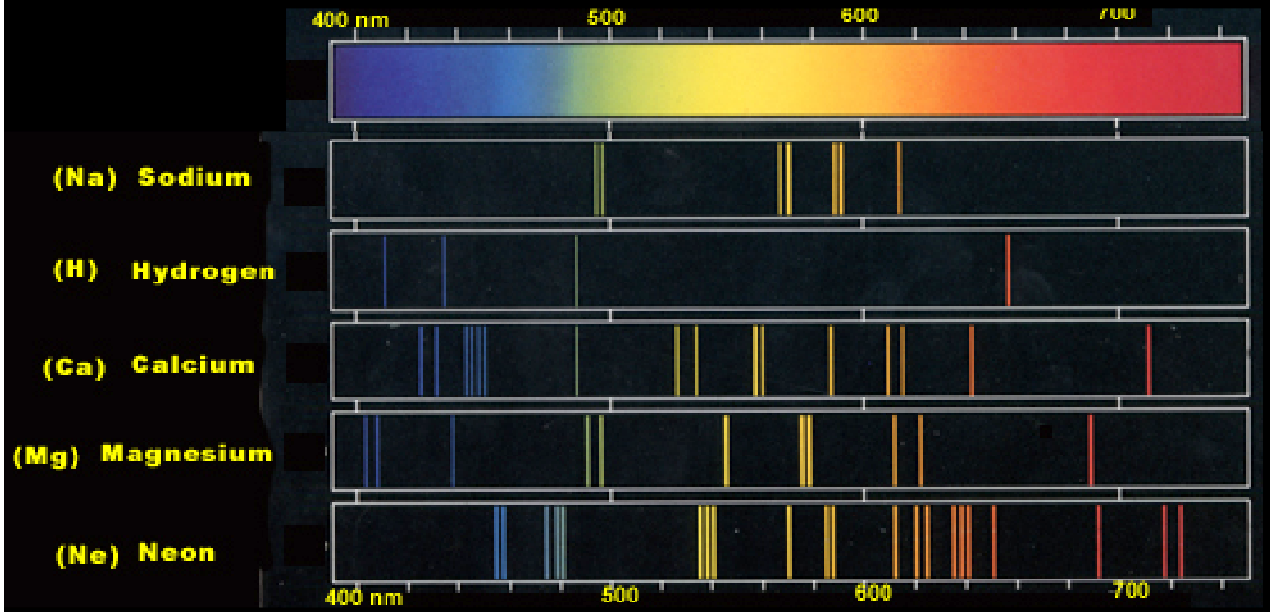
Radiofrecuencia - microondas

ESPECTROSCOPIA

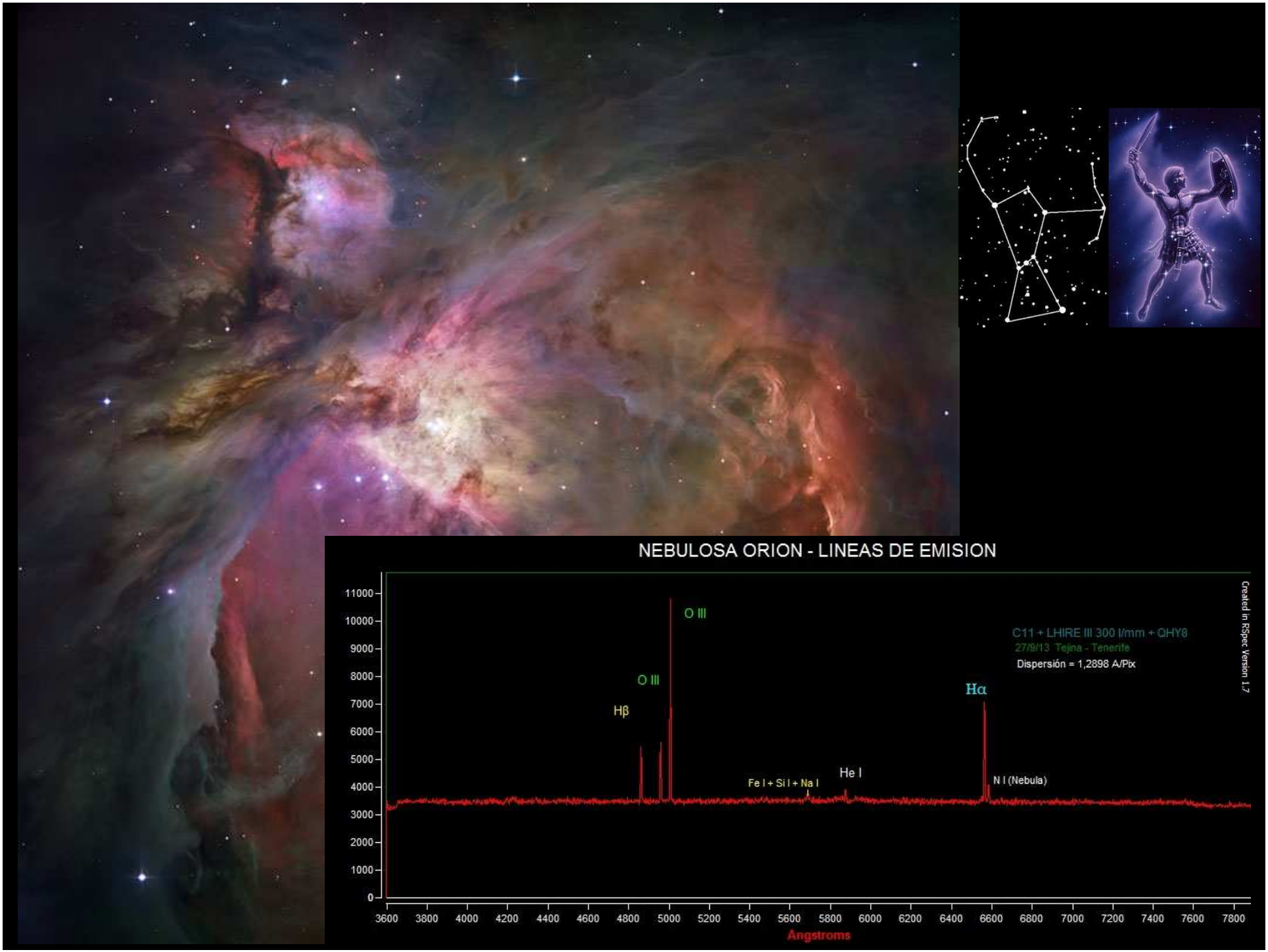




Composición de las estrellas y nebulosas

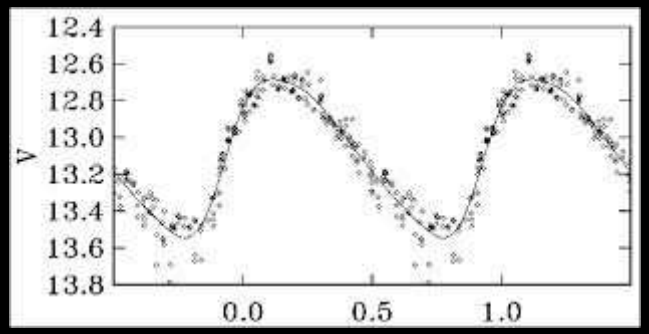


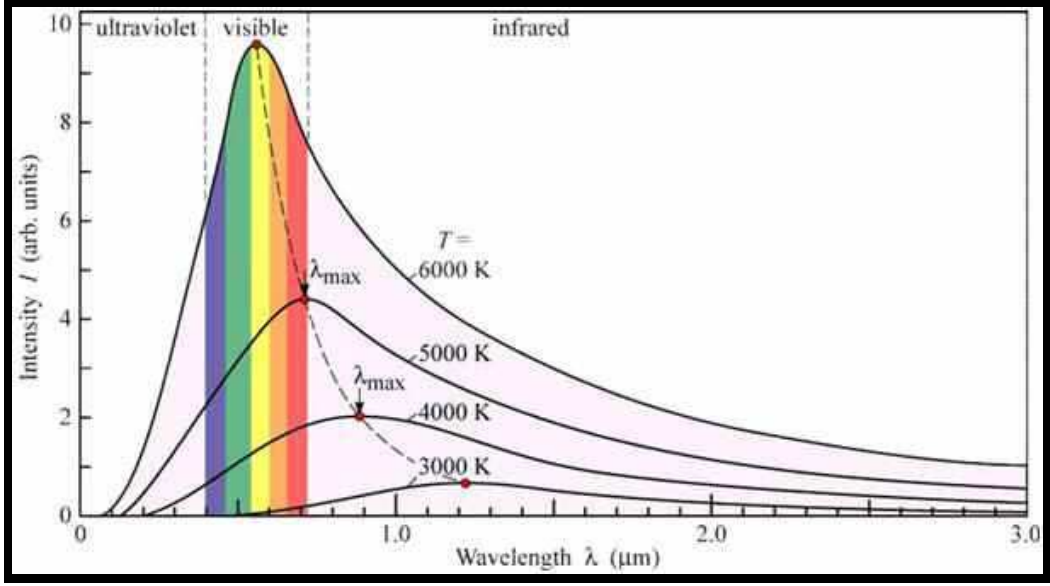
Adapted from Honolulu Community College Science 122 site

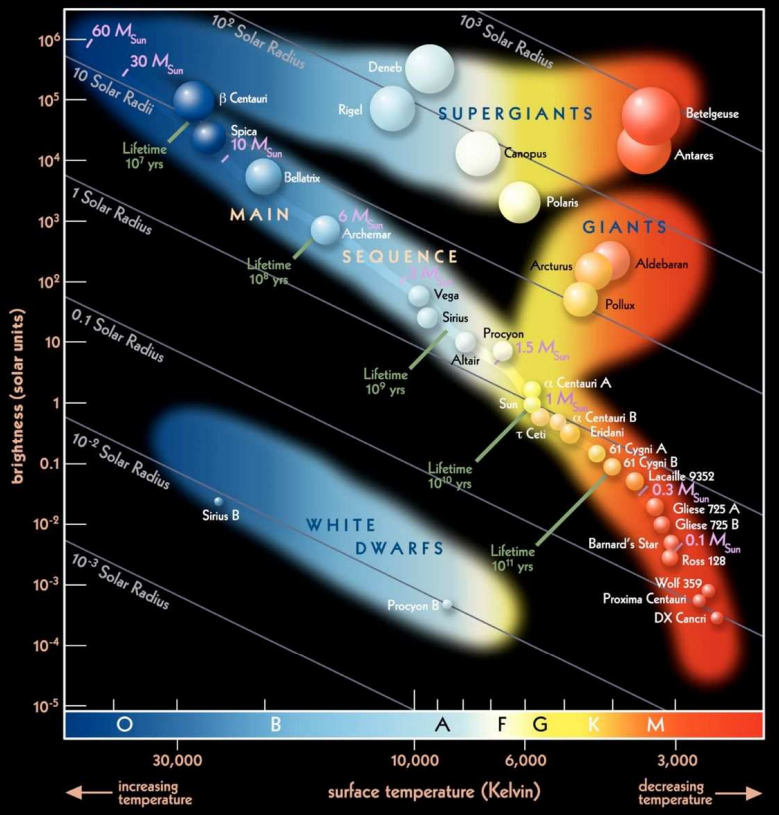

NEBULOSA ORION - LINEAS DE EMISION
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
O III
O III
Hβ
Hα
He I
Fe I + Si I + Na I
N I (Nebula)
C11 + LHIRE III 300 l/mm + QHY8
27/9/13 Tejina - Tenerife
Dispersión = 1,2898 A/Pix
Created in RSpec Version 1.7
3600 3800 4000 4200 4400 4600 4800 5000 5200 5400 5600 5800 6000 6200 6400 6600 6800 7000 7200 7400 7600 7800
Angstroms

Fotometría (magnitud aparente):
Distancia

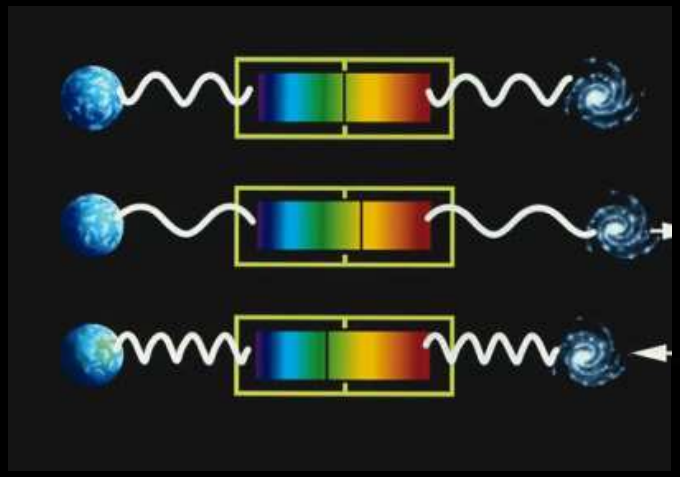
Ley de Wien (longitud de onda máximo):
Temperatura $\lambda_{max}\, T = 0.002898\ m \cdot K$

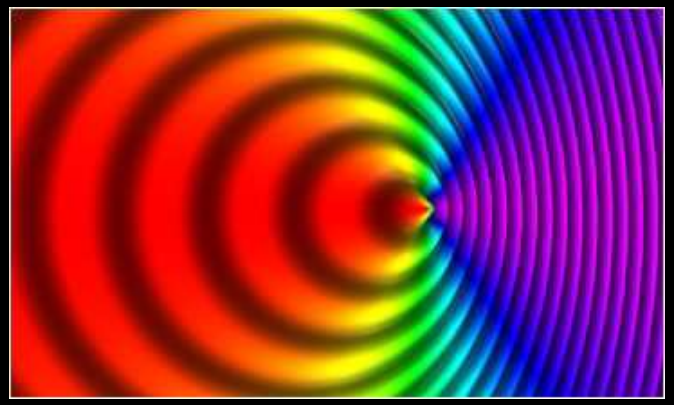


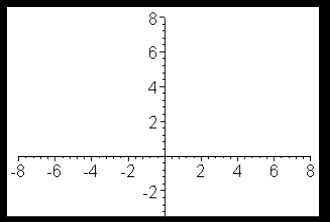


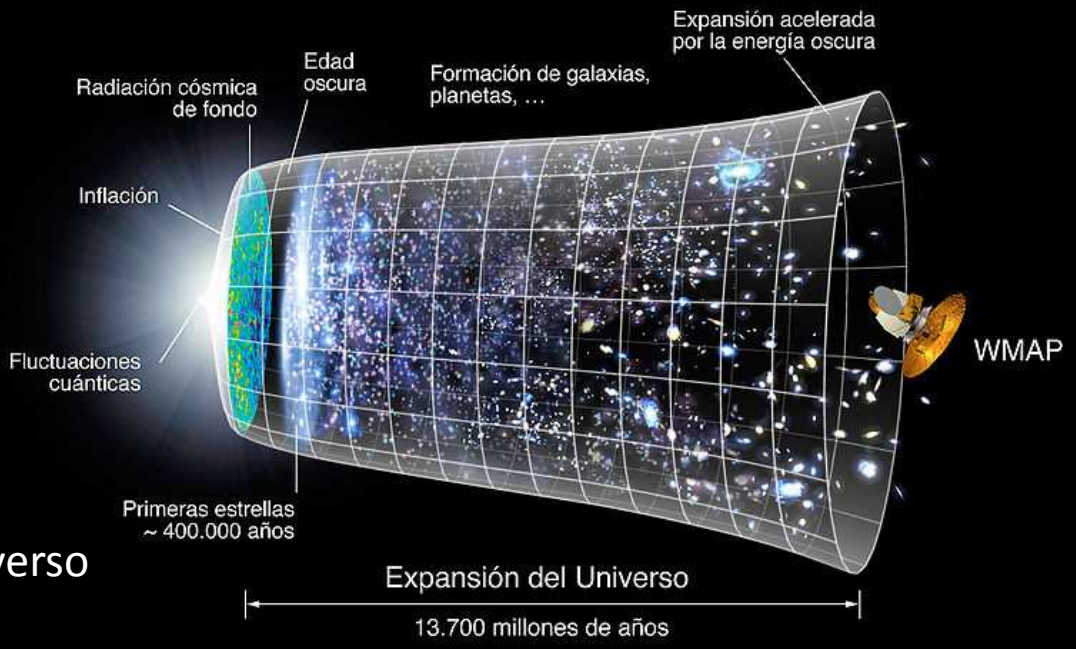


EFECTO DOPPLER





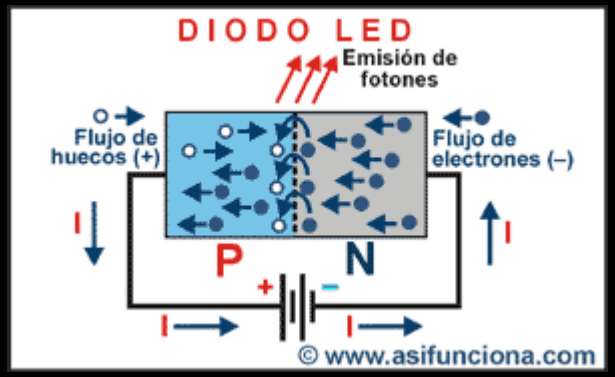


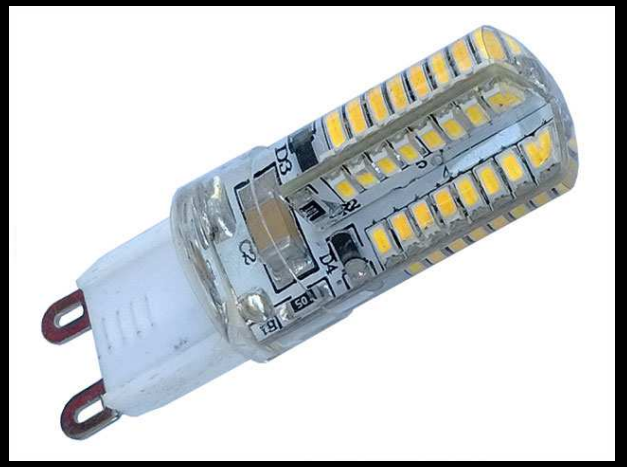


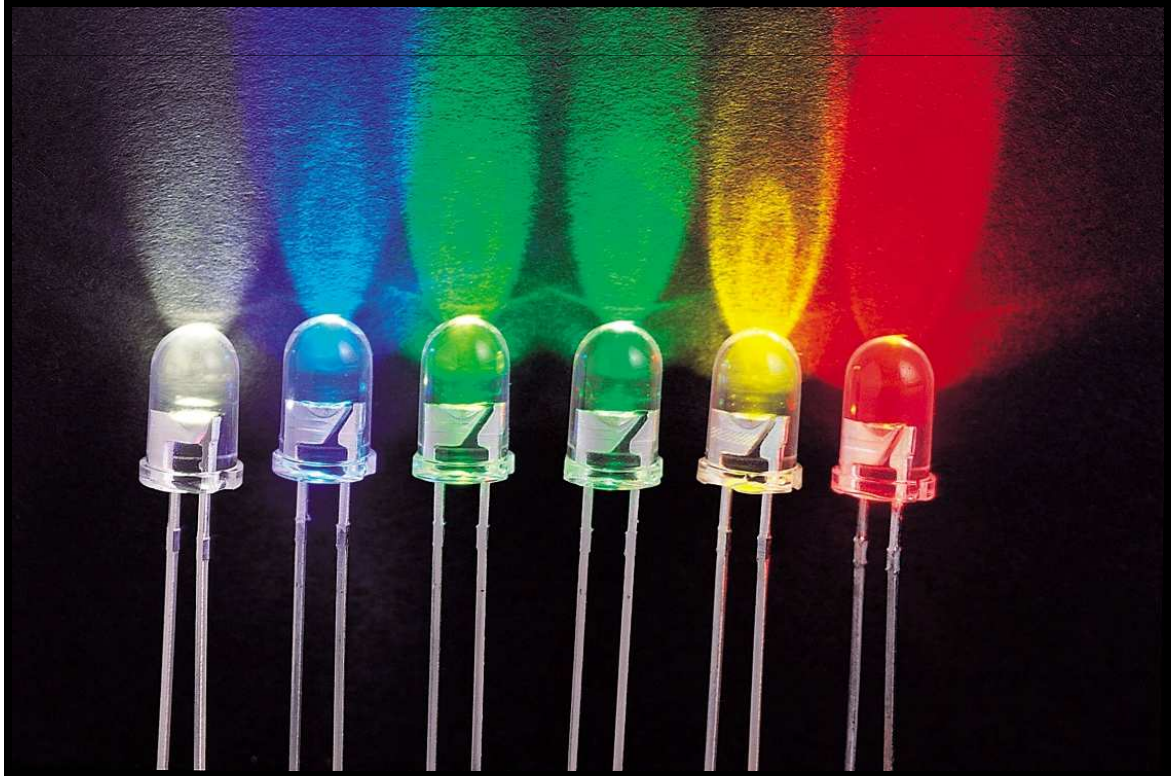
Expansión del universo

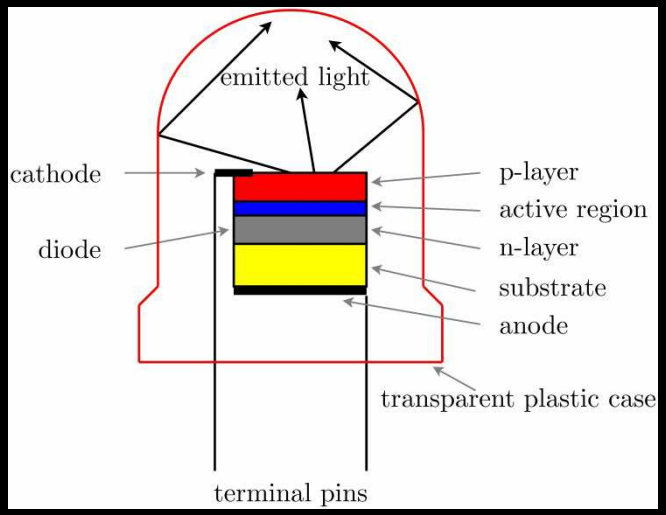
ELECTRÓNICA

FOTODIODO – DIODO LED



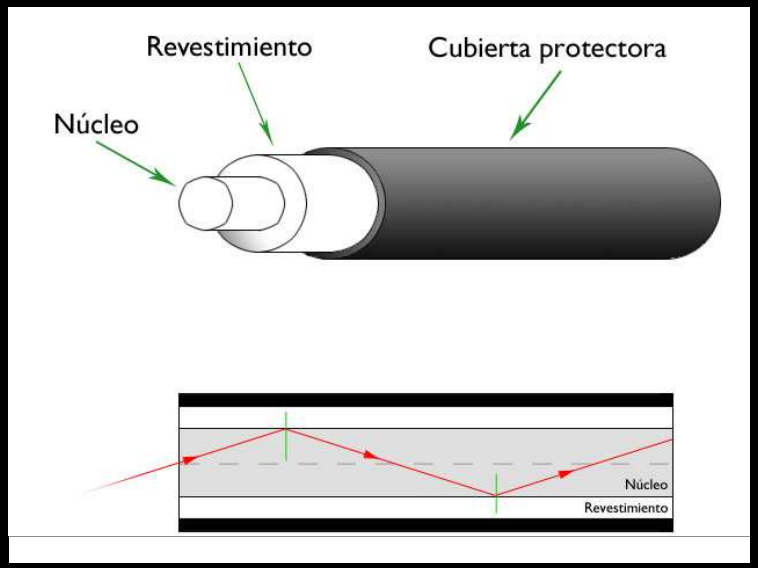


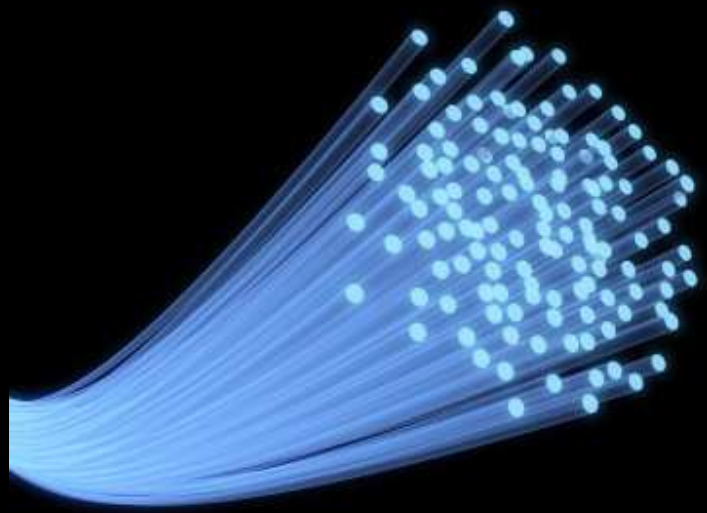


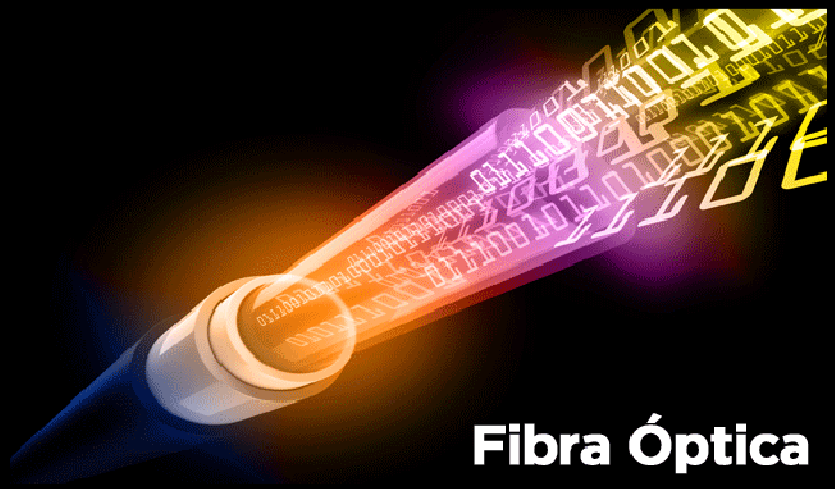


OLED (PANTALLAS FLEXIBLES)

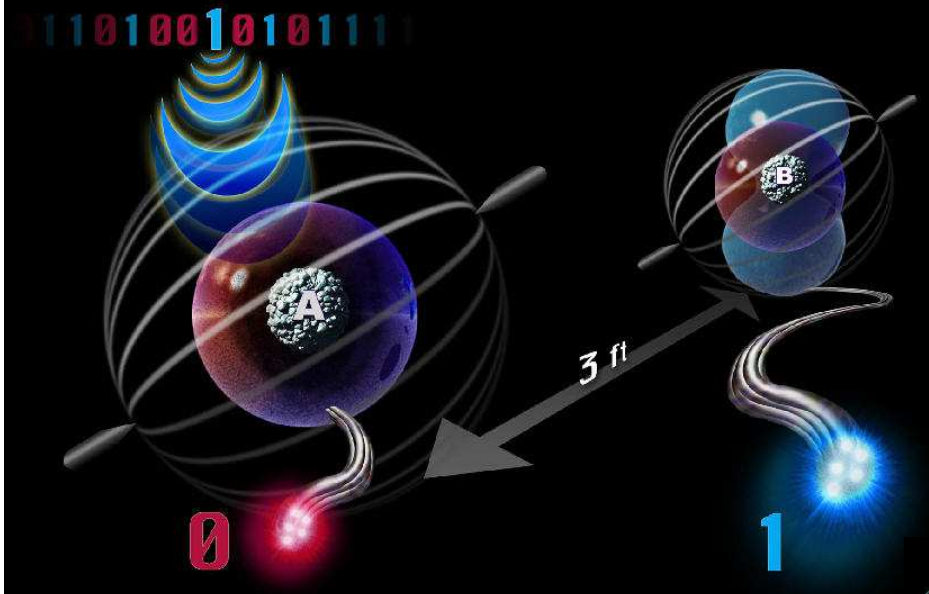
COMUNICACIONES ÓPTICAS



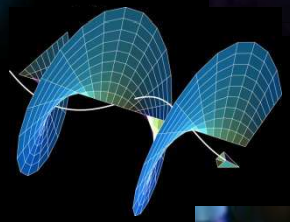




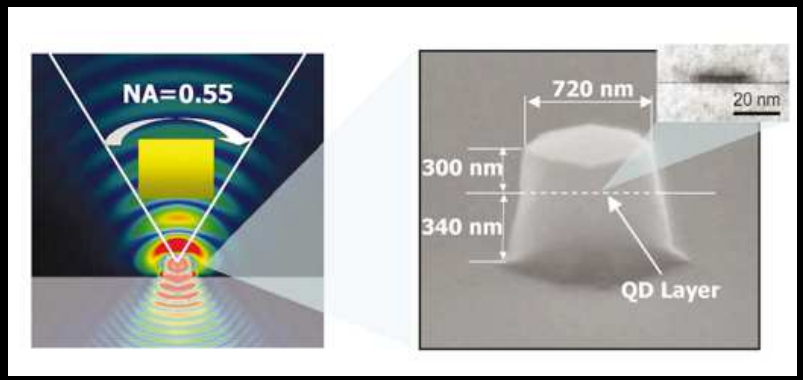
COMUNICACIÓN CUÁNTICA

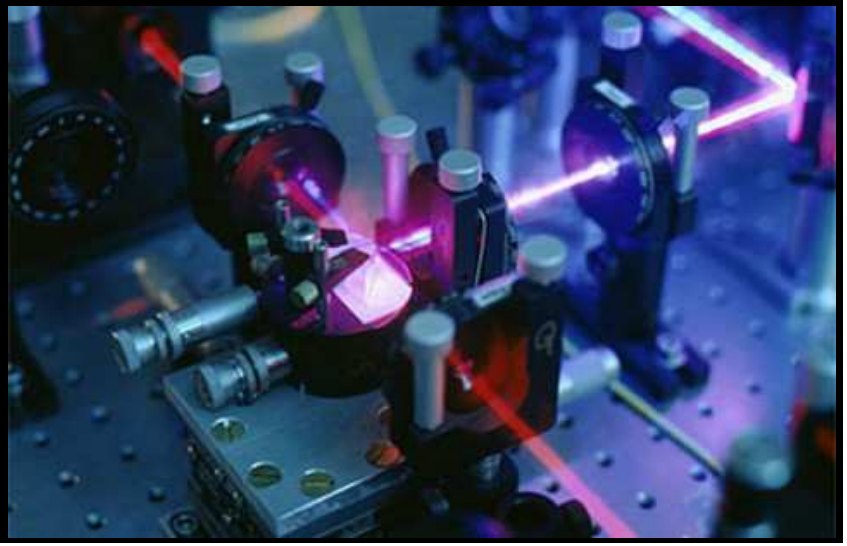


Teleportación

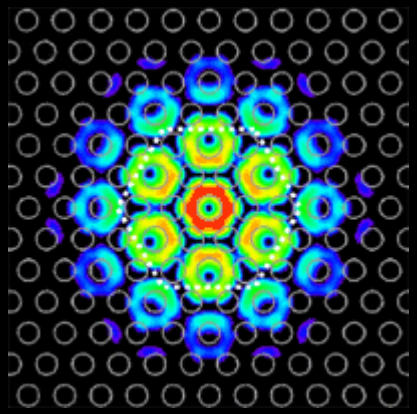


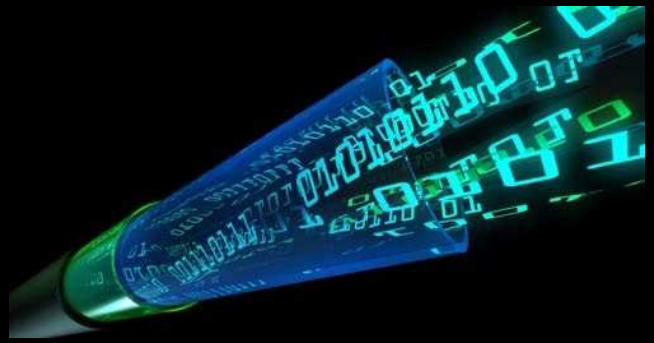
Superposición de estados cuánticos,
entrelazamiento y acción a distancia



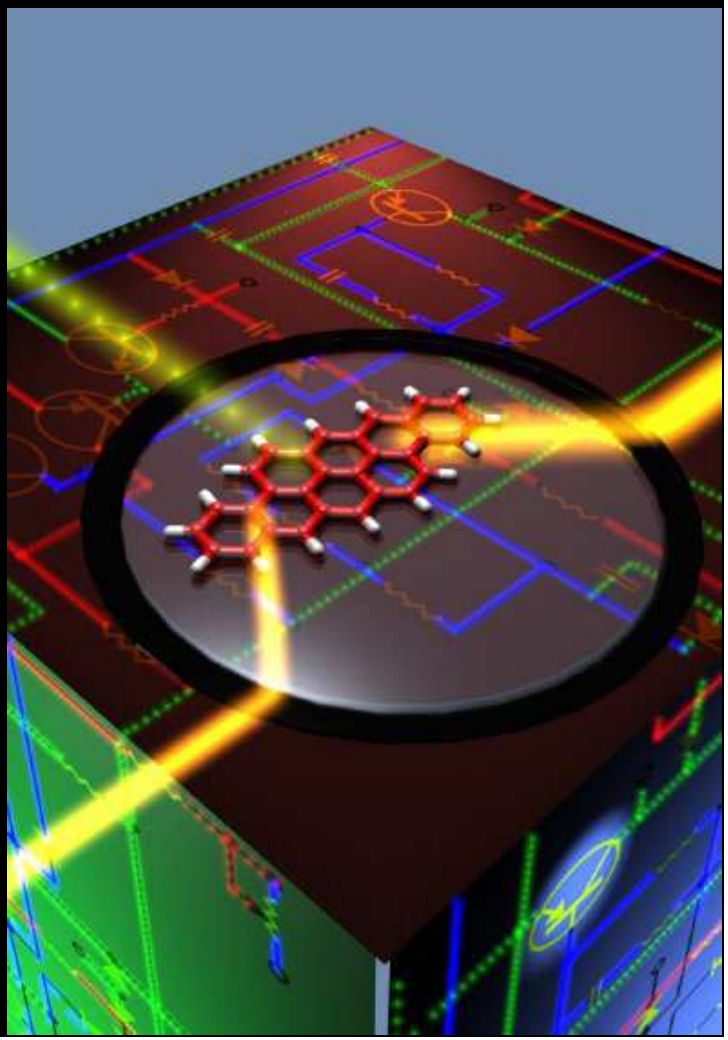


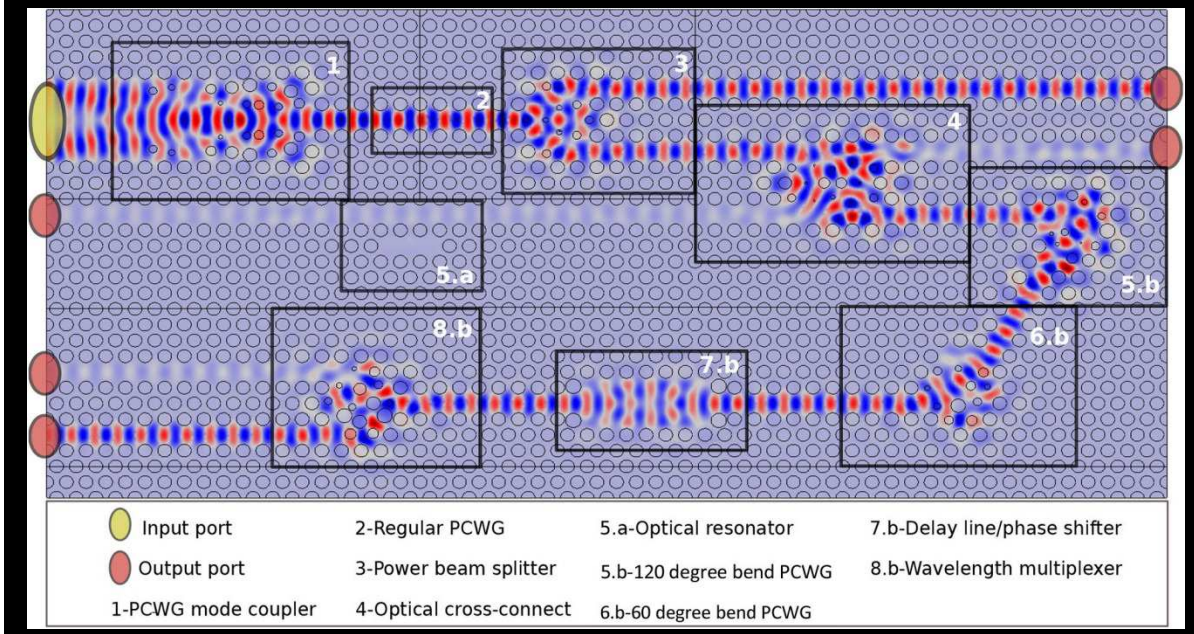
ORDENADOR ÓPTICO



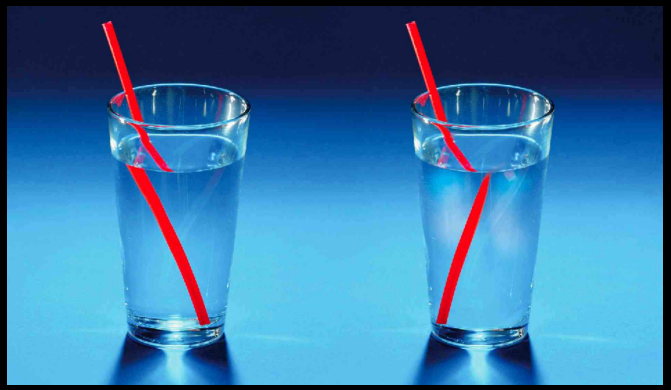


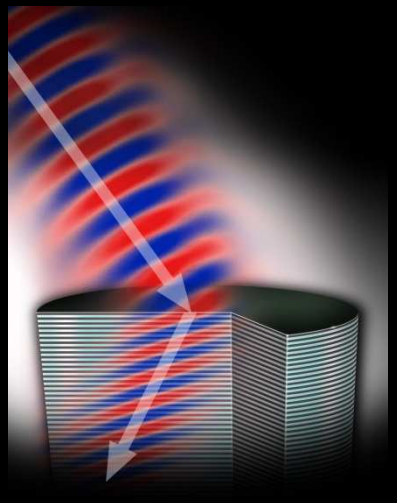
Cristales fotónicos, materiales fotoactivos no lineales

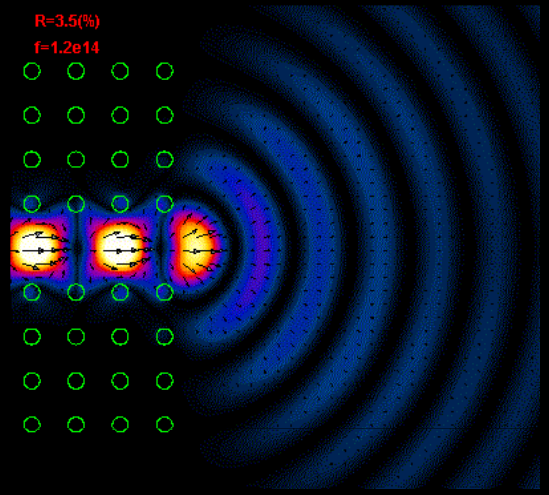


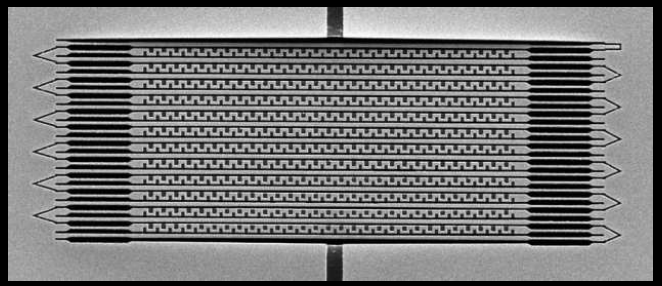


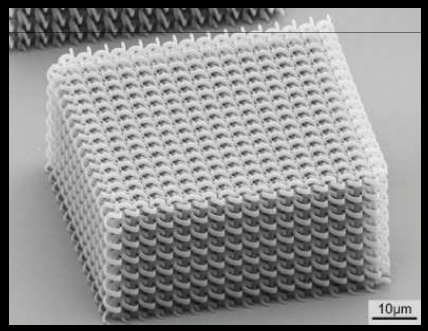
METAMATERIALES



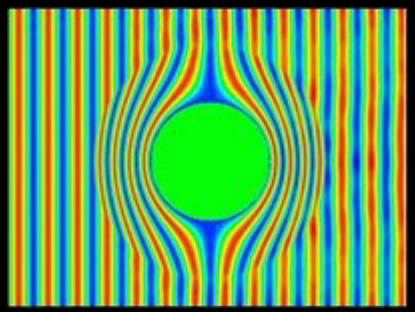


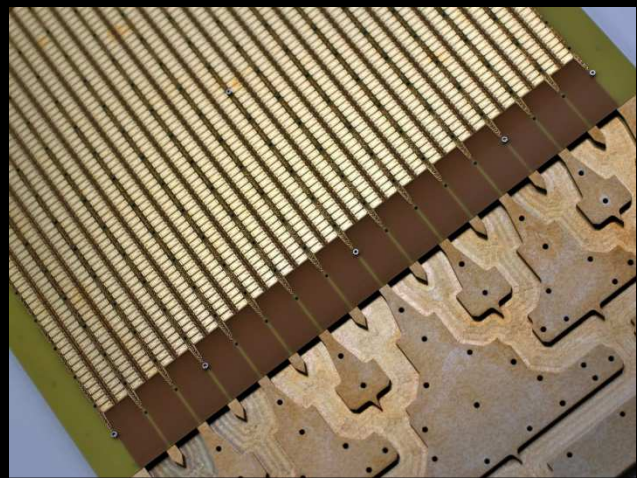






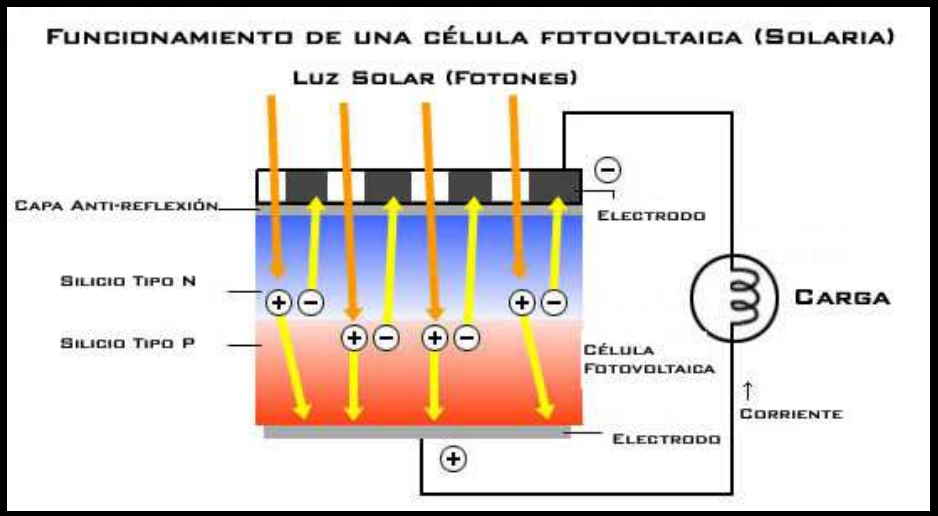
Antenas, filtros, ocultación

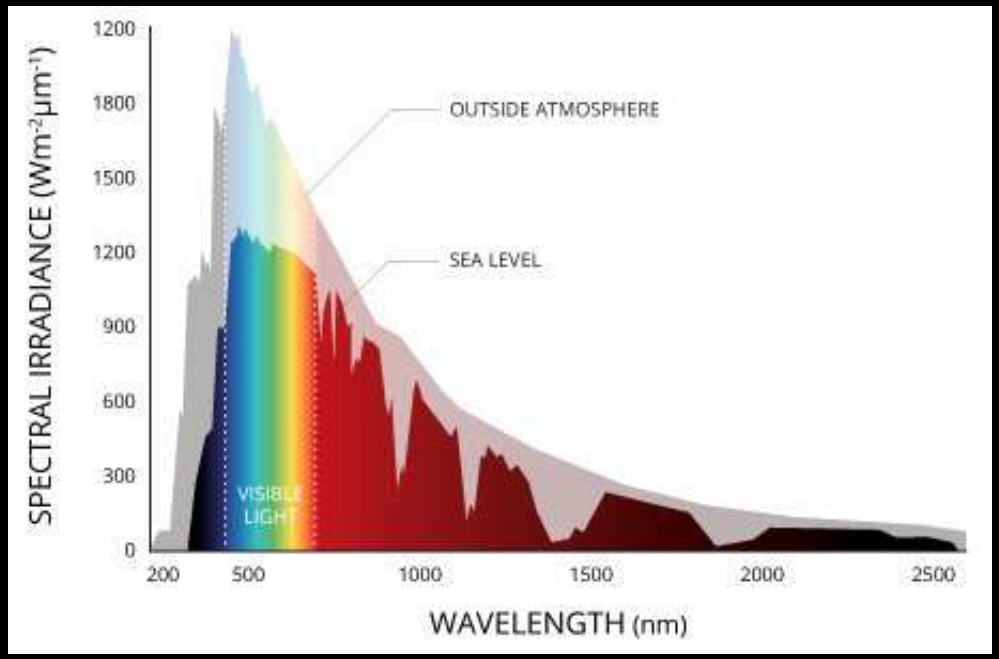


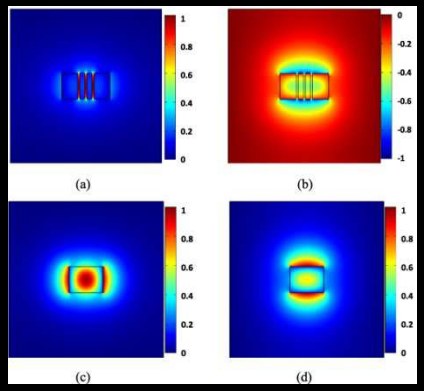


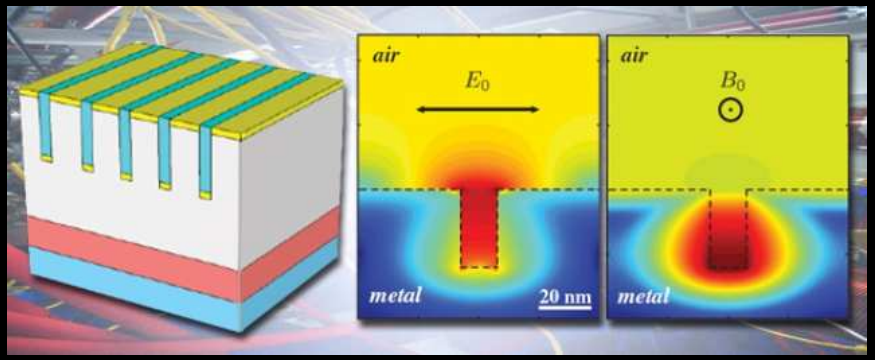

ENERGÍA

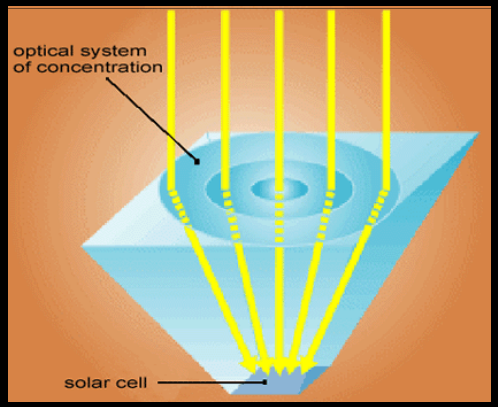
ENERGÍA SOLAR FOTOVOLTAICA

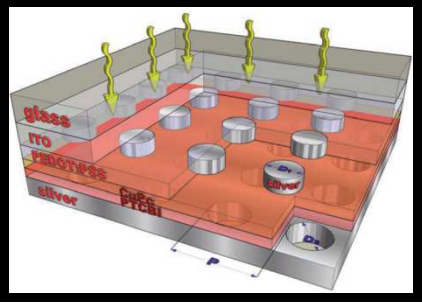






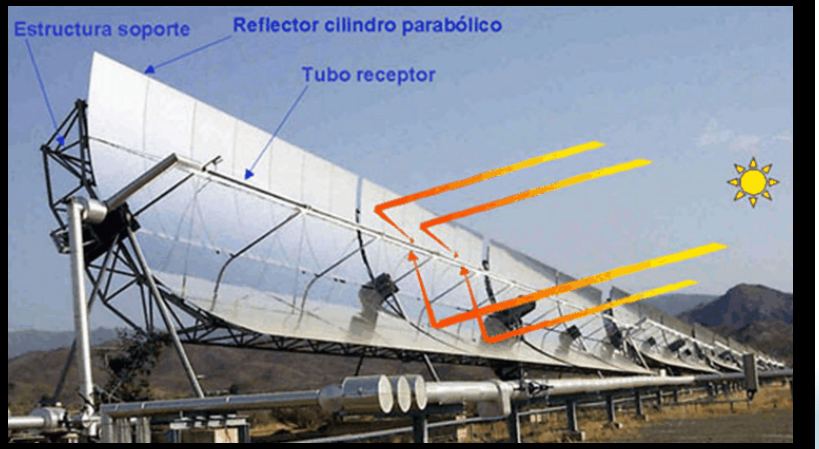




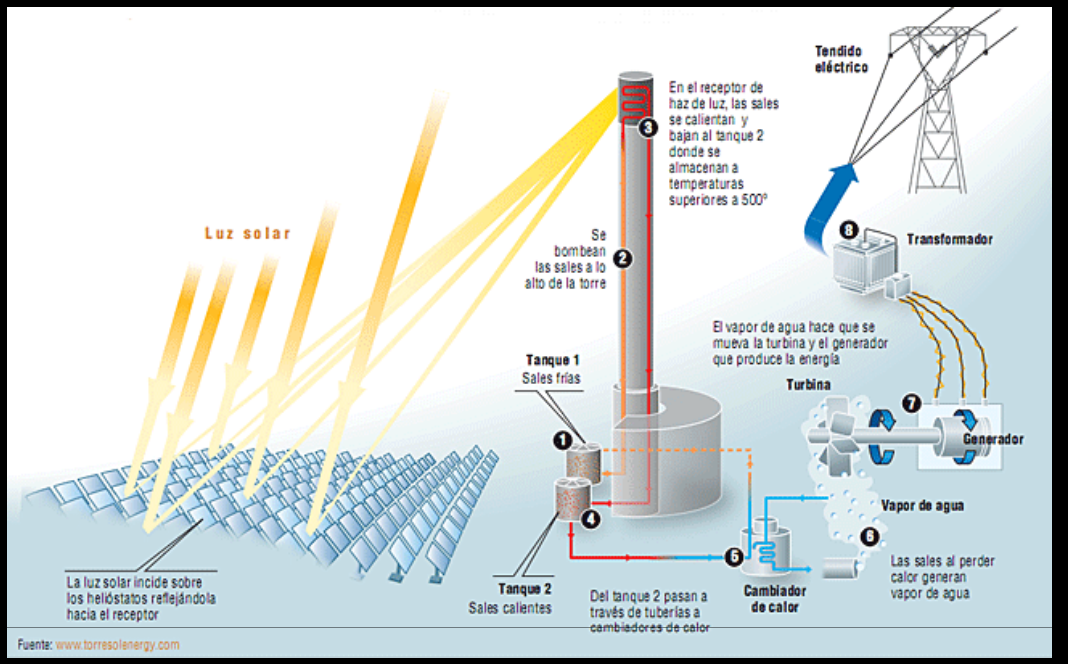


- Células solares de concentración
- Celulas solares infrarrojas

ENERGÍA SOLAR TÉRMICA



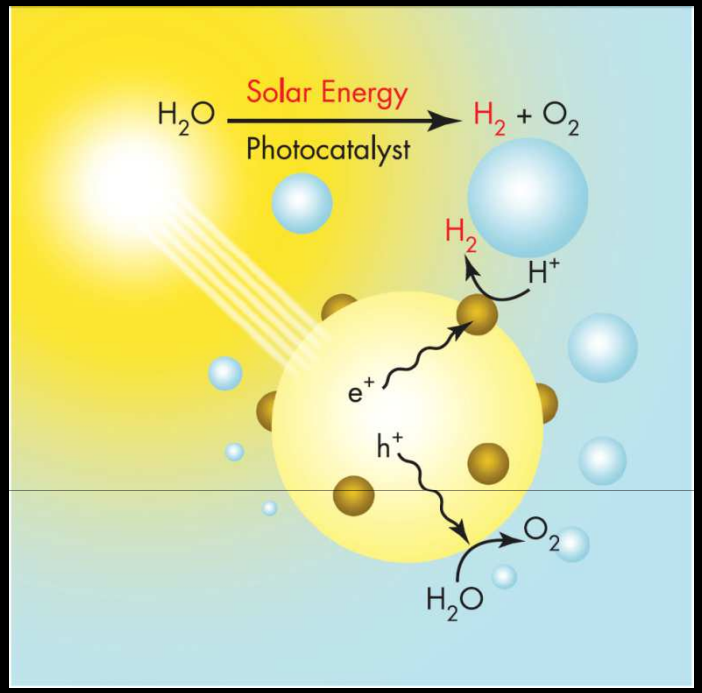
Captación cilindro-parabólica

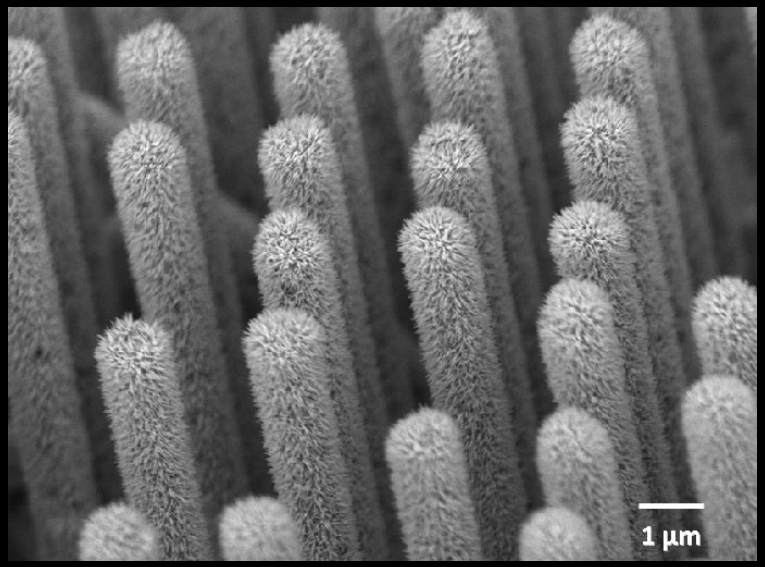


Torre central

Motor Stirling

PRODUCCIÓN DE COMBUSTIBLE SOLAR



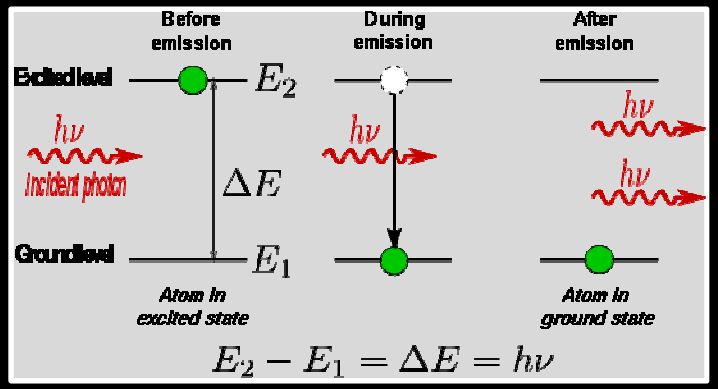


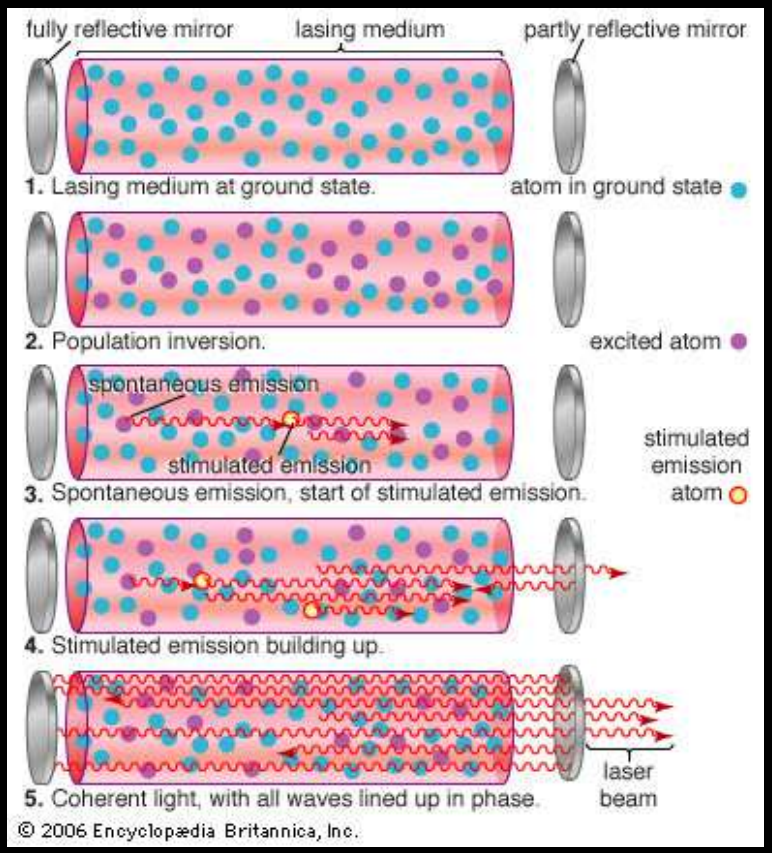
- Fotodisociación del agua: Hidrógeno

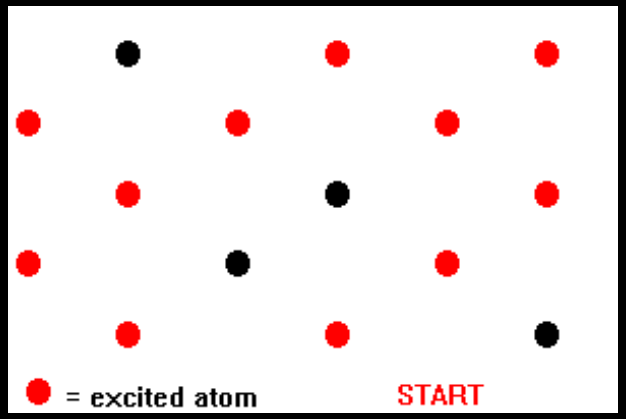
- Producción de hidrocarburos a partir de agua y CO_2

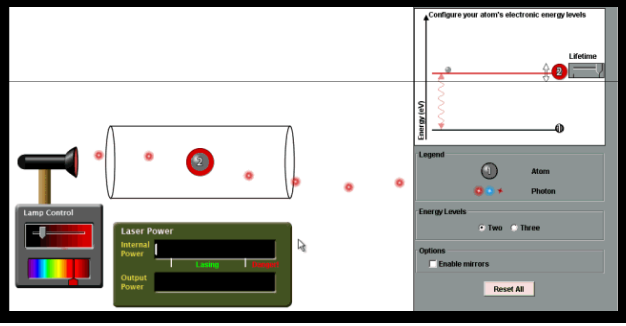
LÁSER:
FUNCIONAMIENTO Y APLICACIONES

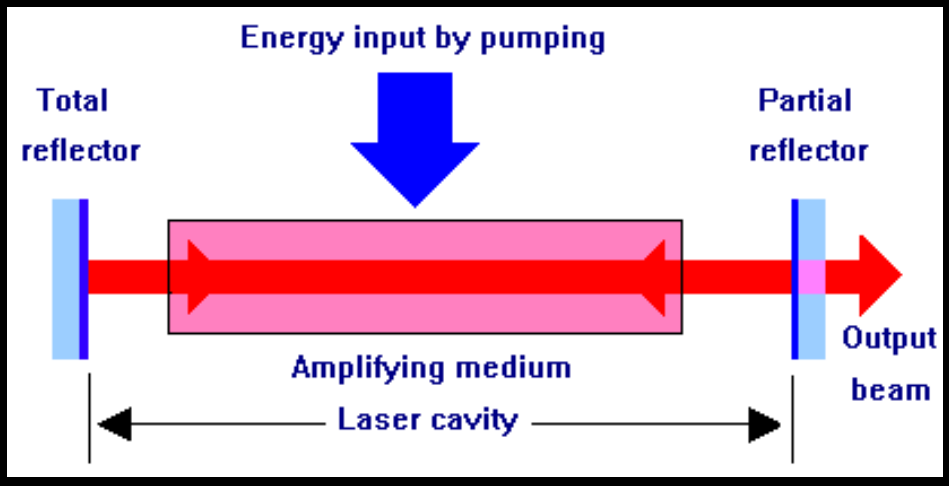
LASER – AMPLIFICACIÓN DE LUZ POR EMISIÓN ESTIMULADA DE RADIACIÓN







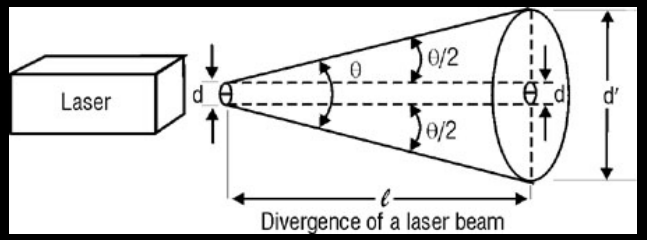




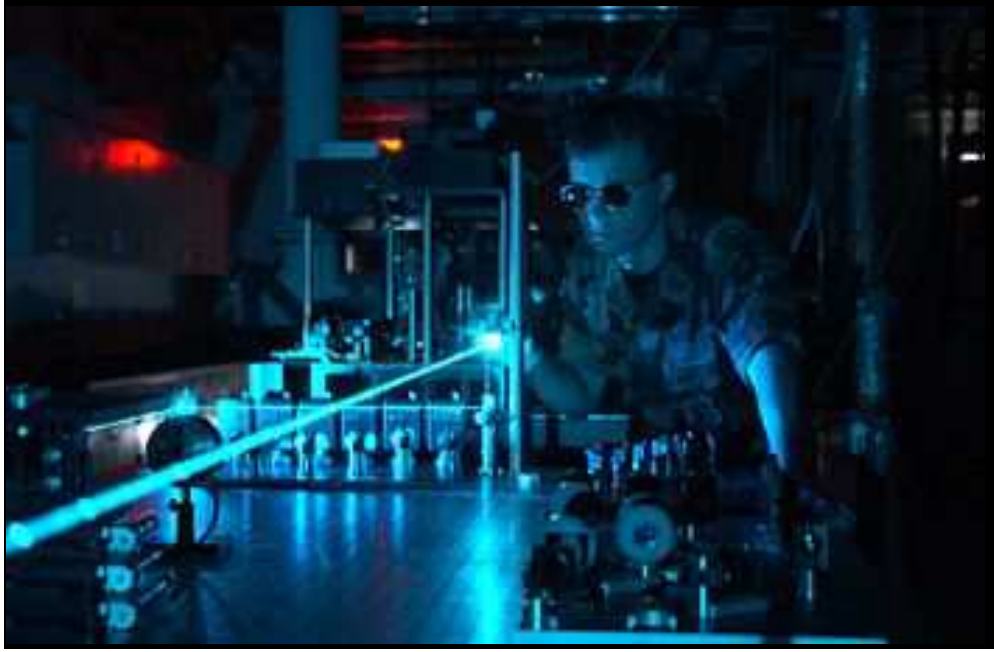
CARACTERÍSTICAS DE LA RADIACIÓN LÁSER

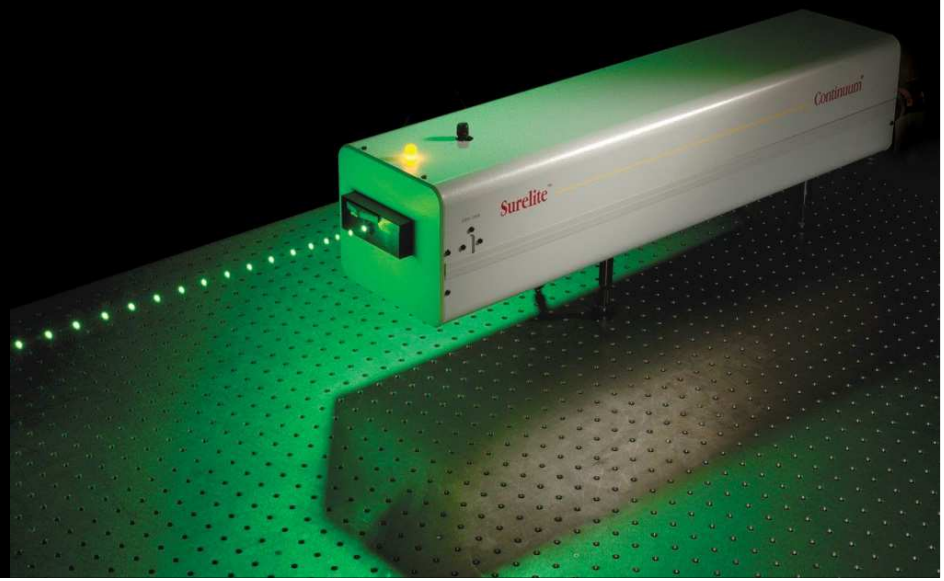
- Monocromática
- Coherente
- Muy poco divergente (direccional)
- Continua / Pulsada (fs – ms)
- Intensidad hasta TW/cm^2
  (T = 10^{12})

$$Intensidad = \frac{Energía}{Area * tiempo}$$



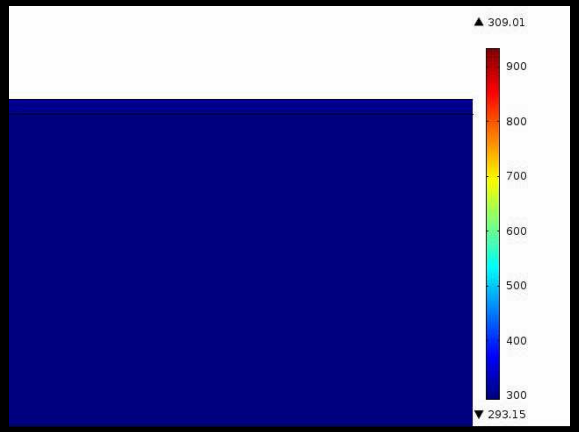
Divergence of a laser beam





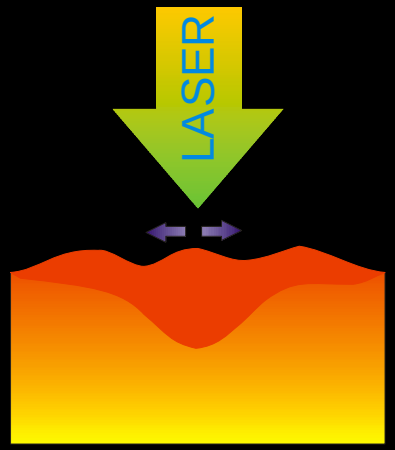
INTERACCIÓN LÁSER - MATERIA

Calentamiento



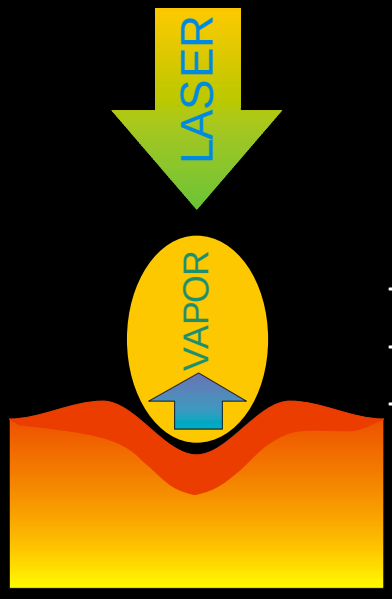
- Propagación del calor
- Difusión de especies químicas
- Reacciones químicas

Fusión



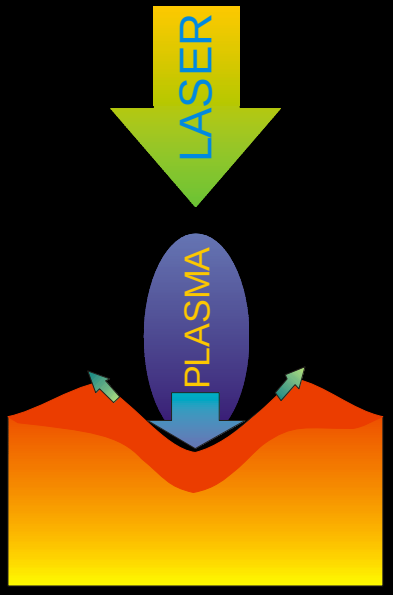
- Movimientos hidrodinámicos
- Difusión
- Convección

Vaporización



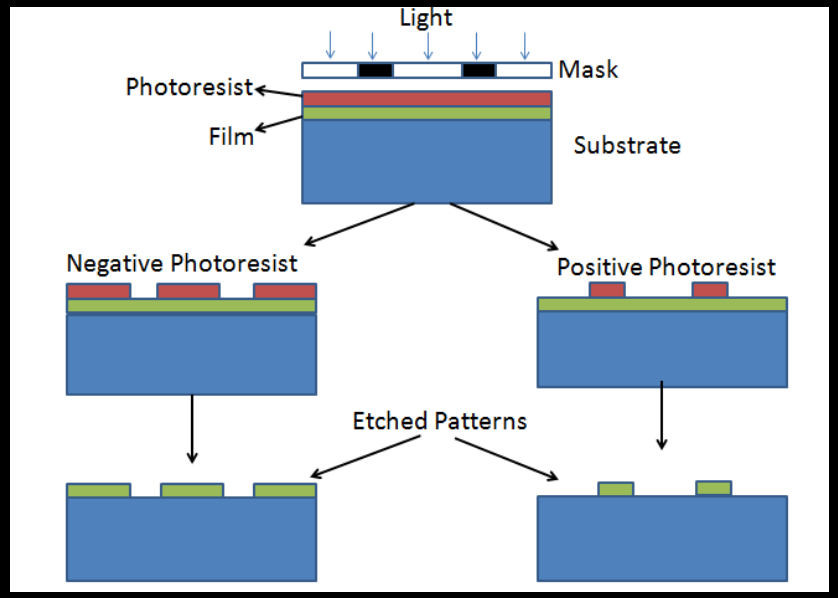
- Formación de cráter
- Redepósito
- Bubbling

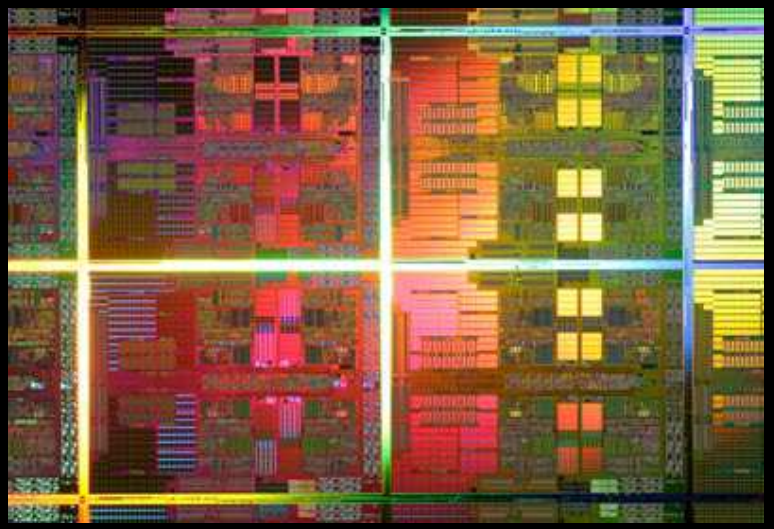
Formación de plasma

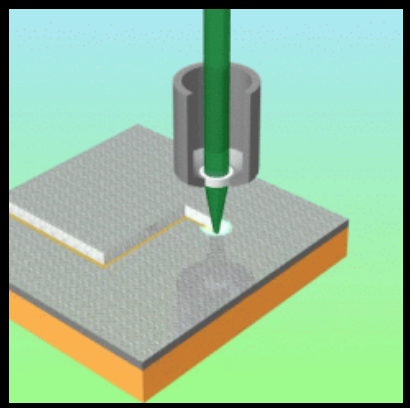


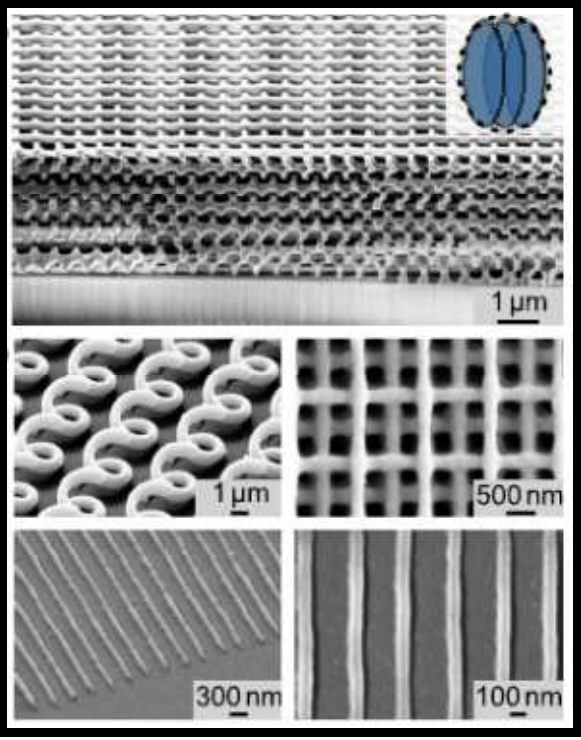
- Plasma de retroceso
- Ondas de choque

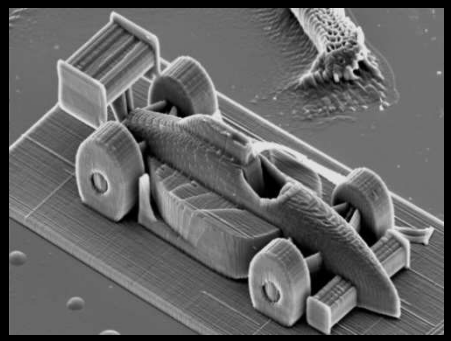
FOTOPOLIMERIZACIÓN DE RESINAS

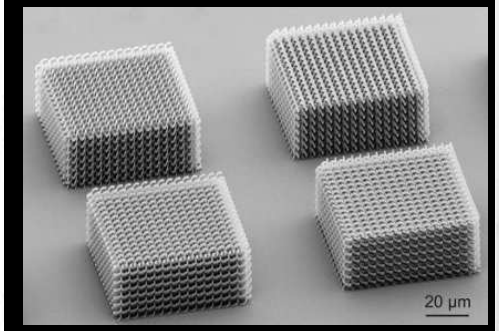


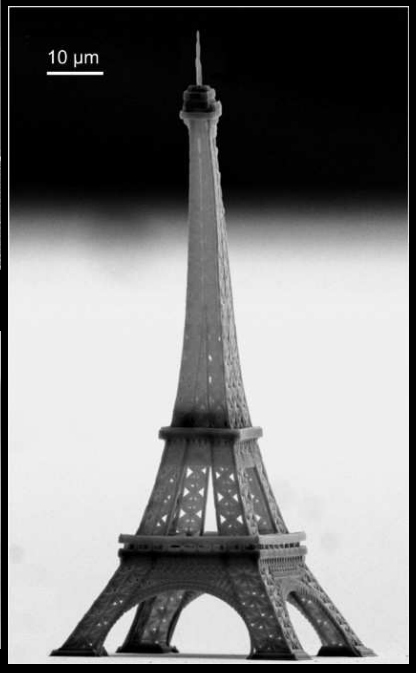






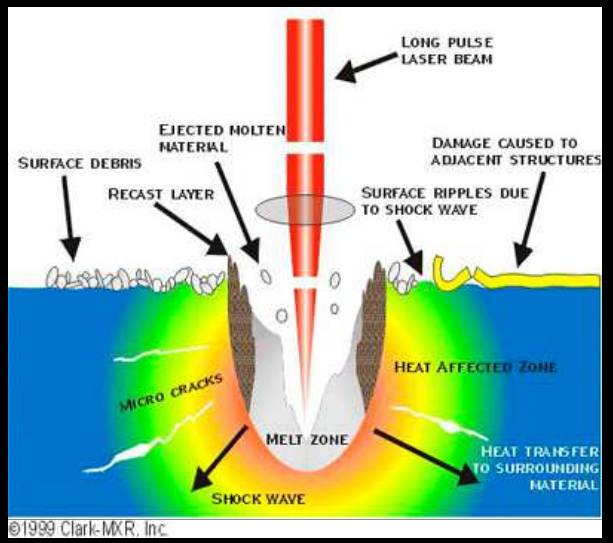


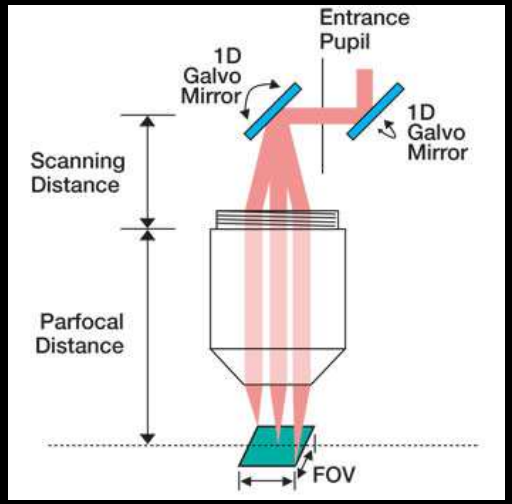




TRATAMIENTO DE MATERIALES

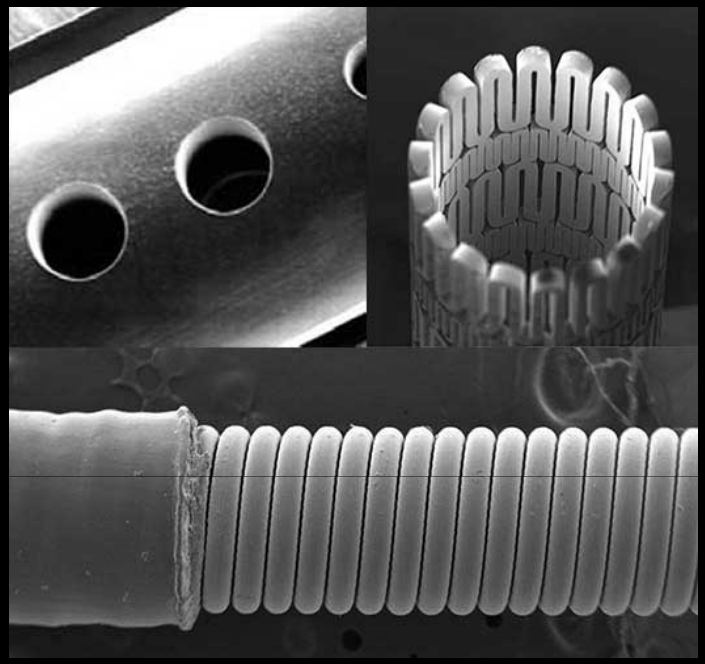
Corte láser

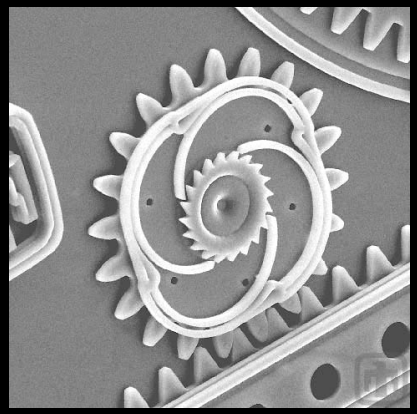


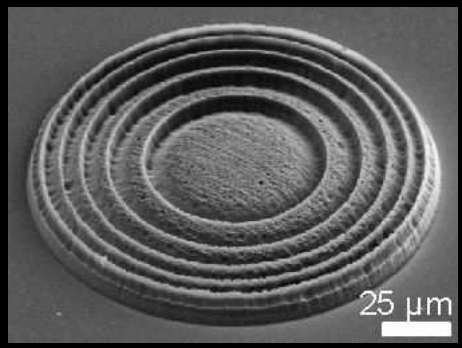


Marcado láser

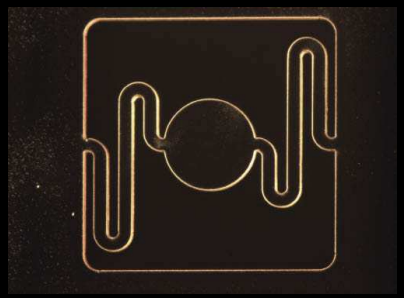
MICROMECANIZADO LÁSER





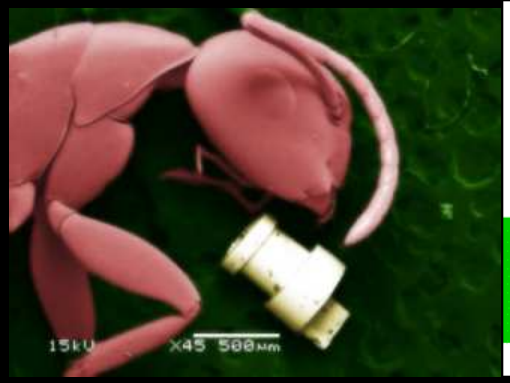


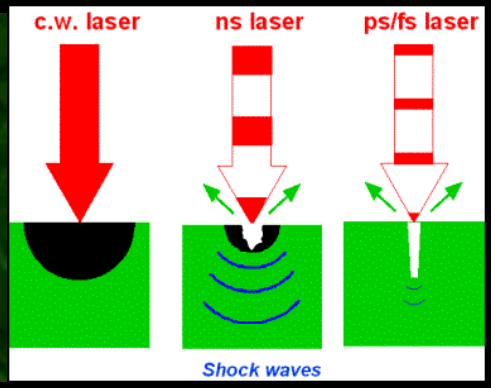
Lente Fresnel



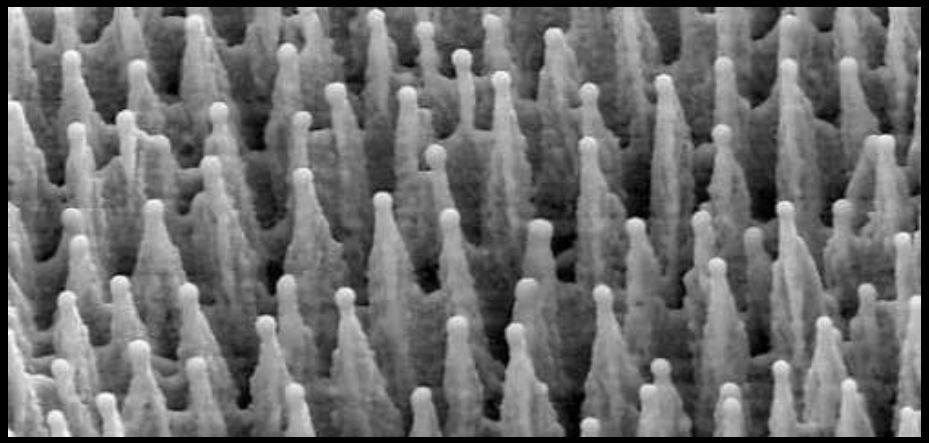
Microfluidica

Ablación con láser de femtosegundo (10^{-15} s):
Absorción multifotón, plasma electrónico, mínima zona afectada térmicamente

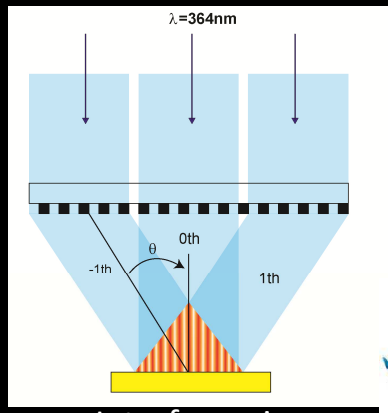




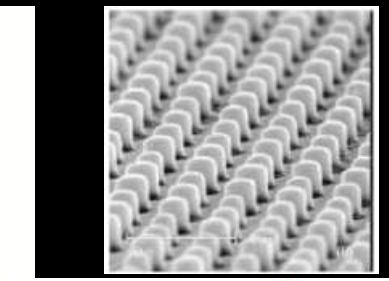
NANOESTRUCTURAS

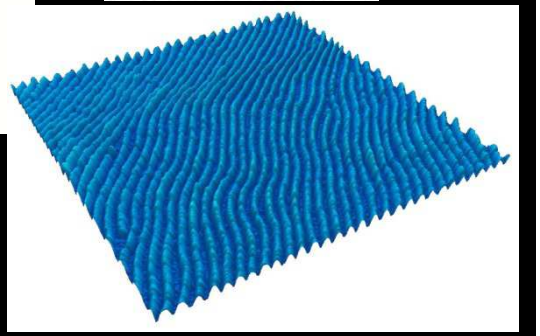


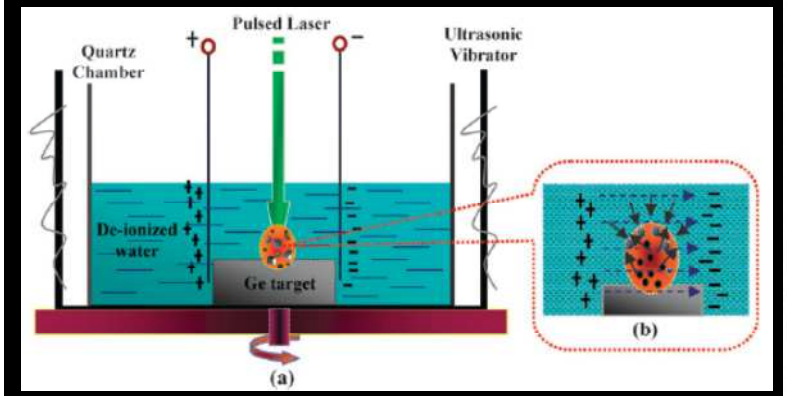
Black silicon

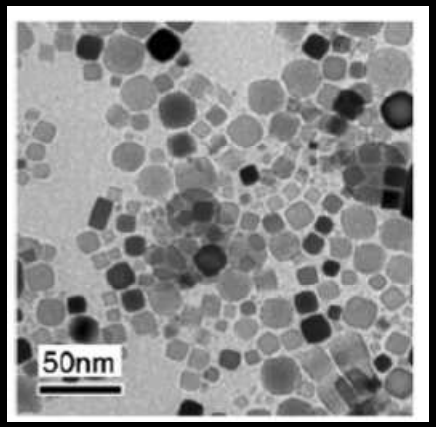


Interferencias

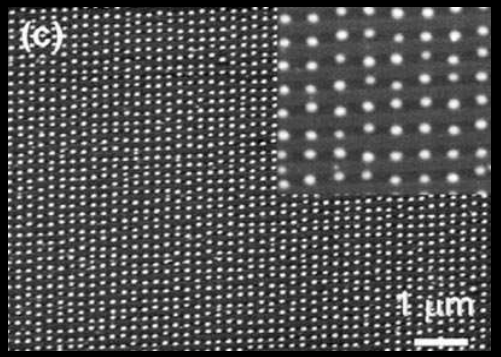






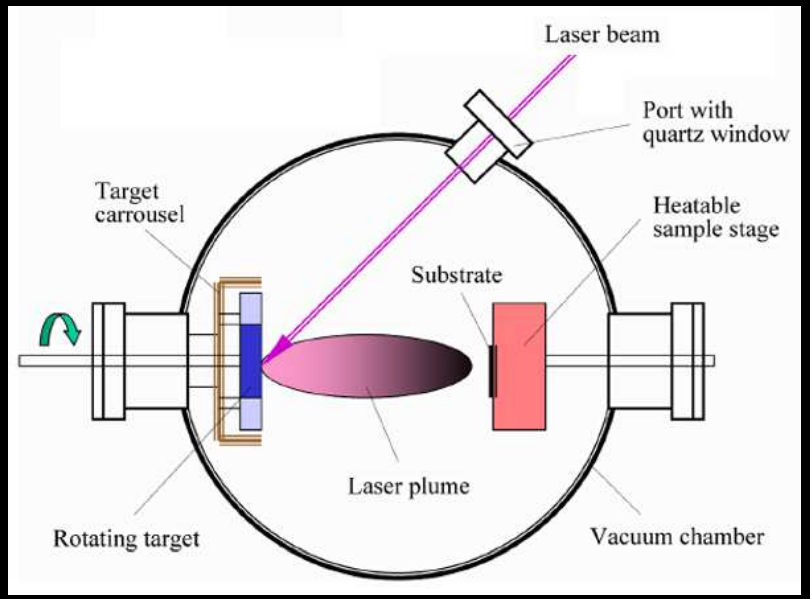


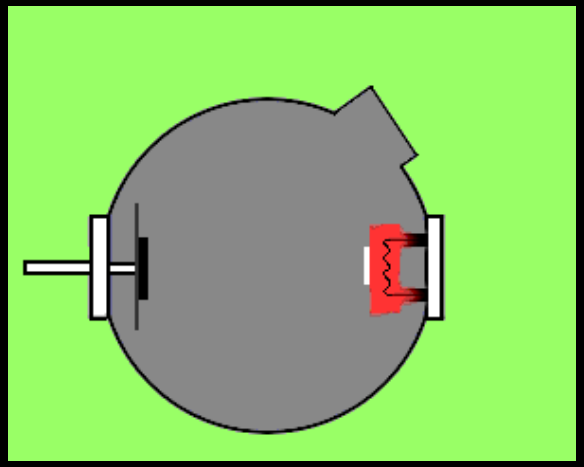
Irradiación en líquidos

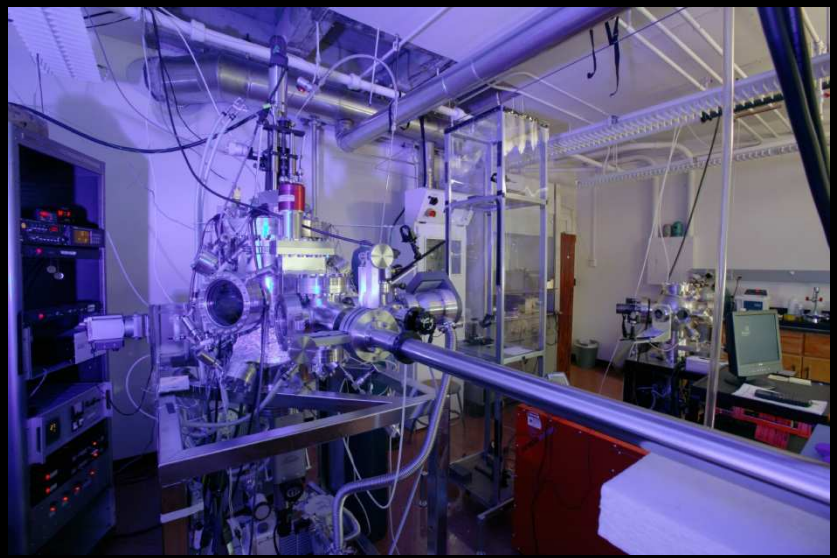


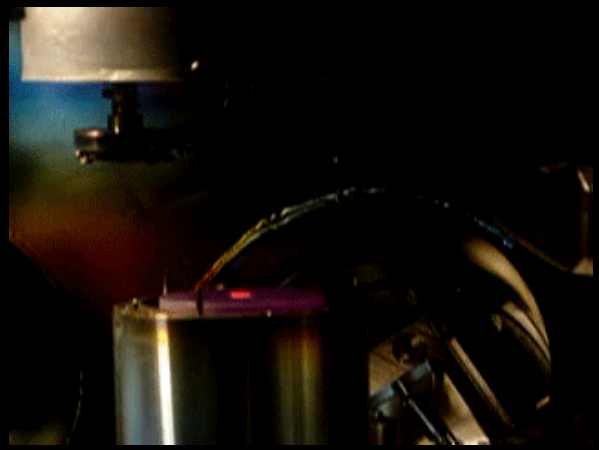
Dewetting

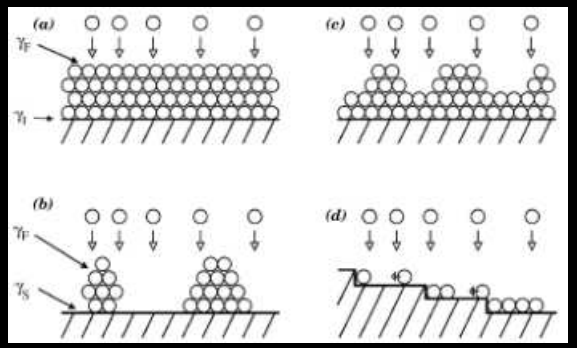
DEPÓSITO POR PULSOS LASER (PLD)

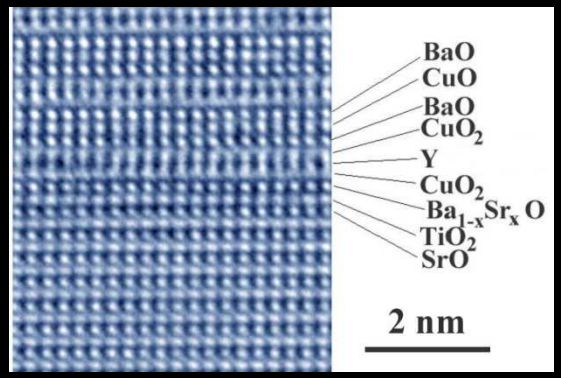




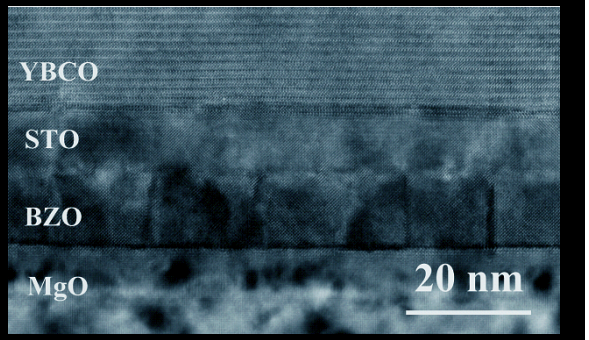


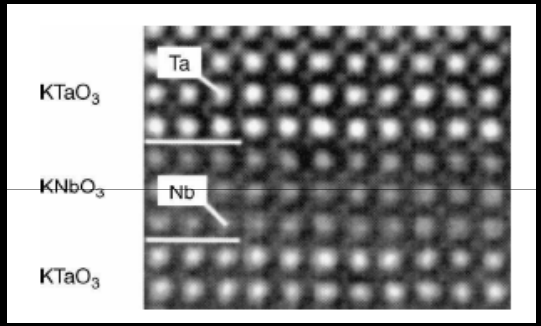




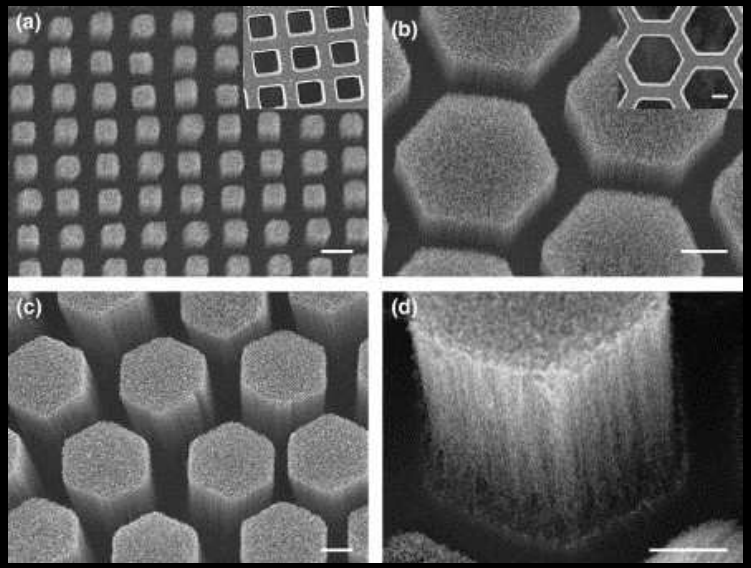


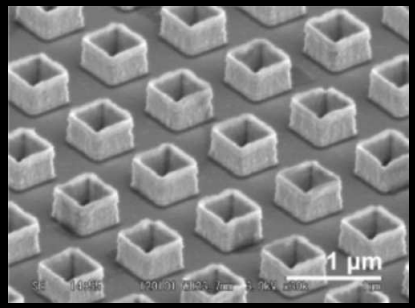
Epitaxias





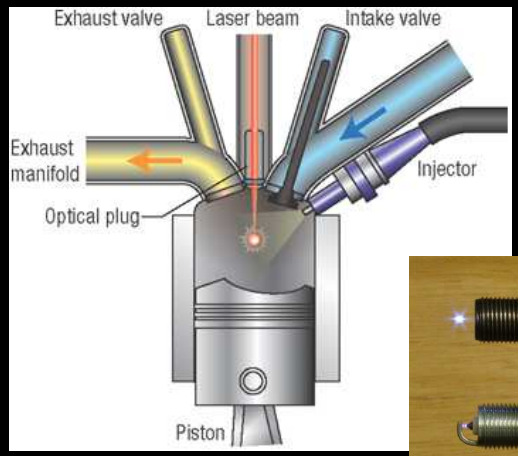
Superredes

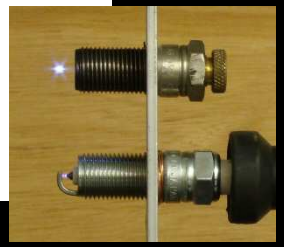




µ-estructuras

OTRAS APLICACIONES EN DESARROLLO

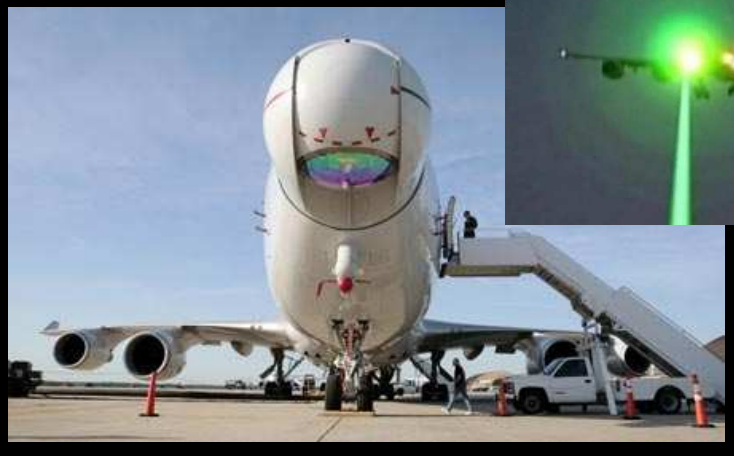




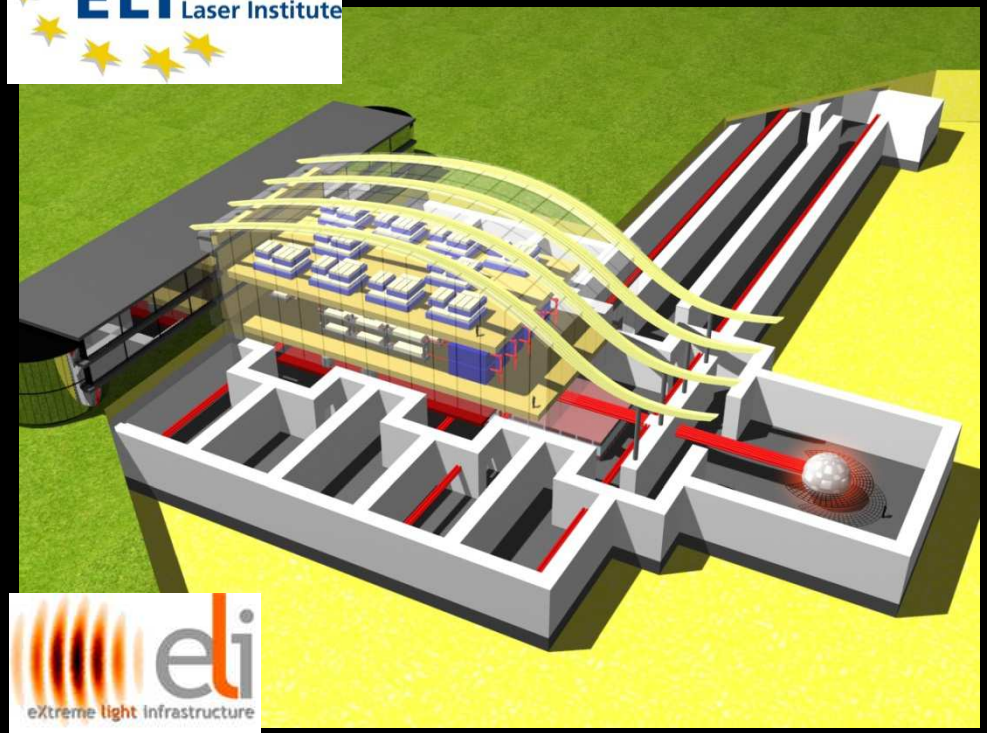
Ignición inducida por láser en motor de explosión

Rayos – lluvia inducidos por láser

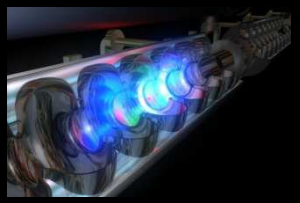
Armamento láser



EXTREME LIGHT INFRASTRUCTURE (ELI-EU) – EUROPEAN XFEL

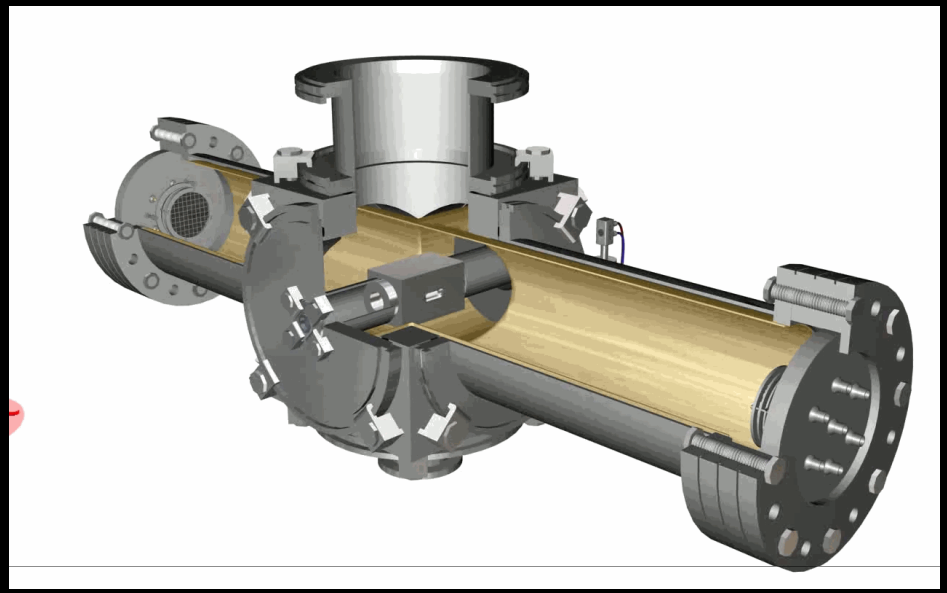


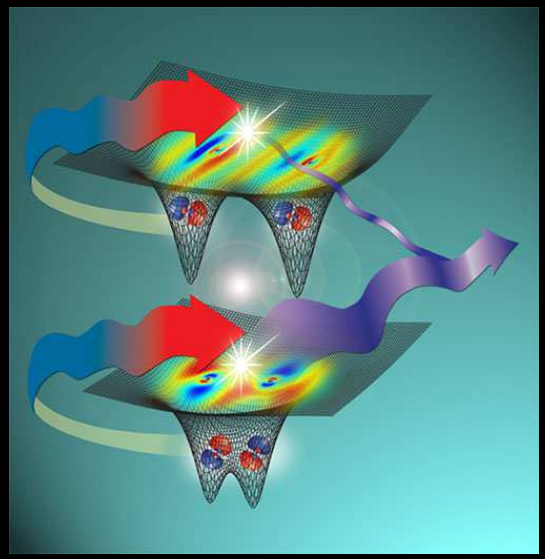
- Attosecond laser, fast dynamics & ultrahigh intensity – Szeged (Hungary)
- PW femtosecond laser, nuclear physics – Bucharest (Romania)
- Compact laser plasma accelerators – Prague (Czech Republic)

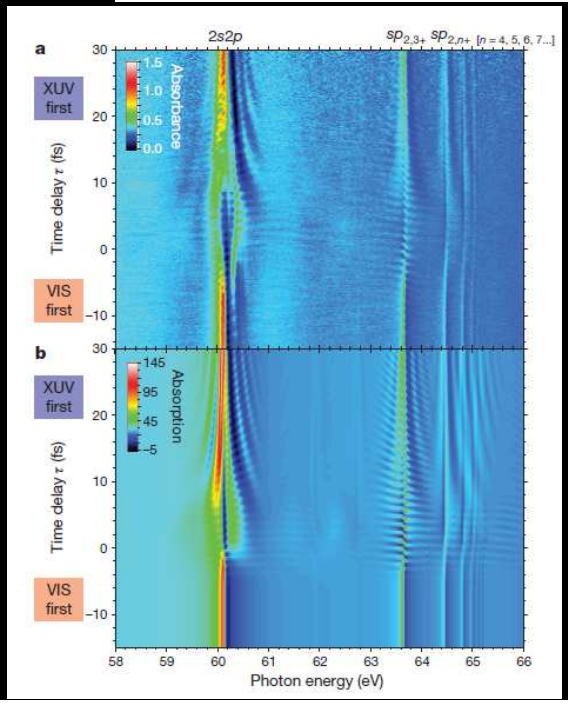


- XFEL: Láser de rayos X
- 3.4 km longitud
- Imágenes atómicas 3D de virus, moléculas, nanomateriales, etc

LÁSERES DE PULSOS ULTRACORTOS



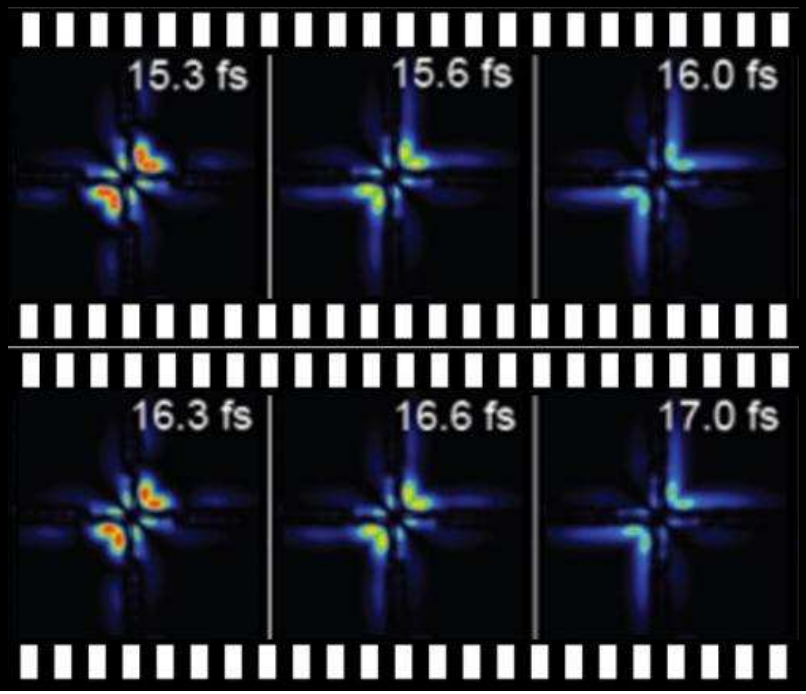




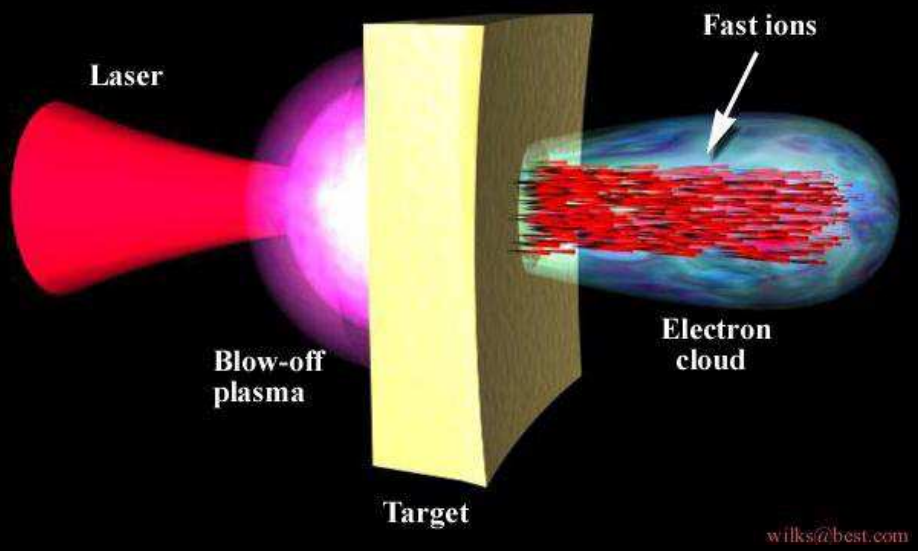
- Pulso attosegundo (10^{-18} s)

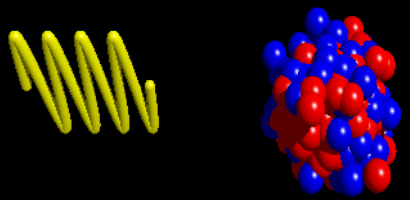
- Espectroscopias ultra-rápidas

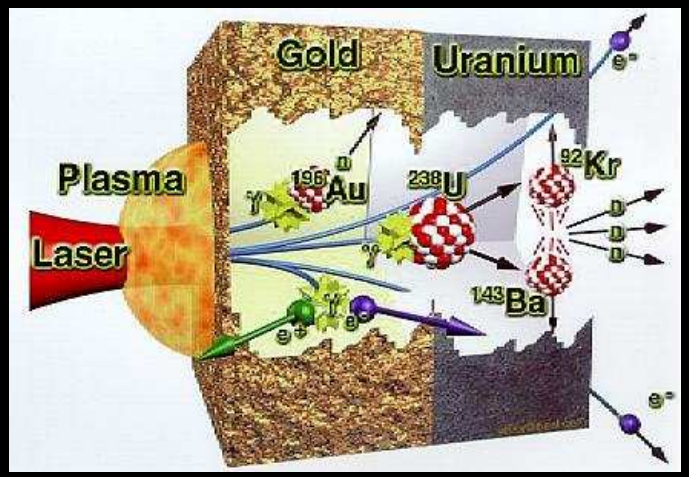
- Evolución temporal de electrones



PULSOS LÁSER ULTRAINTENSOS

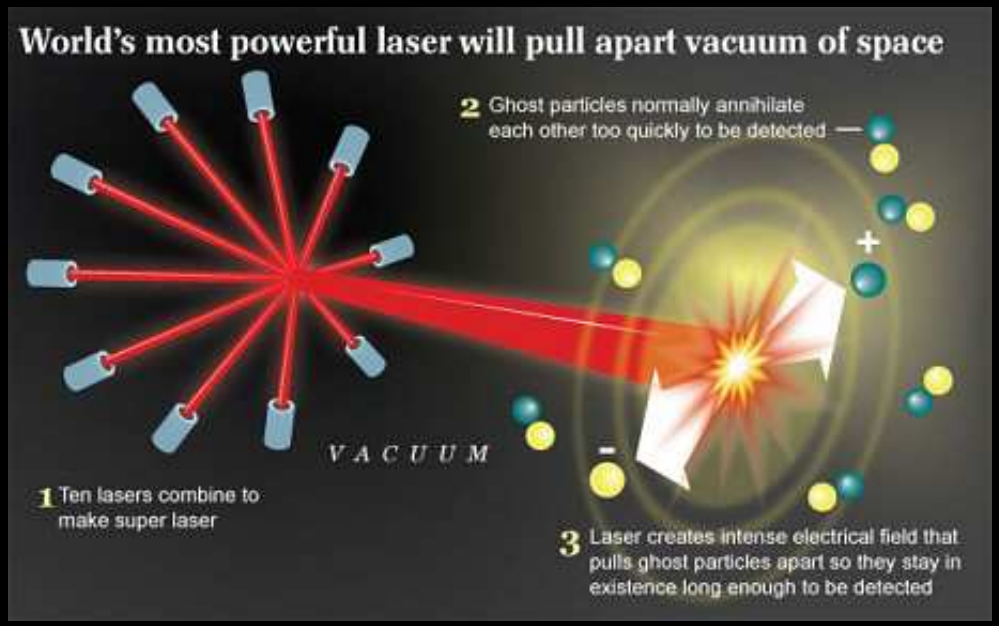


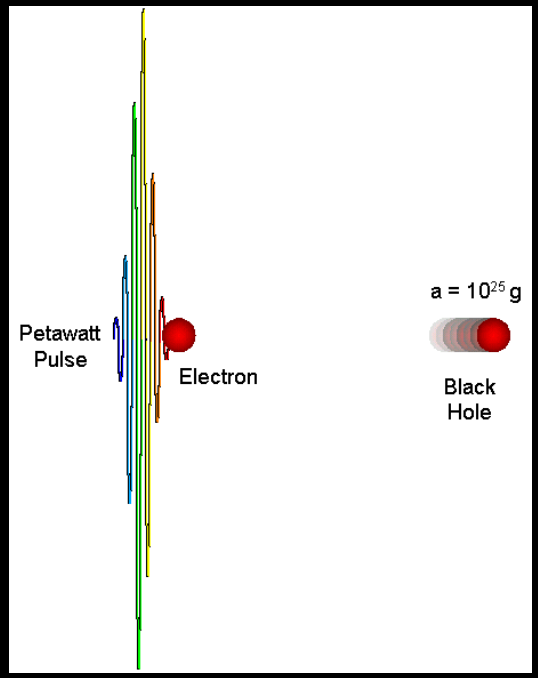




- Intensidad ultra alta:
  hasta ~10^{25} W/cm^2
- Particulas de alta energía ~100 GeV
- Flujos elevados de rayos X y γ
- Reacciones nucleares: transmutación, fotofisión…
- Medicina nuclear e imagen, aceleradores de partículas…

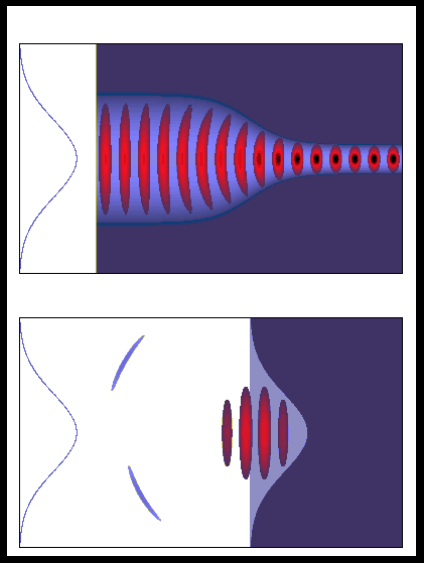
Vacío cuántico

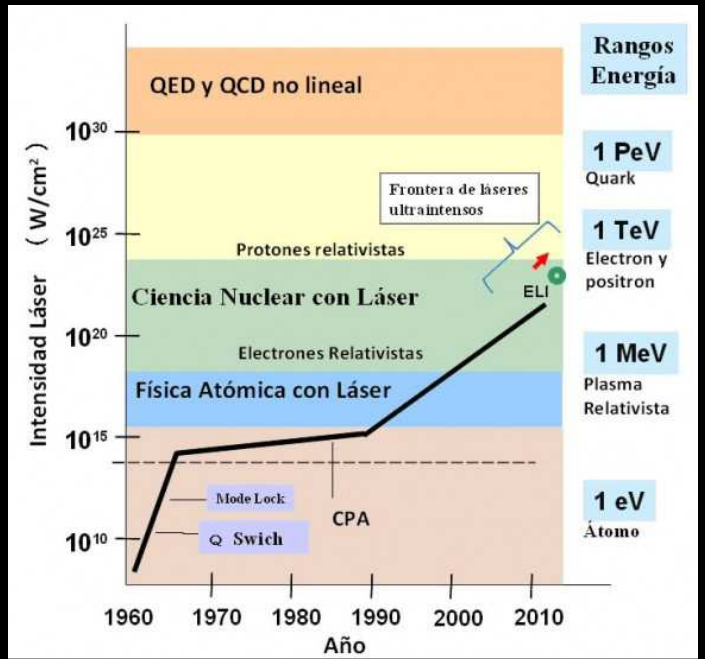


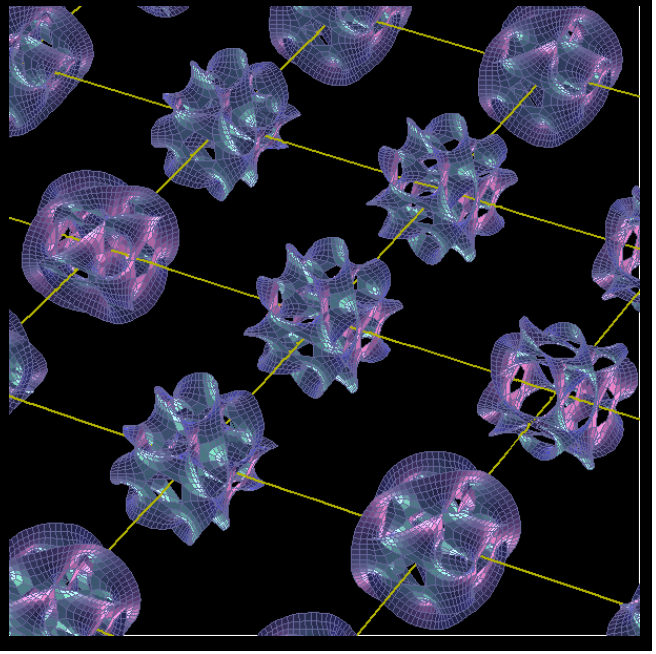


Intensidad > 10^{25} W/cm^2

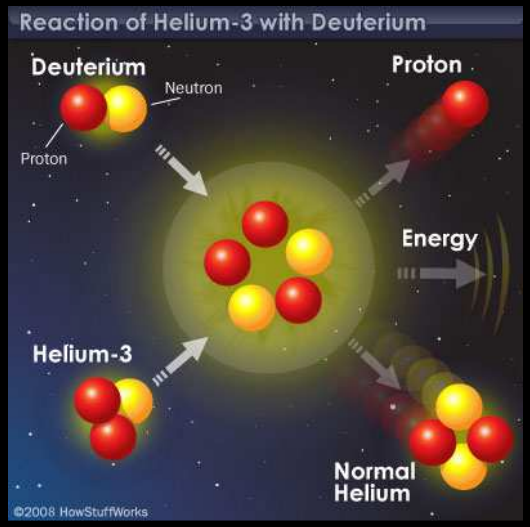
Agujeros negros, dimensiones extra

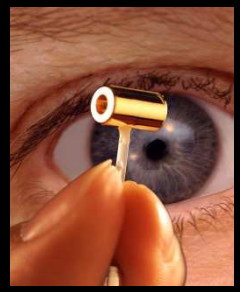


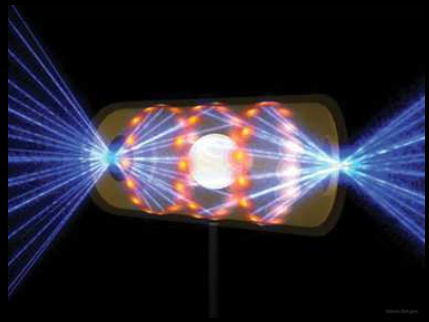


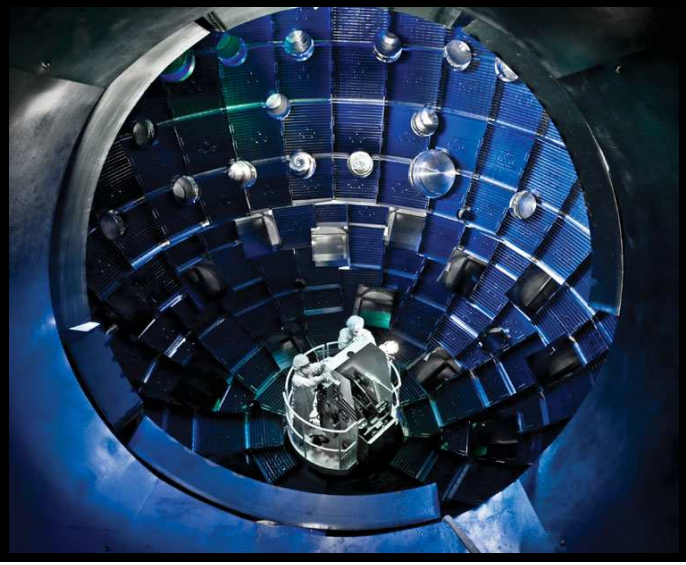


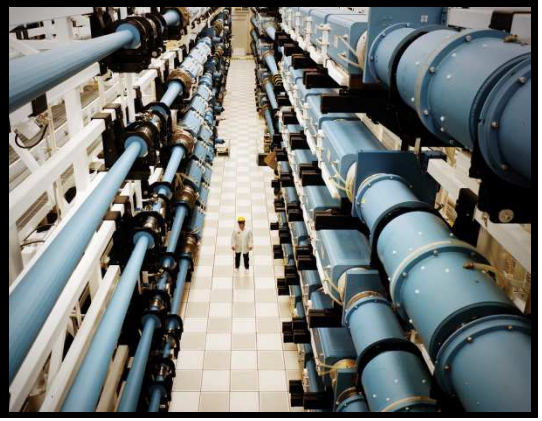
FUSIÓN NUCLEAR INDUCIDA POR LÁSER

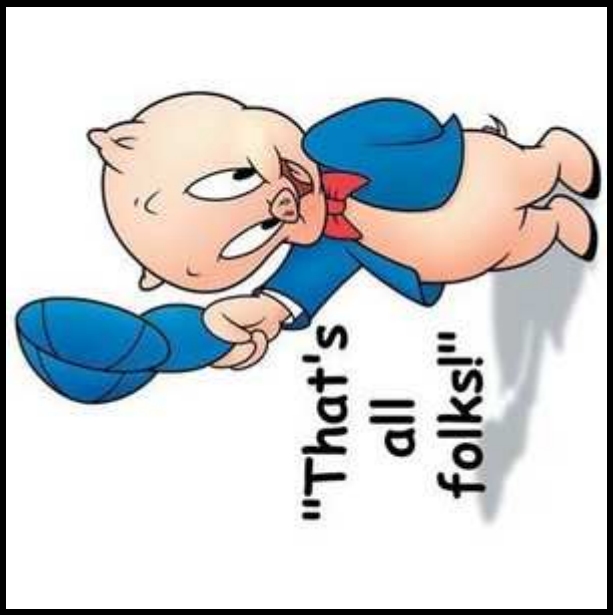











"That's
all
folks!"