Міжнародний день світла

16 травня

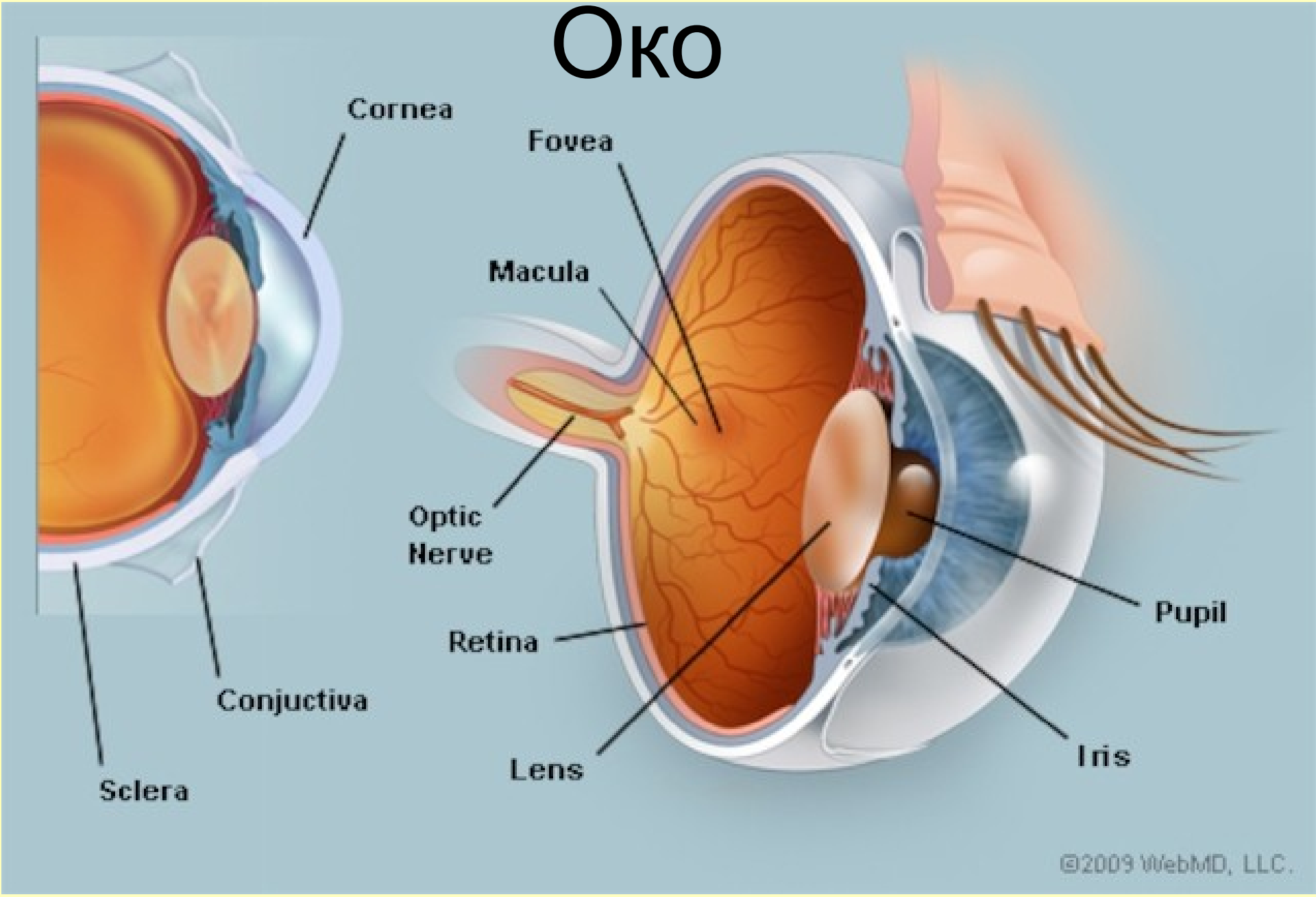
Програма:

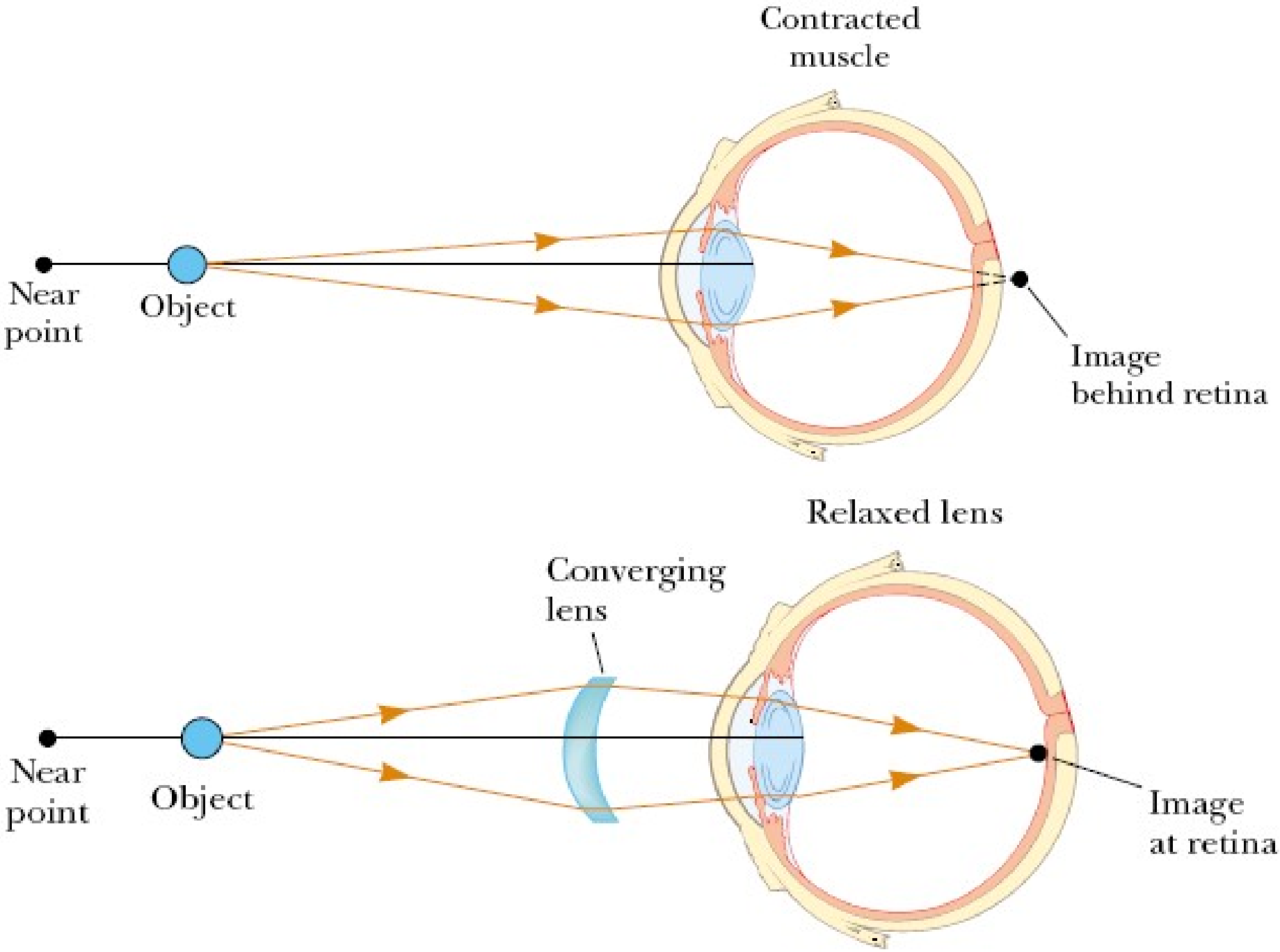
1. Юрій Скоренький «Fiat lux! – Нехай буде світло!»
2. Віталій Мочарський «Лазер – найвизначніший винахід людства?»
3. Марічка Юрчак «Мистецтво та світло: все ясно»
4. Олександр Крамар «Оптичні ілюзії»

Fiat Lux!

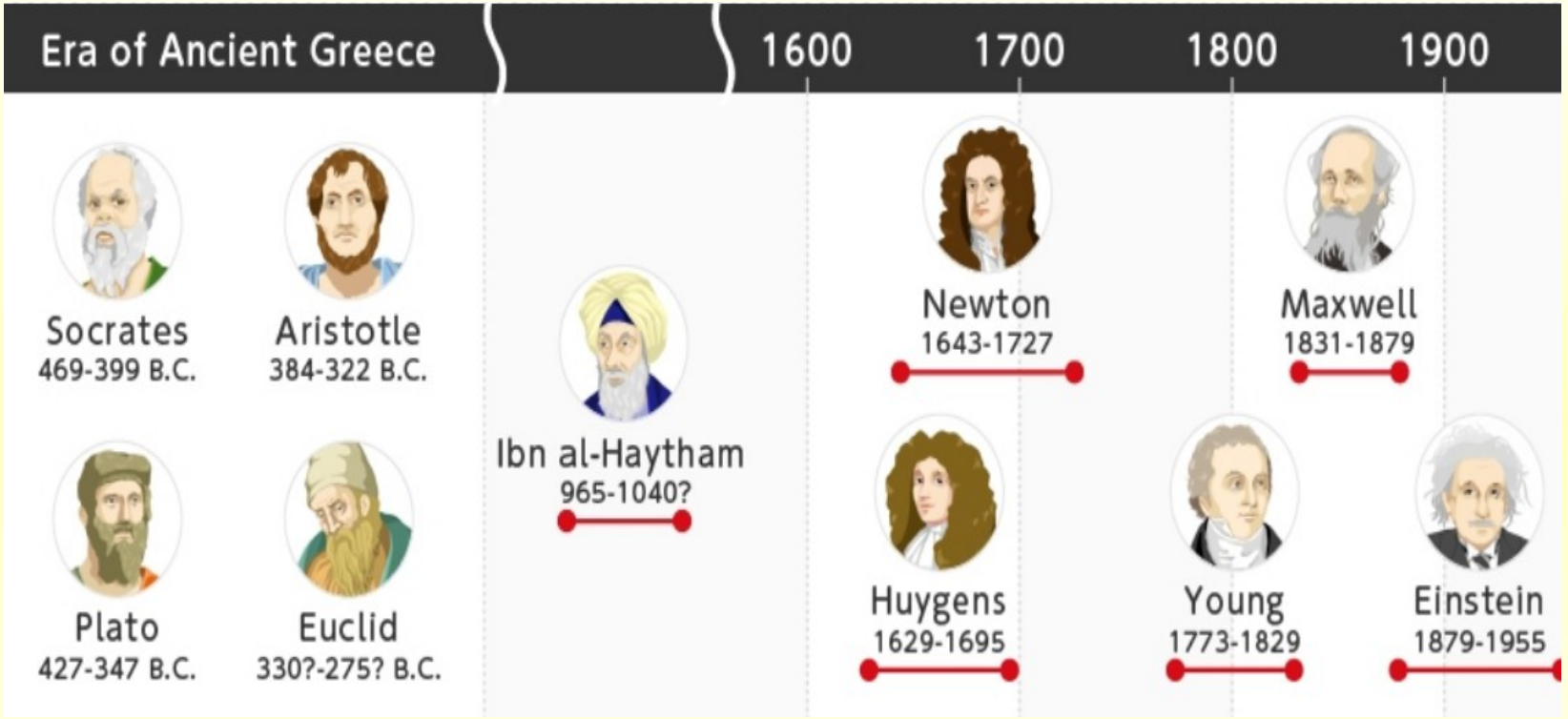
Юрій Скоренький
кафедра фізики
Тернопільського національного технічного університету
імені Івана Пулюя
16 травня 2019 року

Око


Cornea
Fovea
Macula
Optic Nerve
Pupil
Retina
Conjuctiva
Lens
Iris
Sclera
©2009 WebMD, LLC.


Contracted muscle
Near point
Object
Image behind retina
Relaxed lens
Converging lens
Near point
Object
Image at retina

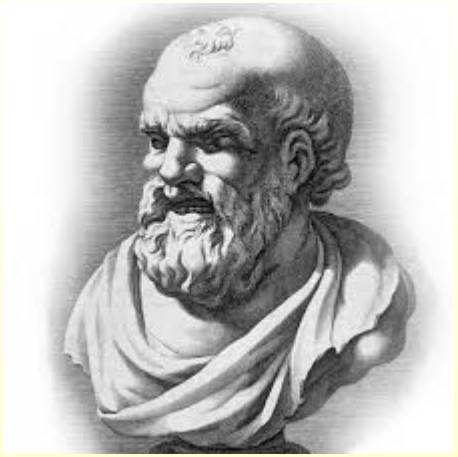
Історія оптики



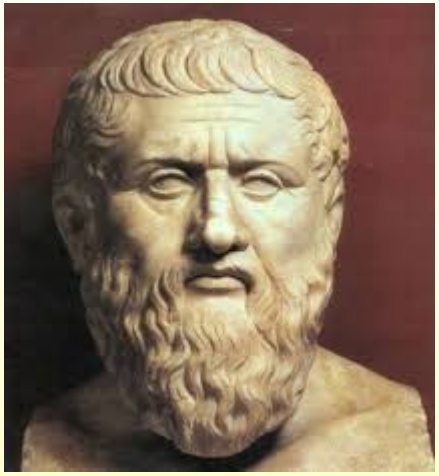
http://photonterrace.net/en/photon/history/

https://www.britannica.com/topic/sun-worship/media/573676/4334

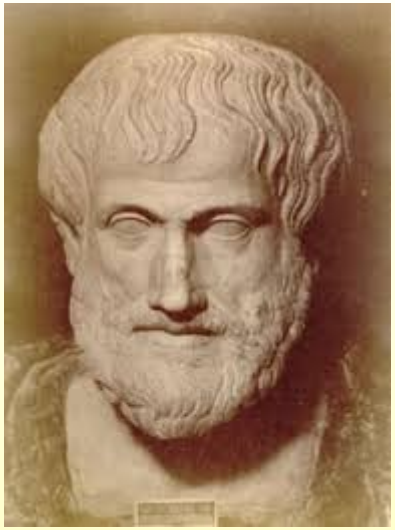
Античність



Демокріт (460-370 ВС): ***тіла випромінюють промені***

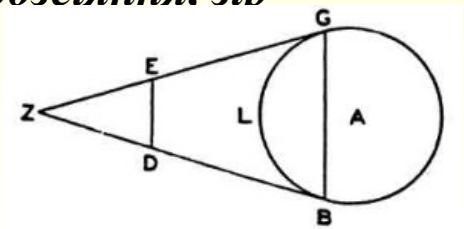


Платон (427-347 ВС): ***три потоки: від тіла, яке бачимо, від світного тіла, від очей***



Арістотель (384-322 ВС): ***“Кольори – суміш світла та темяви.”***

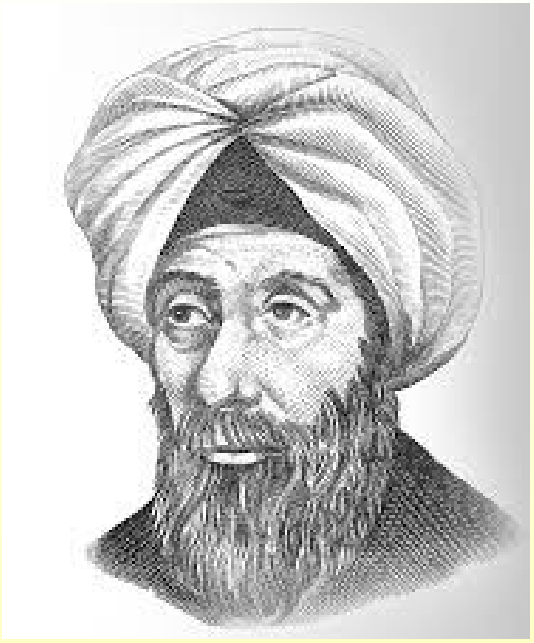
Евклід (330-275 В.С.) ***Ὀπτικά : геометрична оптика, промені, відбивання, розсіяння. зір***



http://photonterrace.net/en/photon/history/

http://scienceworld.wolfram.com

Середні віки



Абу Алі аль-Хасан Ібн аль-Хайсам (Альхацен) 965-1040 AD

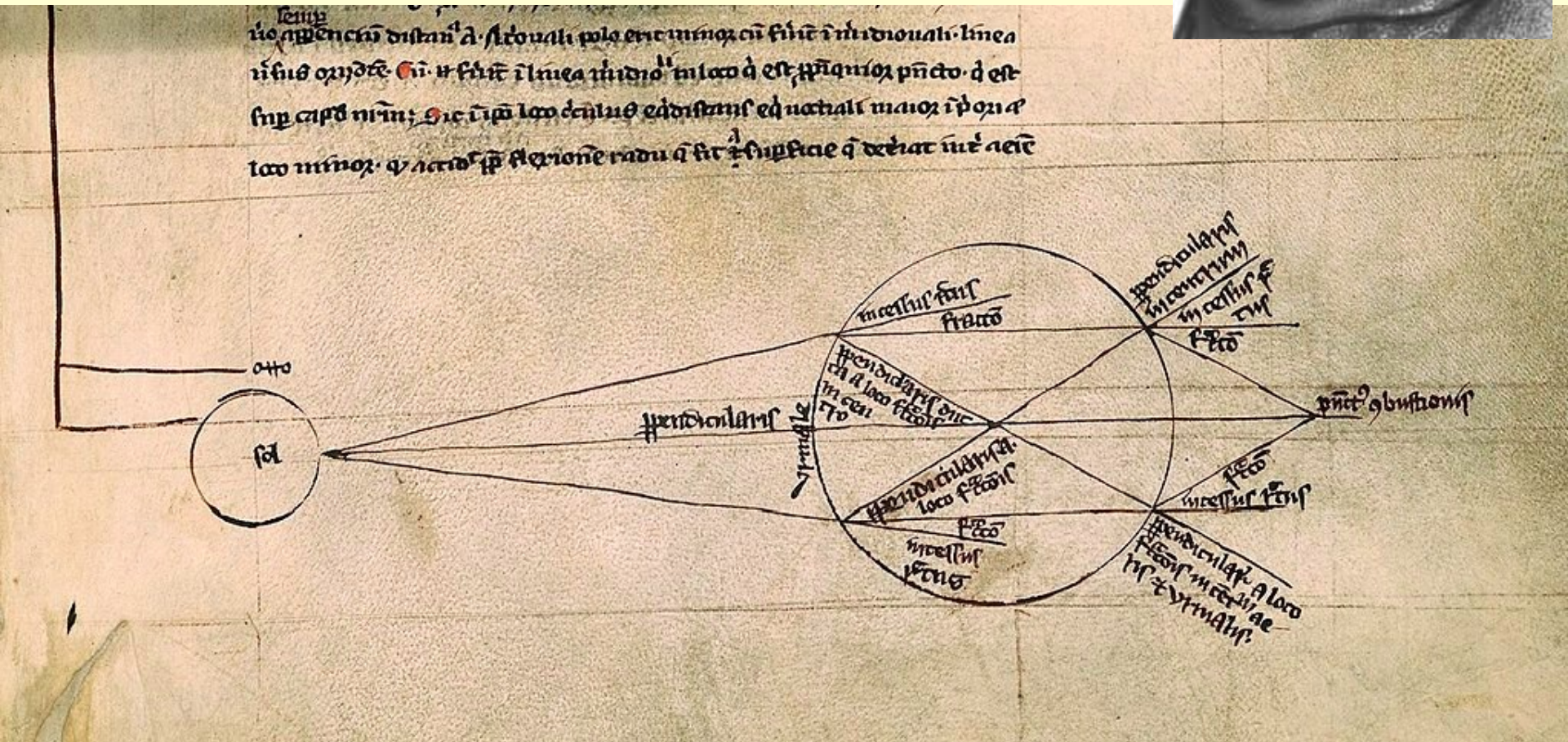
Книга оптики: “Чому Місяць біля горизонту виглядає більшим?” - експерименти та спостереження заломлення та відбивання світла з використанням лінз та дзеркал, припущення про скінченну швидкість світла.

https://science.sciencemag.org/content/sci/297/5582/773.full.pdf

http://www.harvardmagazine.com/on-line/090351.html

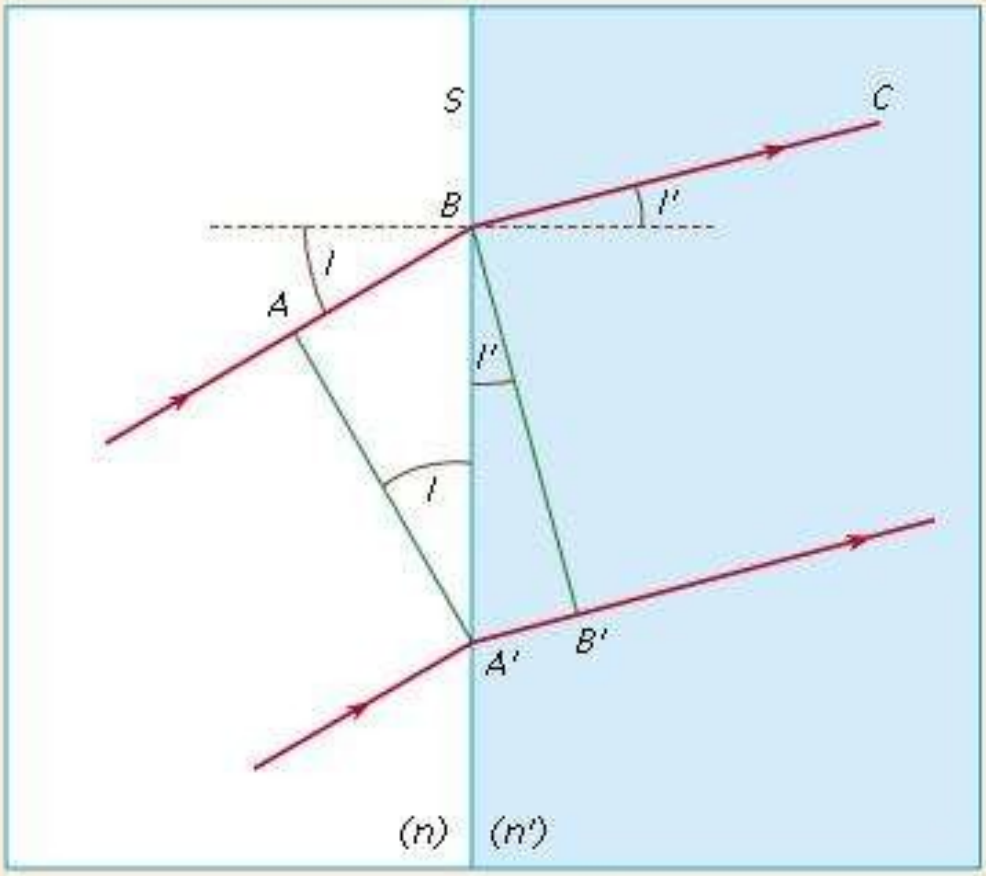
Роджер Бекон (1214-1292):

“*кожне тіло випромінює певну якість (потугу), за якою його розрізняють інші тіла”

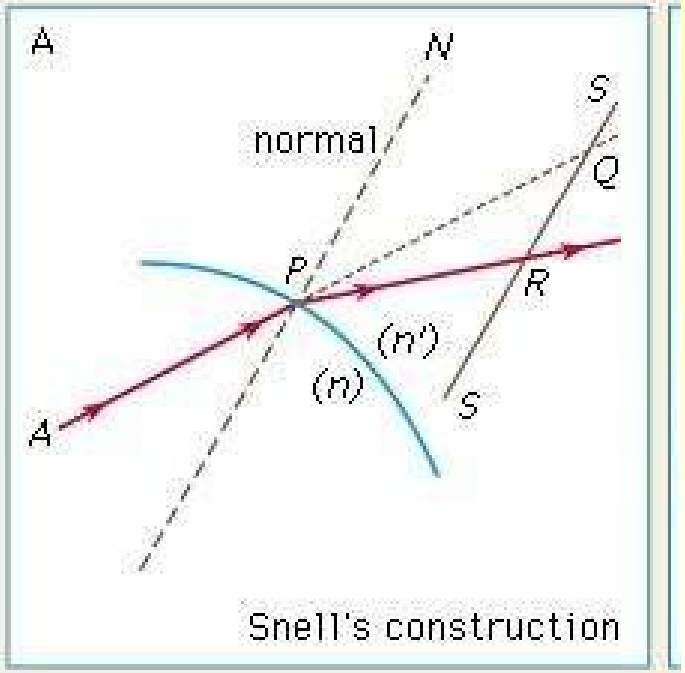


Вілеброрд Снел ван Роєн (1580-1626)

закон заломлення (графічно)

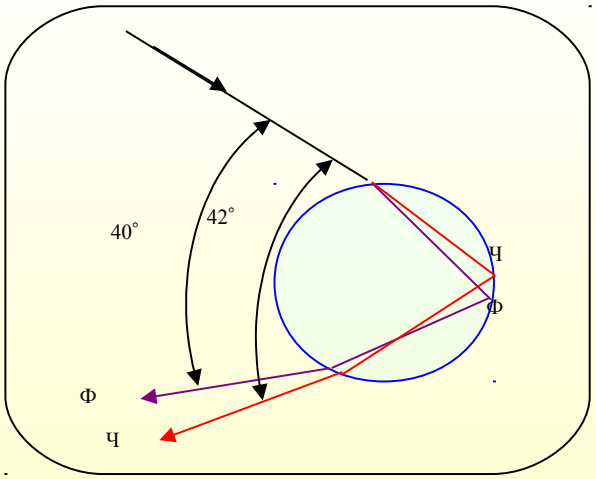


Encyclopaedia Britannica, Inc.



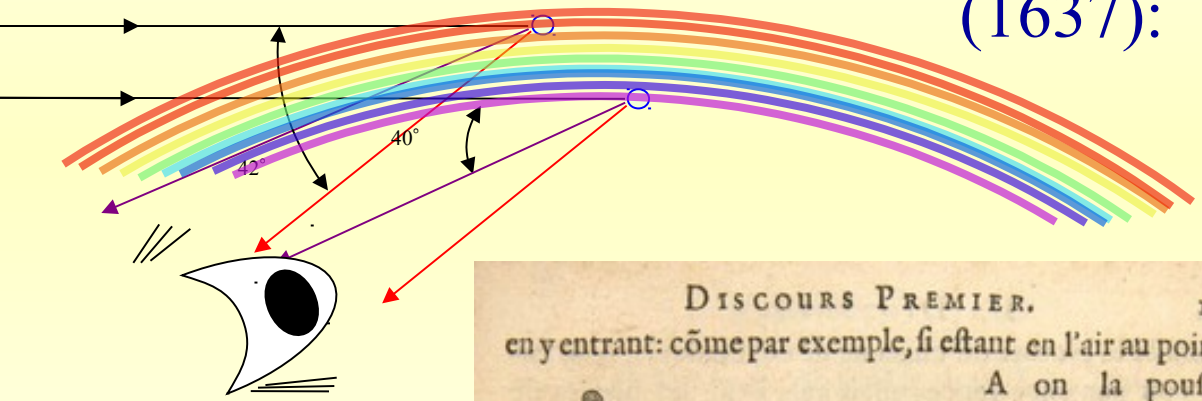
www.britannica.com/biography/Willebrord-Snell

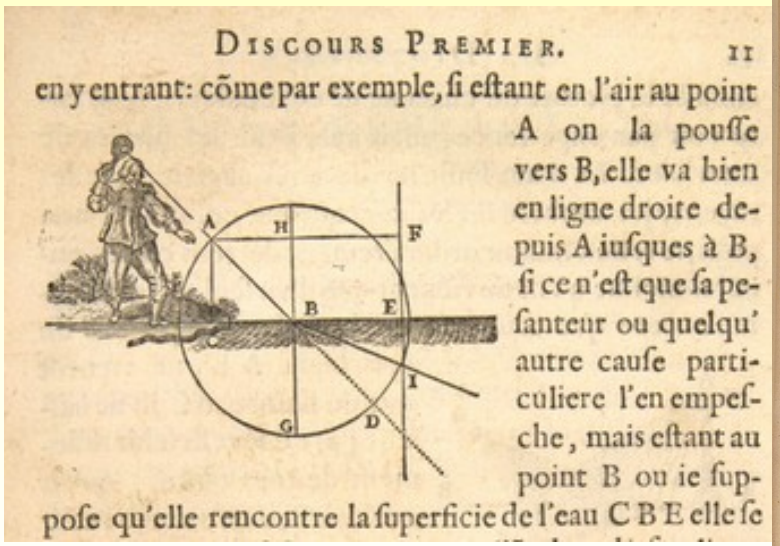
Закон Снелліуса $n_1 \sin\theta_1 = n_2 \sin\theta_2$



Рене Декарт (1596-1650)

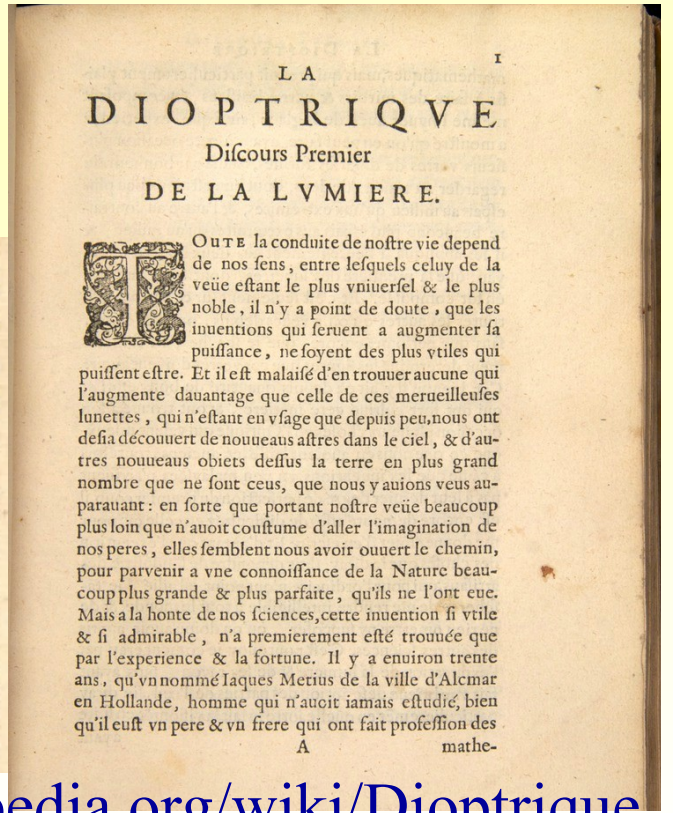
Діоптрика (1637):





DISCOURS PREMIER. 11

en y entrant: cõme par exemple, ſi eſtant en l'air au point A on la pouſſe vers B, elle va bien en ligne droite depuis A iuſques à B, ſi ce n'eſt que ſa peſanteur ou quelqu' autre cauſe particuliere l'en empeſche, mais eſtant au point B ou ie ſuppoſe qu'elle rencontre la ſuperficie de l'eau C B E elle ſe



LA DIOPTRIQVE

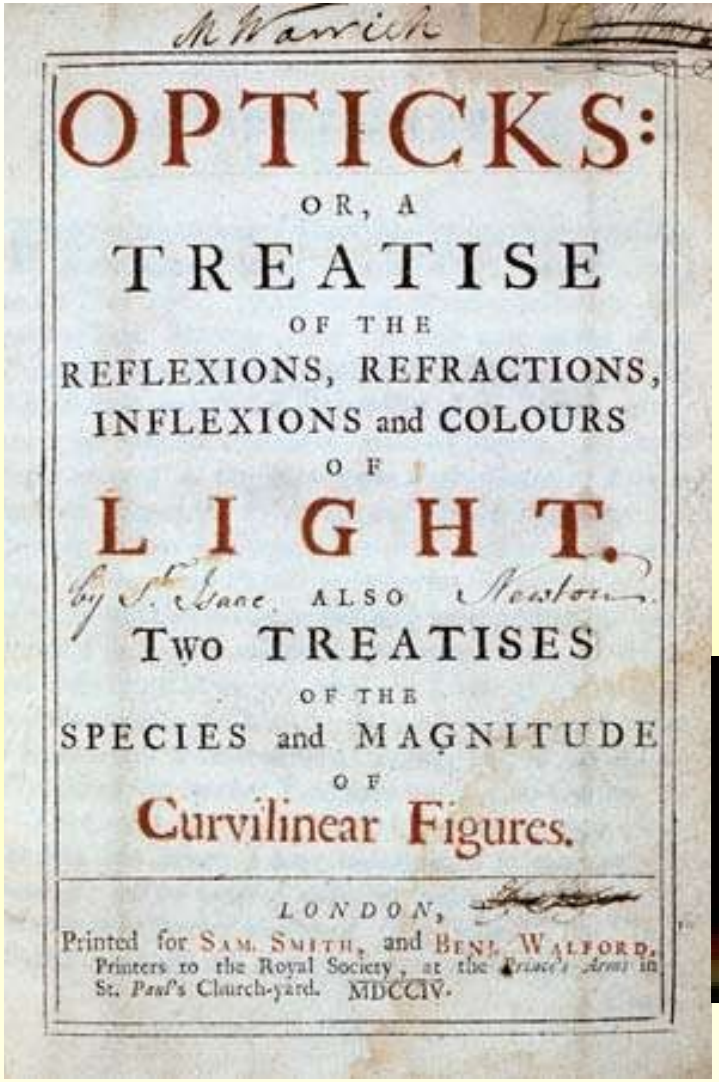
Diſcours Premier

DE LA LVMIERE.

TOUTE la conduite de noſtre vie depend de nos ſens, entre leſquels celuy de la veüe eſtant le plus vniuerſel & le plus noble, il n'y a point de doute, que les inuentions qui ſeruent a augmenter ſa puiſſance, ne ſoyent des plus vtiles qui puiſſent eſtre. Et il eſt malaiſé d'en trouuer aucune qui l'augmente dauantage que celle de ces merueilleuſes lunettes, qui n'eſtant en vſage que depuis peu, nous ont deſia découuert de nouueaus aſtres dans le ciel, & d'autres nouueaus obiets deſſus la terre en plus grand nombre que ne ſont ceus, que nous y auions veus auparauant: en ſorte que portant noſtre veüe beaucoup plus loin que n'auoit couſtume d'aller l'imagination de nos peres, elles ſemblent nous avoir ouuert le chemin, pour parvenir a vne connoiſſance de la Nature beaucoup plus grande & plus parfaite, qu'ils ne l'ont eue. Mais a la honte de nos ſciences, cette inuention ſi vtile & ſi admirable, n'a premierement eſté trouuée que par l'experience & la fortune. Il y a enuiron trente ans, qu'vn nommé Iaques Metius de la ville d'Alcmar en Hollande, homme qui n'auoit iamais eſtudié, bien qu'il euſt vn pere & vn frere qui ont fait profeſſion des

A mathe-

en.wikipedia.org/wiki/Dioptrique



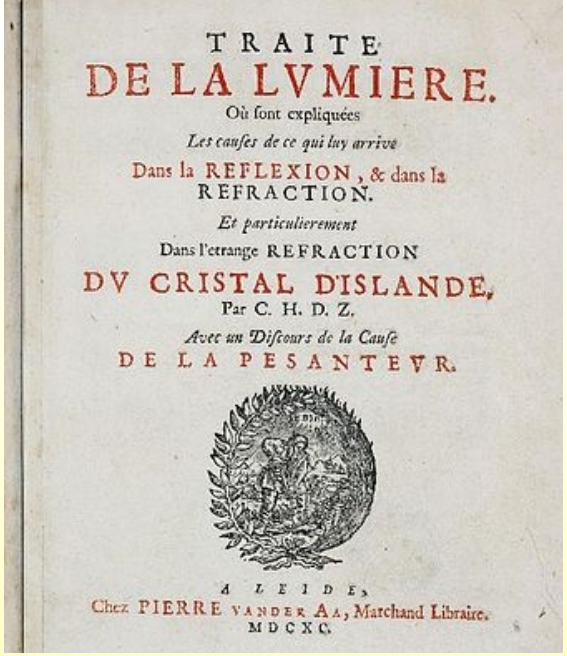
OPTICKS:
OR, A
TREATISE
OF THE
REFLEXIONS, REFRACTIONS,
INFLEXIONS and COLOURS
OF
LIGHT.
ALSO
Two TREATISES
OF THE
SPECIES and MAGNITUDE
OF
Curvilinear Figures.
LONDON,
Printed for SAM. SMITH, and BENJ. WALFORD,
Printers to the Royal Society, at the Prince's Arms in
St. Paul's Church-yard. MDCCIV.

Айзек Ньютон (1643-1727)

“Світло складається з кольорових частинок”

Експерименти з лінзами, призмами, дзеркалами, телескопами (перший рефлектор без хроматичної аберації)мікроскопами, розклад світла в спектр.

www.britannica.com/biography/Isaac-Newton

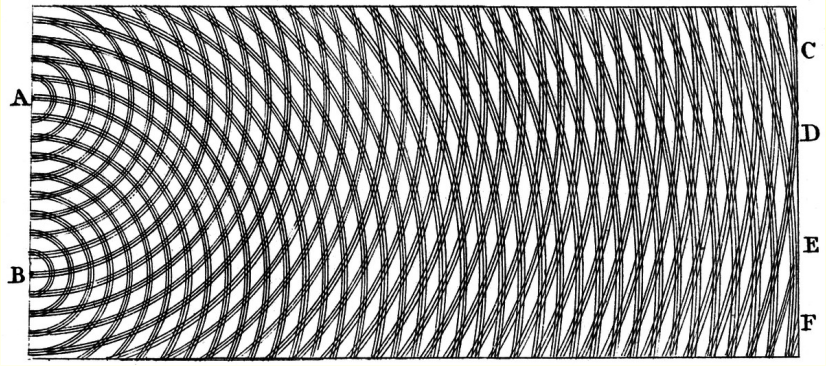

TRAITE
DE LA LVMIERE.
Où sont expliquées
Les causes de ce qui luy arrive
Dans la REFLEXION, & dans la REFRACTION.
Et particulierement
Dans l'etrange REFRACTION
DV CRISTAL DISLANDE,
Par C. H. D. Z.
Avec un Discours de la Cause
DE LA PESANTEVR.
A LEIDE,
Chez PIERRE VANDER AA, Marchand Libraire.
MDCXC.

Християн Гюйгенс (1629-1695)

“*Світло – це хвиля*”
(1690)

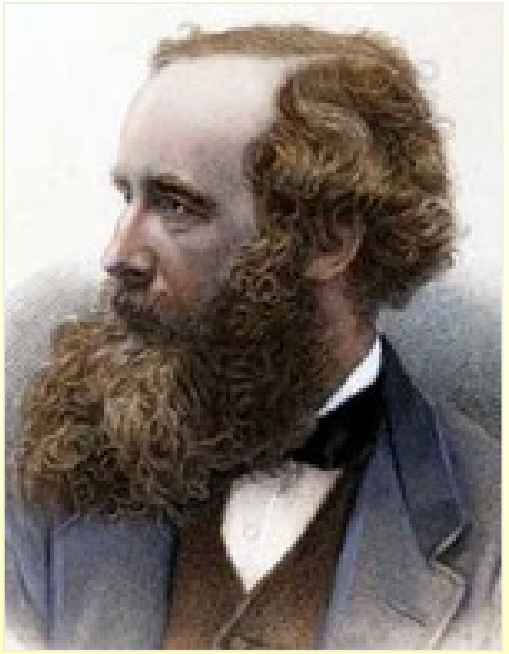
Томас Юнг (1773-1829)

Огюстен Жан Френель (1788-1827



http://photonterrace.net/en/photon/history/
http://scihi.org/augustin-jean-fresnel-wave-theory-light/

Джеймс Клерк Максвелл
(1831-1879)



Генріх Герц
(1857-1894)

$$\mathrm{div}\boldsymbol{D} = \rho$$

$$\mathrm{div}\boldsymbol{B} = 0$$

$$\mathrm{rot}\boldsymbol{H} = i + \frac{\partial \boldsymbol{D}}{\partial t}$$

$$\mathrm{rot}\boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t}$$

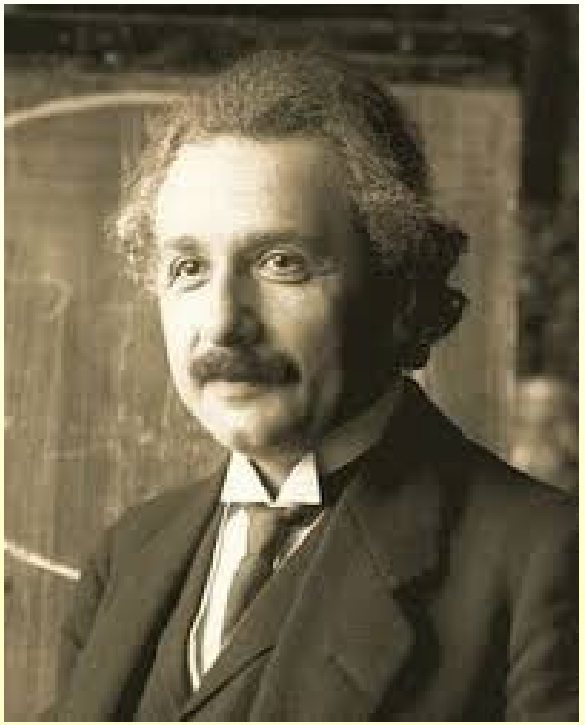
Побудував теорію електромагнітного поля

Експериментально підтвердив теорію Максвела

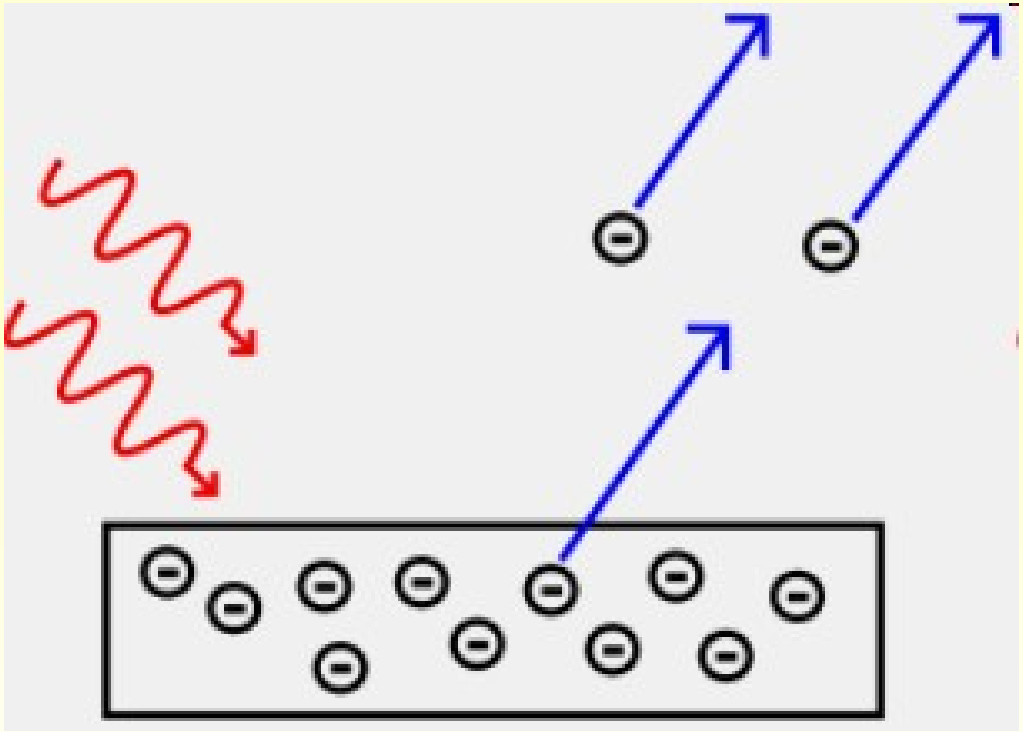
www.famousscientists.org/

photonterrace.net/en/photon/history/

Альберт Ейнштейн
(1879-1955)



“Світло це фотони”

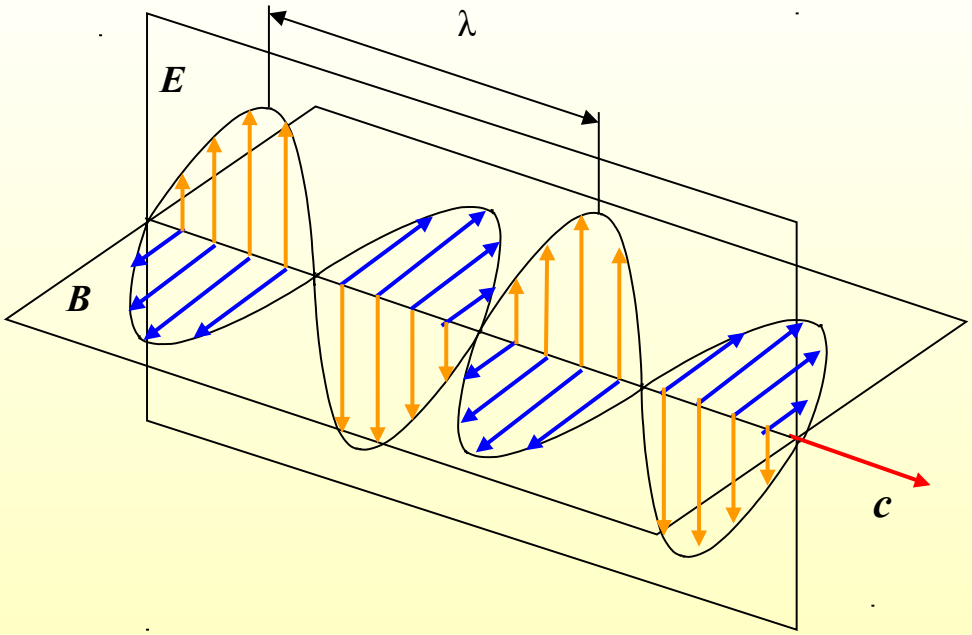


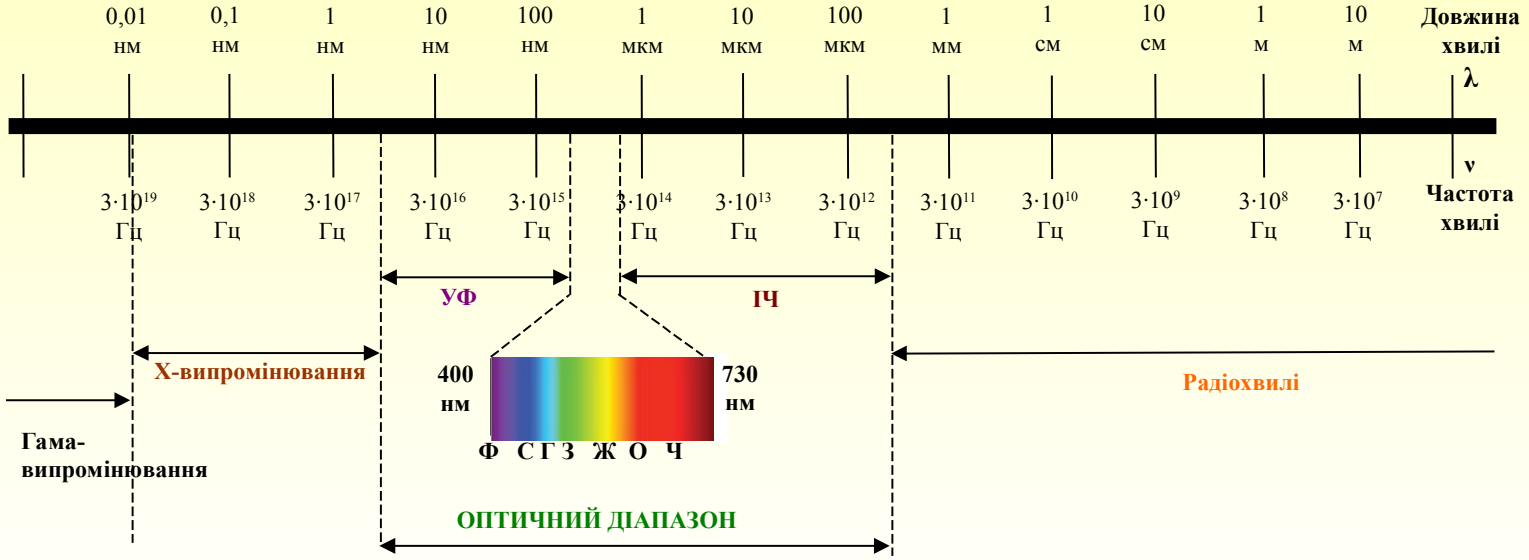
$$E = mc^2$$

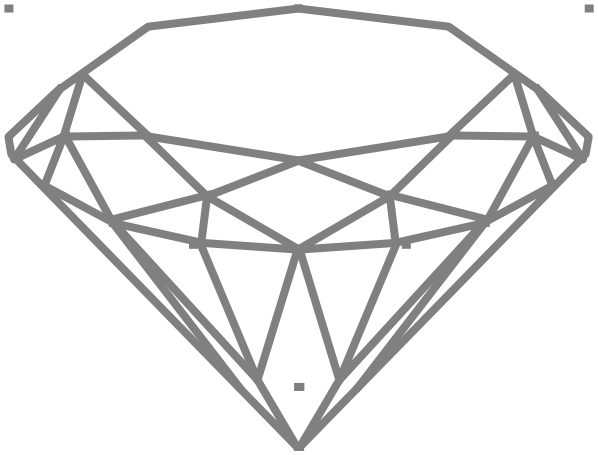
$$R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

http://photonterrace.net/en/photon/history/

Світло – це електромагнітна хвиля і потік фотонів одночасно!







Олександр Смакула

Carl Zeiss AG [DE] https://www.zeiss.com/corporate/int/history/company-history/at-a-gl

ZEISS

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Home / History / Company History / At a Glance / Milestones

Innovations

Here you will find an overview of the most impor

1827 – 1894 1895 – 1945 1946 – 1989 1990 –

1902

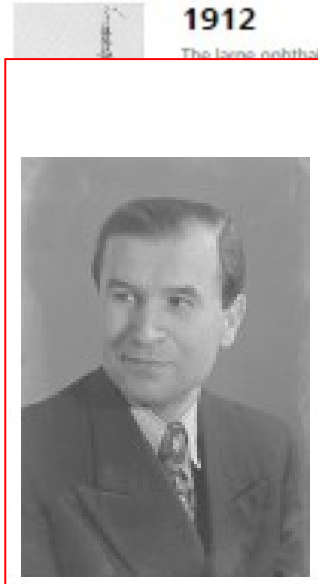
Tessar® lens, the "eagle eye of the camera".

1922

Length measuring machine based on Eppenstein's principle.

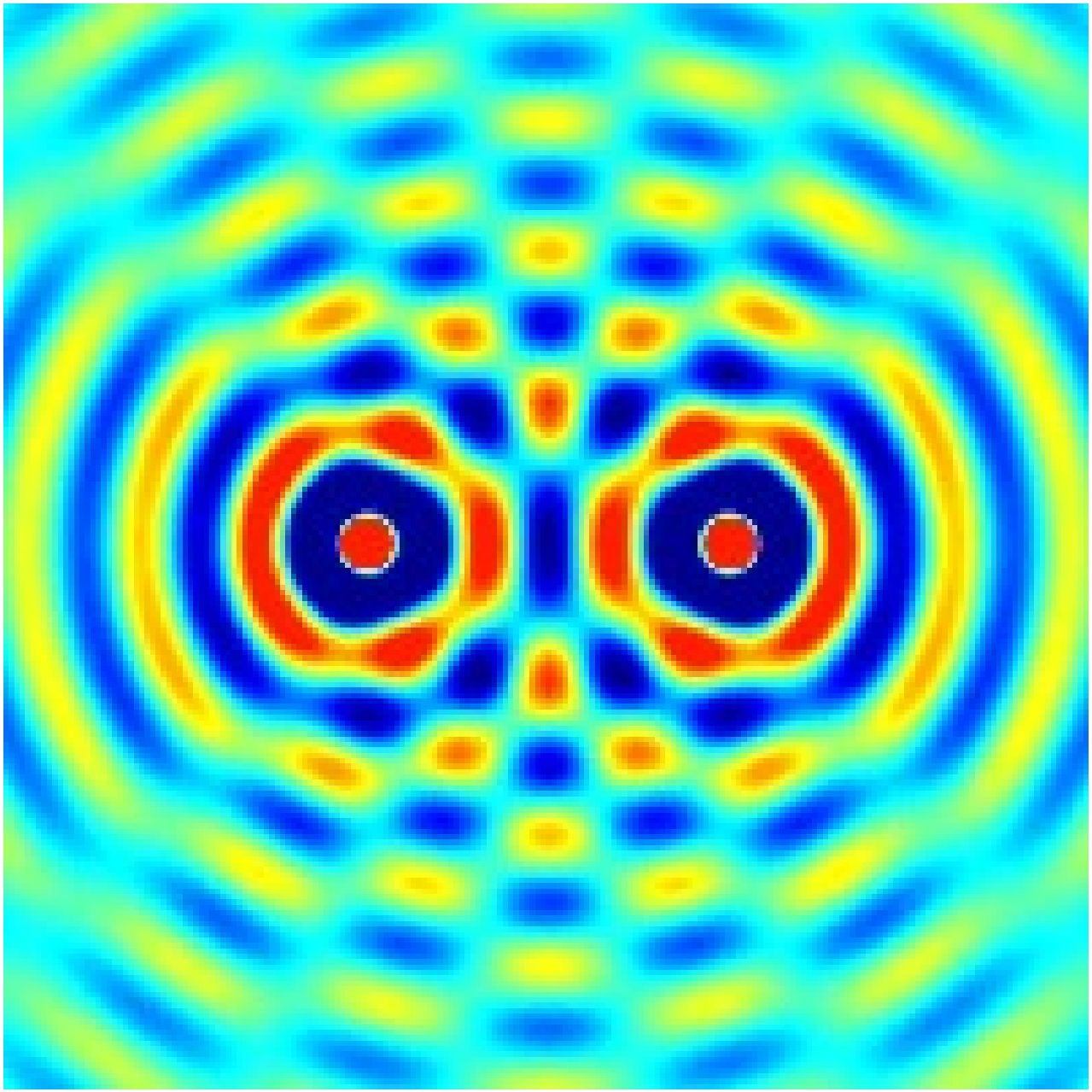
1935

Patent for the coating technique developed by Alexander Smakula to reduce reflections on glass

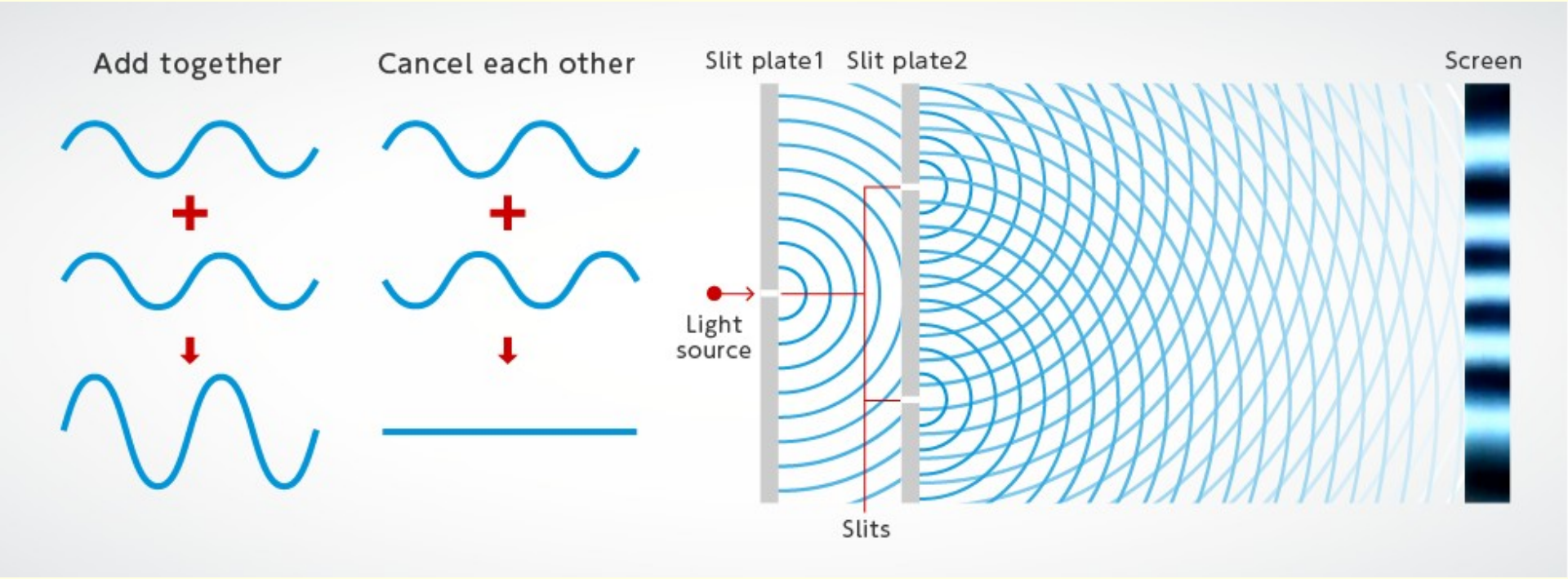


1935

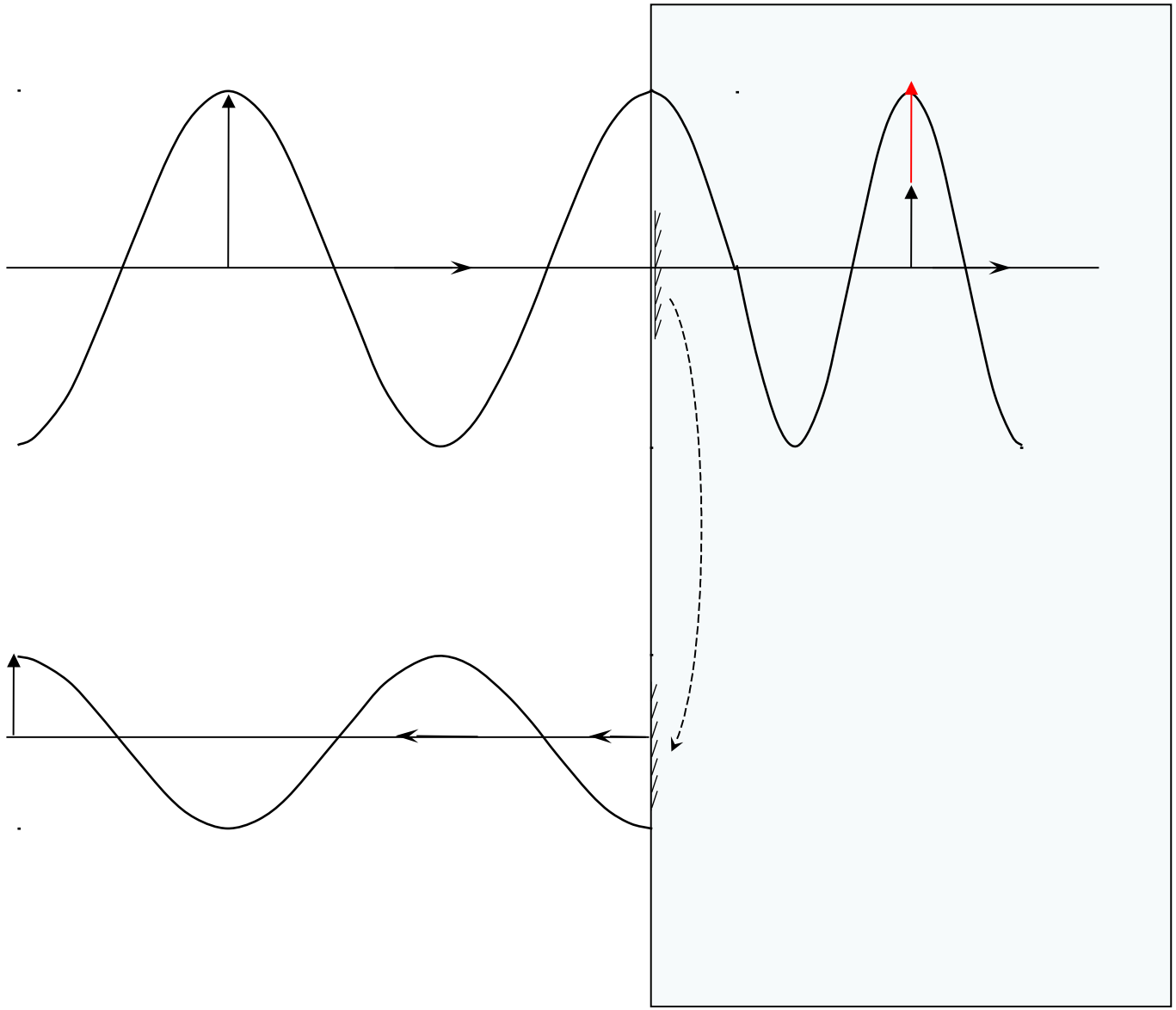
Patent for the coating technique developed by Alexander Smakula to reduce reflections on glass

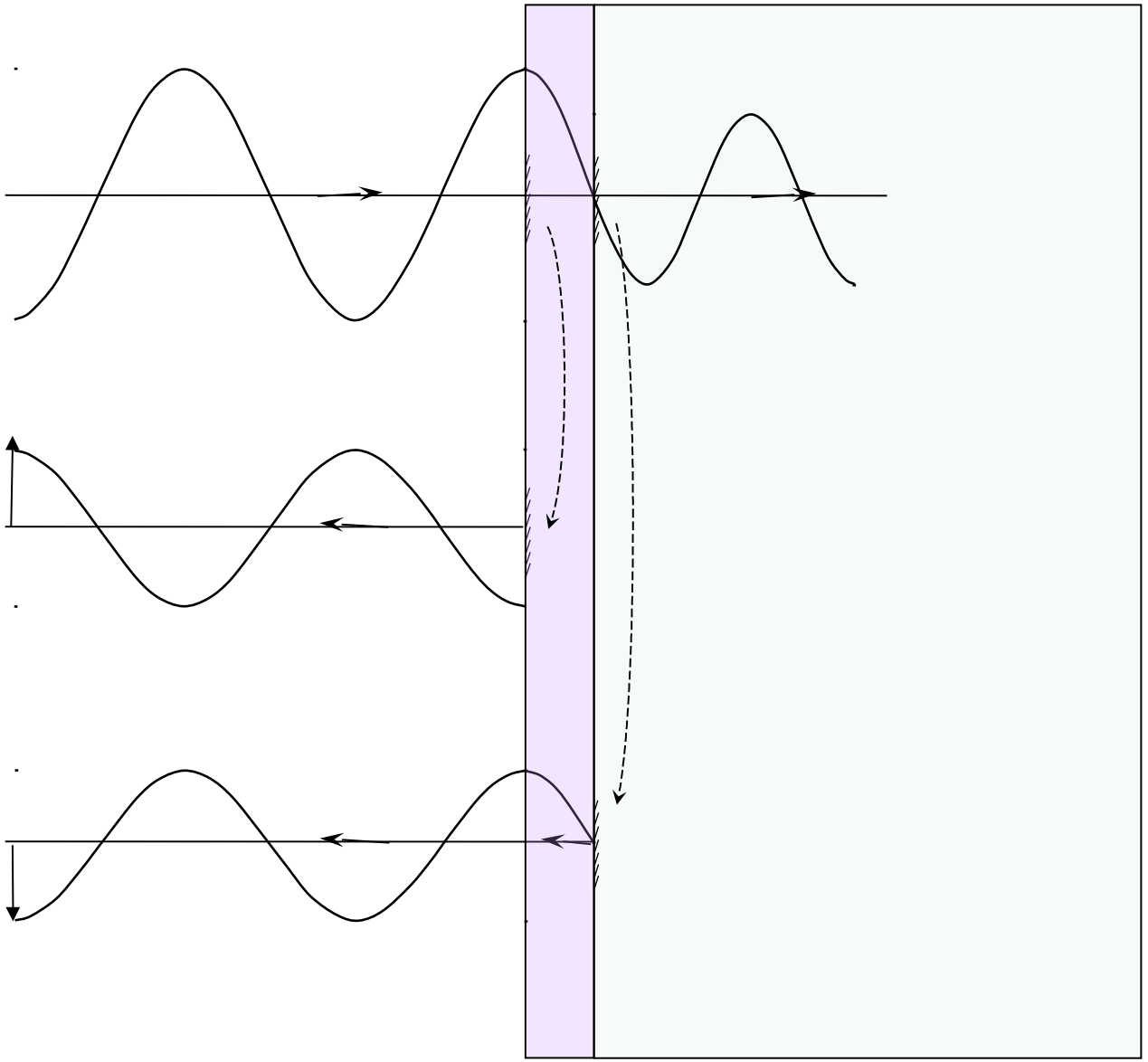


Інтерференційний дослід



http://photonterrace.net/en/photon/duality/





Коефіцієнт відбивання

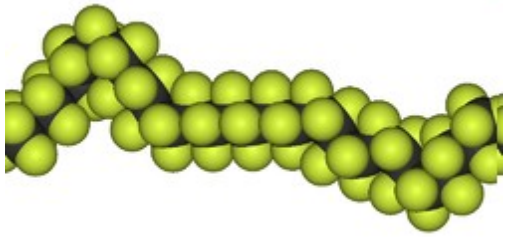
$$R = \left(\frac{n_0 - n_S}{n_0 + n_S}\right)^2$$

крон n_0=1,52

MgF_2 n_S=1,38

J.S. Rayleigh Proc. London Math. Soc., 11 (1879) pp. 51-56

фторполімери



$-(CH_2CHF)_n-$

polyvinylfluoride

$-(C_2H_2F_2)_n-$

polyvinylidene fluoride

C_nF_{2n+2}

silsesquioxane resin

polytetrafluoroethylene

(PhSiO.sub.(3-x)/2(OH)x)mHSiO.sub.(3-x)/2(OH)x)n(MeSiO- .sub.(3-x)/2(OH)x)p

ZEISS C Sonnar T* 50mm f/1.5 ZM Lens

Leica M-Mount Lens
Aperture Range: f/1.5 to f/16
ZEISS T* Anti-Reflective Coating
Manual Focus Design

You Pay: **$1,261.00**

www.bhphotovideo.com/c/product/446177-EG/Zeiss_1407_067_50mm_f_1_5_ZM_Lens.html

Нобелівська премія з фізики 2018

KUNGL. VETENSKAPSAKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

“for groundbreaking inventions in the field of laser physics”

Артур Ешкін
(Bell Laboratories, Holmdel, NJ, USA)

“for the optical tweezers and their application to biological systems”

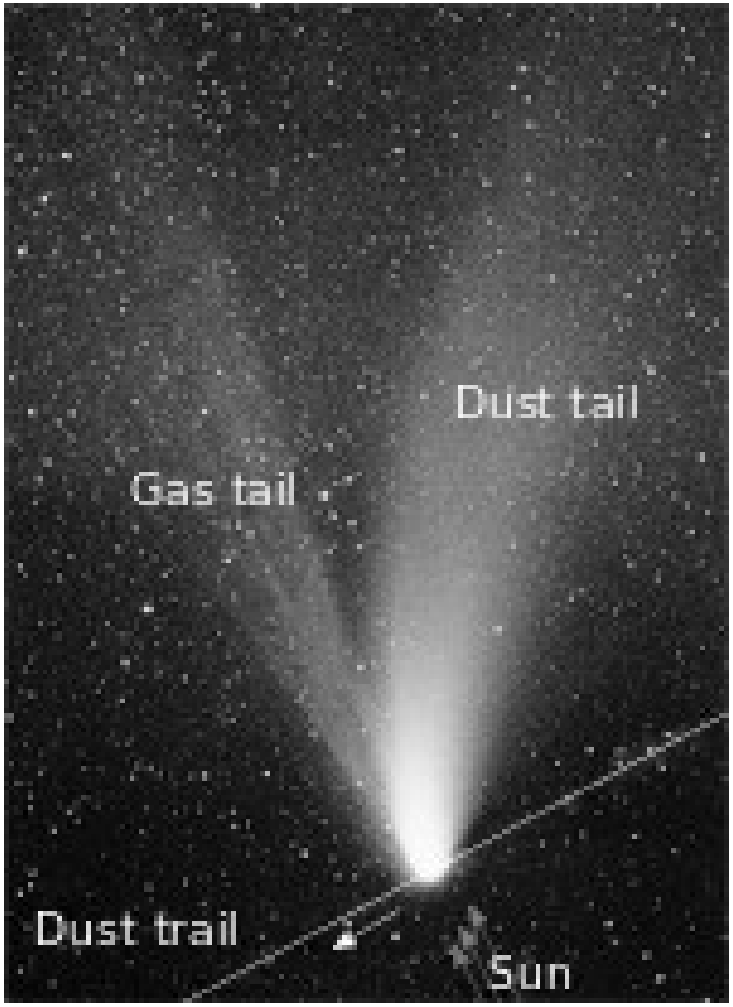
"за оптичний пінцет та його застосування до біологічних систем“

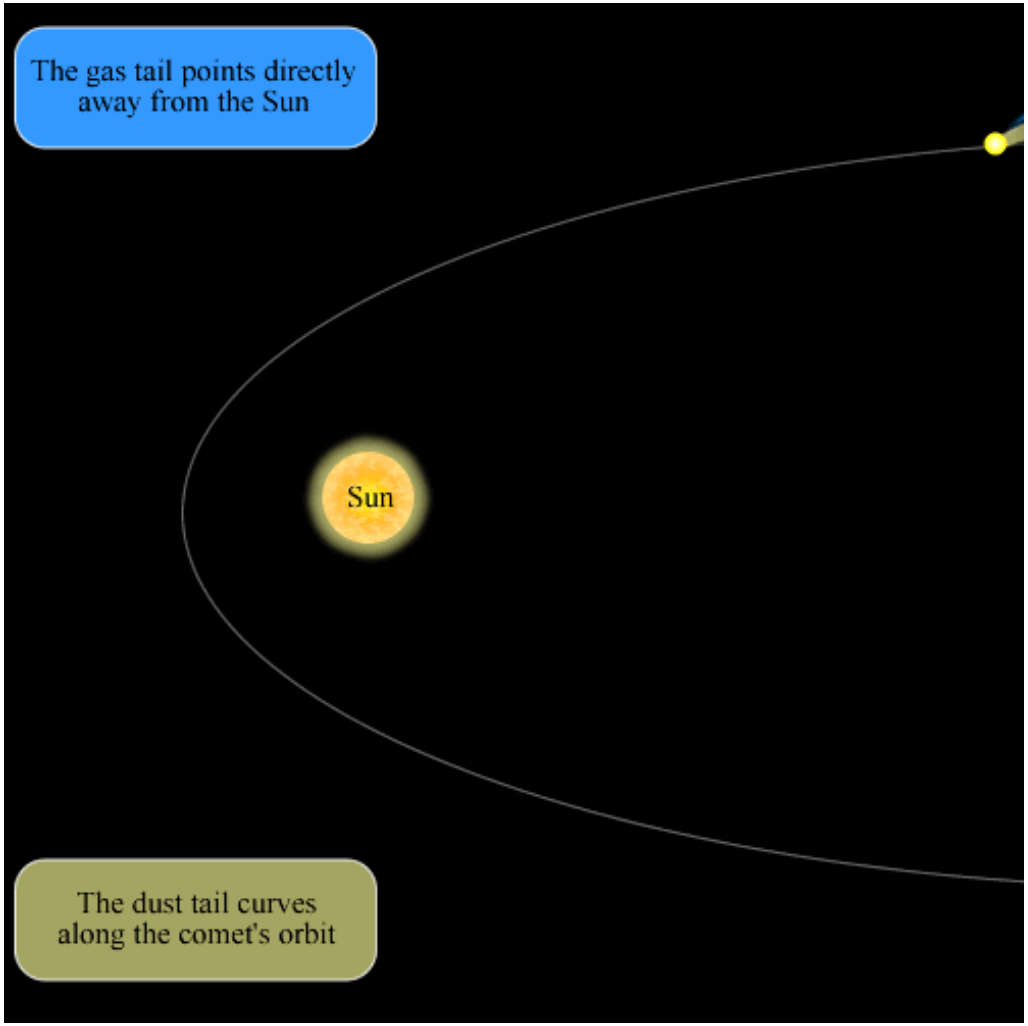
Жерар Муру
(École Polytechnique, Palaiseau, France)

Донна Стрікленд
(University of Waterloo, Waterloo,Canada)

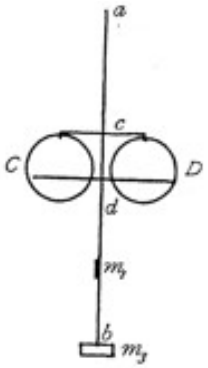
“for their method of generating high-intensity, ultra-short optical pulses”

"за метод генерації високоенергетичних ультракоротких оптичних імпульсів“





astronomy.swin.edu.au/cosmos/c/cometary+tails

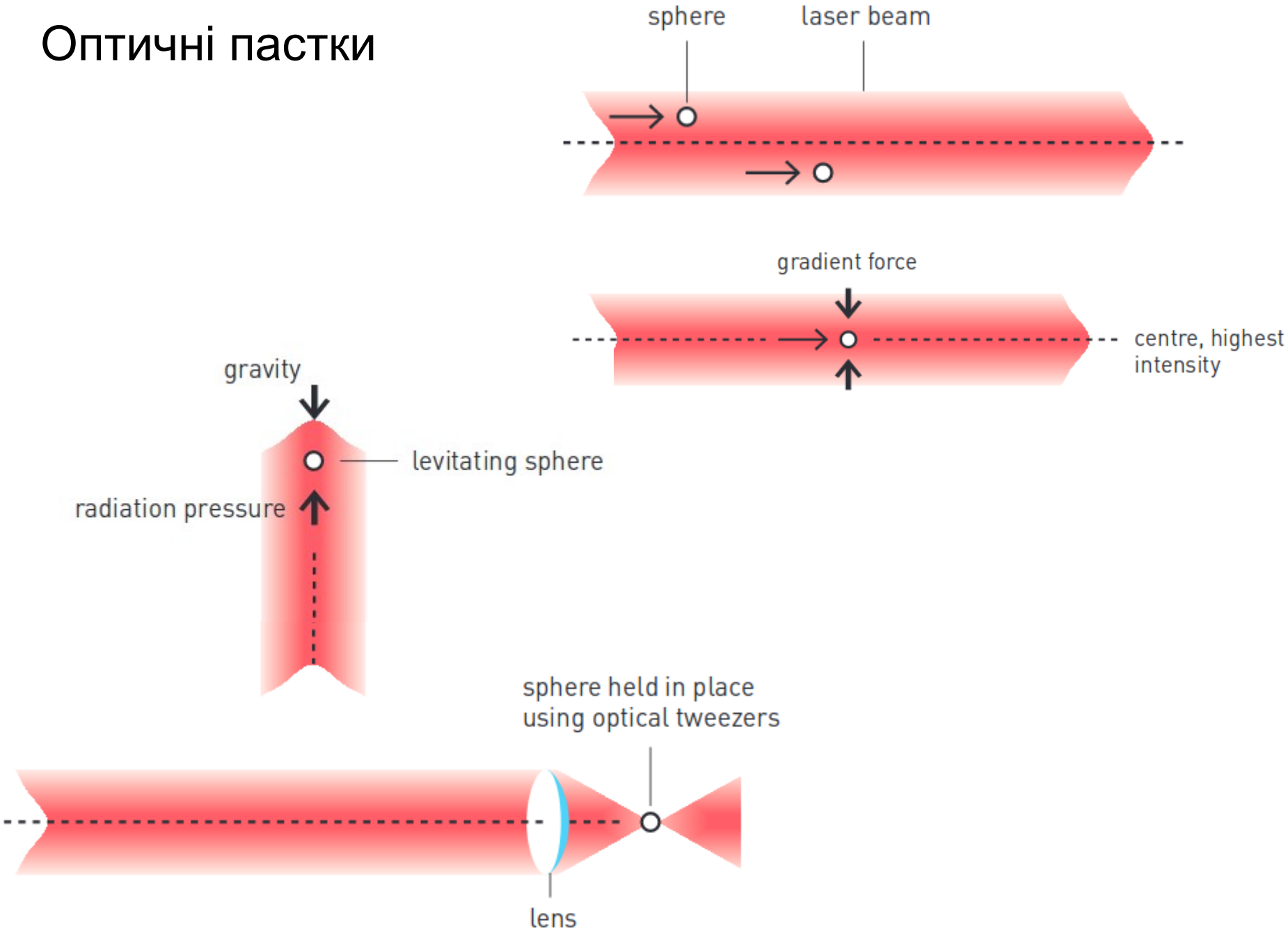


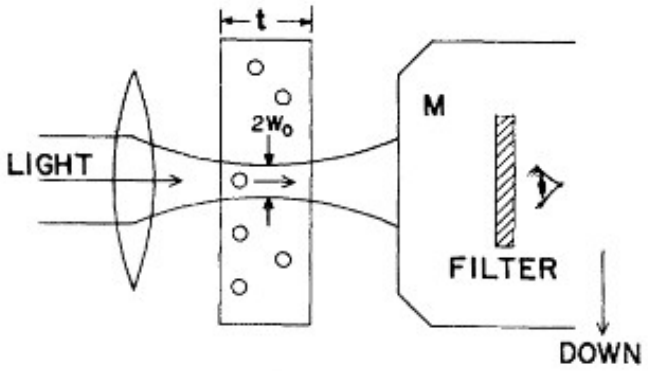
Nichols, E. F., and Hull, G. F., A preliminary communication on the pressure of heat and light radiation, Phys. Rev. 13, 307 (1901); The Pressure Due to Radiation. (Second Paper.), Phys. Rev. 17, 26 (1903)

Lebedev, P., Untersuchungen uber die Druckkrafte des Lichtes, Ann. Phys. (Leipzig) 6, 433 (1901)

www.dartmouth.edu/~pressureoflight/history/history1.html

Оптичні пастки





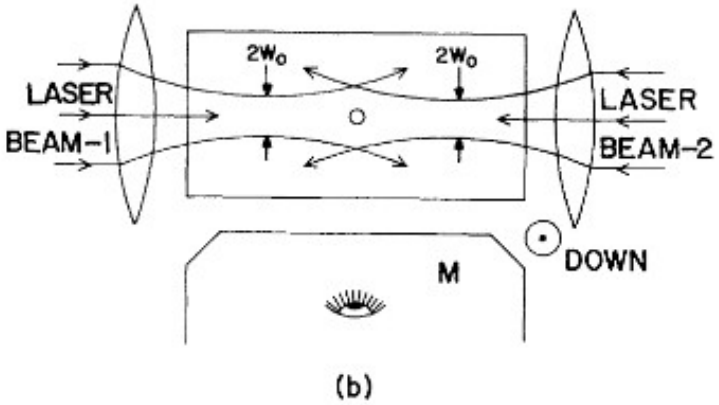


FIG. 1. (a) Geometry of glass cell, $t = 120\ \mu$m, for observing micron particle motions in a focused laser beam with a microscope M. (b) The trapping of a high-index particle in a stable optical well. Note position of the TEM_{00}-mode beam waists.

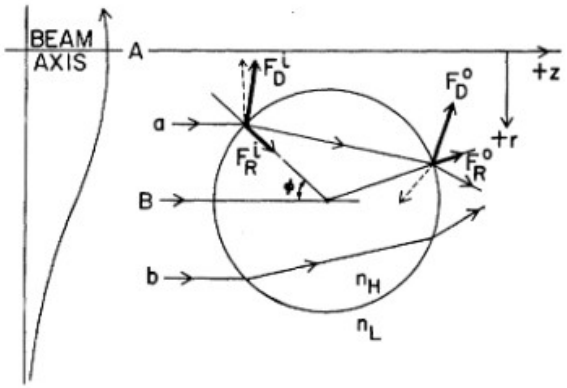


FIG. 2. A dielectric sphere situated off the axis A of a TEM_{00}-mode beam and a pair of symmetric rays a and b. The forces due to a are shown for $n_H > n_L$. The sphere moves toward $+z$ and $-r$.

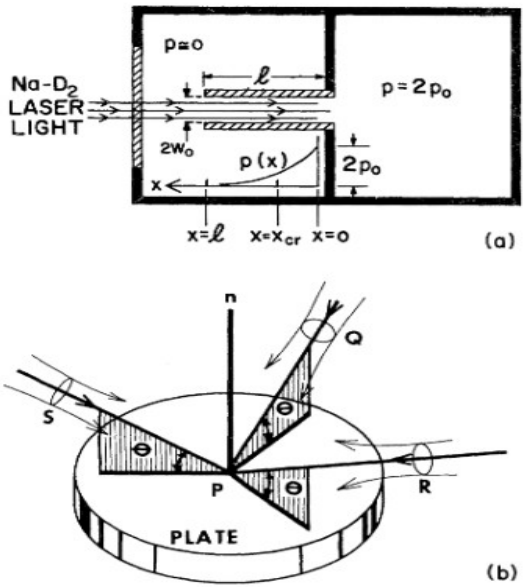
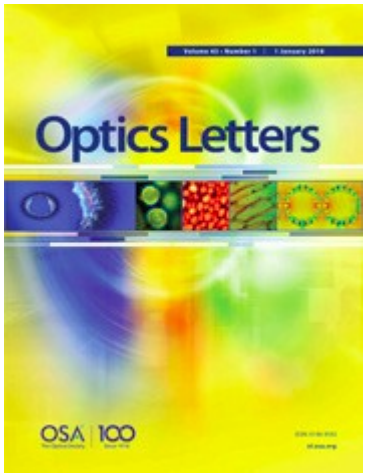


FIG. 3. (a) Schematic optical gas pump and graph of Na pressure $p(x)$. (b) Geometry of gas confinement about point P of a plane surface.



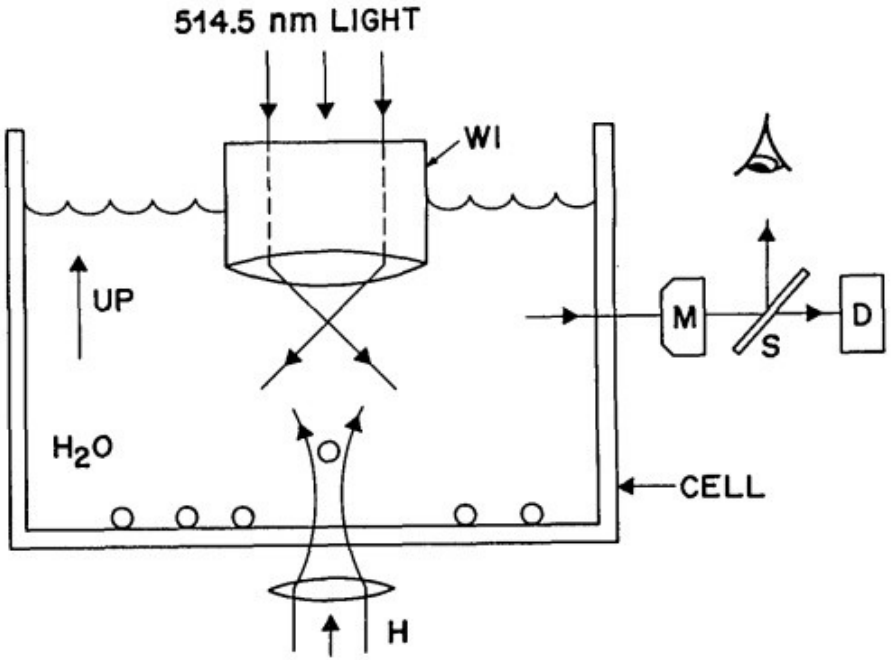
Observation of a single-beam gradient force optical trap for dielectric particles

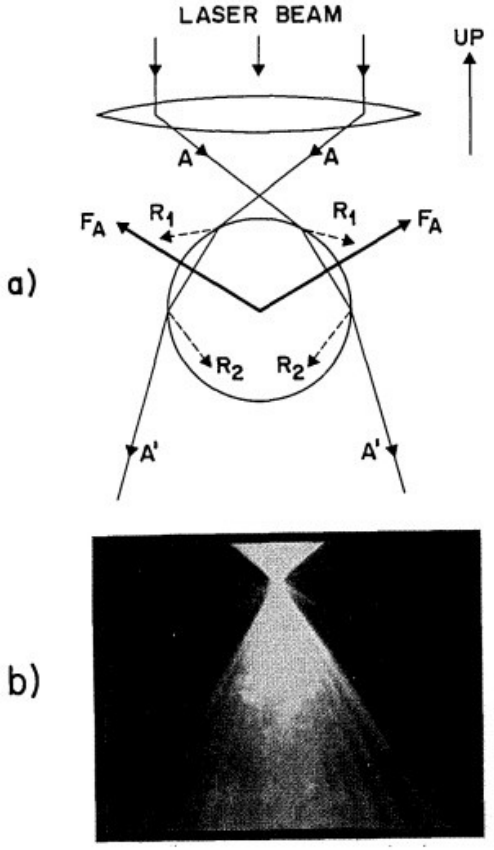
A. Ashkin, J. M. Dziedzic, J. E. Bjorkholm, and Steven Chu

We report the first experimental observation to our knowledge of a single-beam gradient force radiation-pressure particle trap.[1] With such traps dielectric particles in the size range from 10 μm down to ~25 nm were stably trapped in water solution. These results

1. A. Ashkin, Phys. Rev. Lett. **40,** 729 (1978).
2. A. Ashkin, Science **210,** 1081 (1980); V. S. Letokhov and V. G. Minogin, Phys. Rep. **73,** 1 (1981).
3. A. Ashkin and J. P. Gordon, Opt. Lett. **8,** 511 (1
4. A. Ashkin and J. M. Dziedzic, Phys. Rev. Lett. (1985).

Optics Letters Vol. 11, Issue 5, pp. 288-290 (1986) · https://doi.org/10.1364/OL.11.000288





OSA The Optical Society

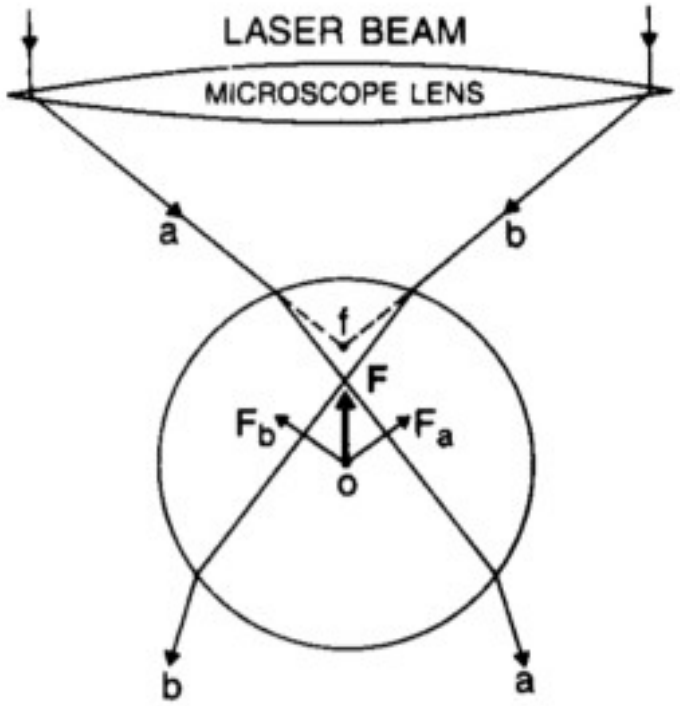


Figure 1: *Qualitative ray optics description of the restoring backward force in an optical tweezers trap, for a dielectric sphere that is located below the focus* **f** *and assumed to be large compared with the wavelength of the light. Rays of light carry momentum and are bent by refraction when passing the dielectric sphere. By conservation of momentum and Newton's second law, the momentum change of the refracted rays results in an oppositely directed force*

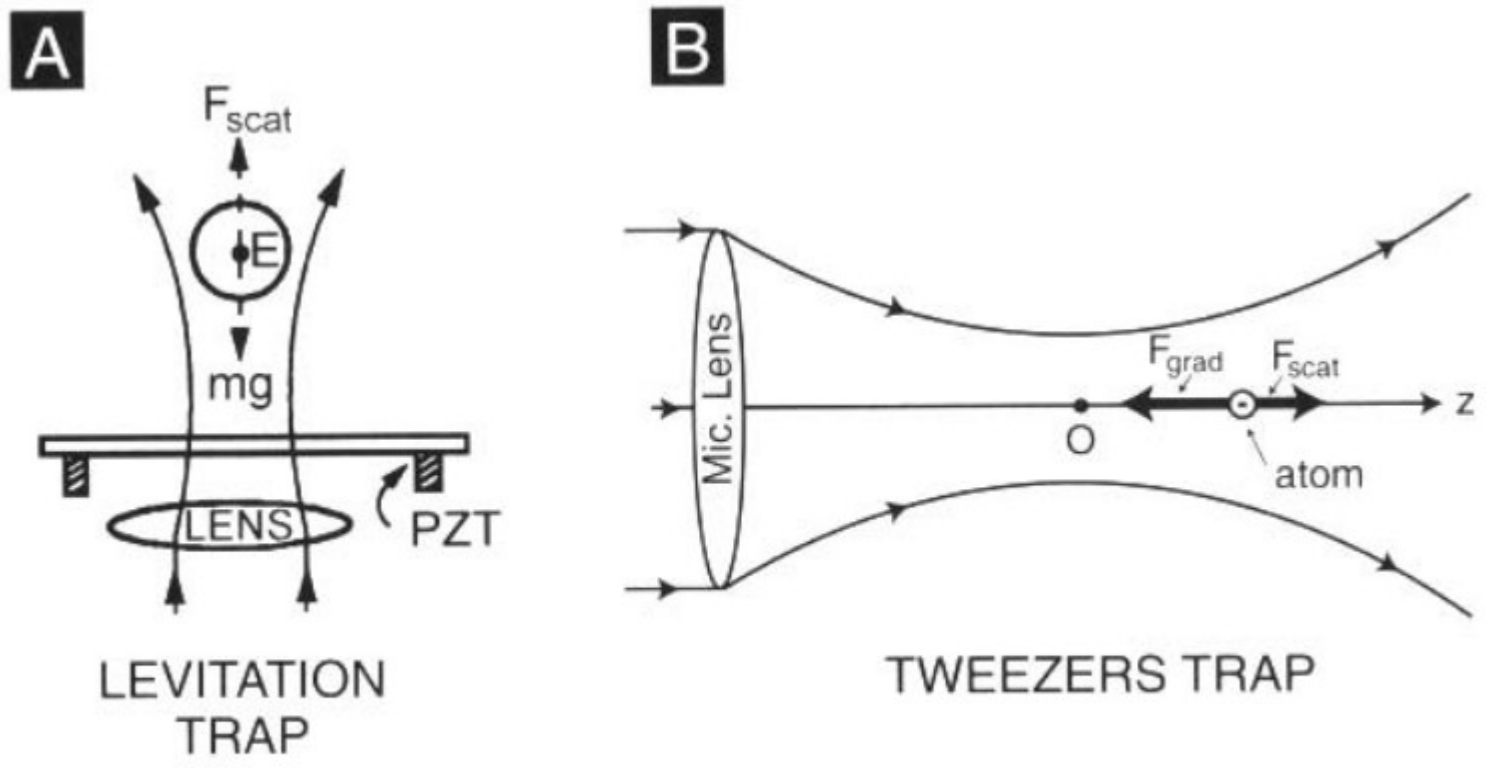


Figure 2. (A) Geometry of levitation trap. (B) Tweezer trap for atoms. $F_{grad} > F_{scat}$ giving a net backward restoring force toward E.

https://www.jpk.com/products/force-sensing-optical-tweezers-a

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M. Ericsson,[1] D. Hanstorp,

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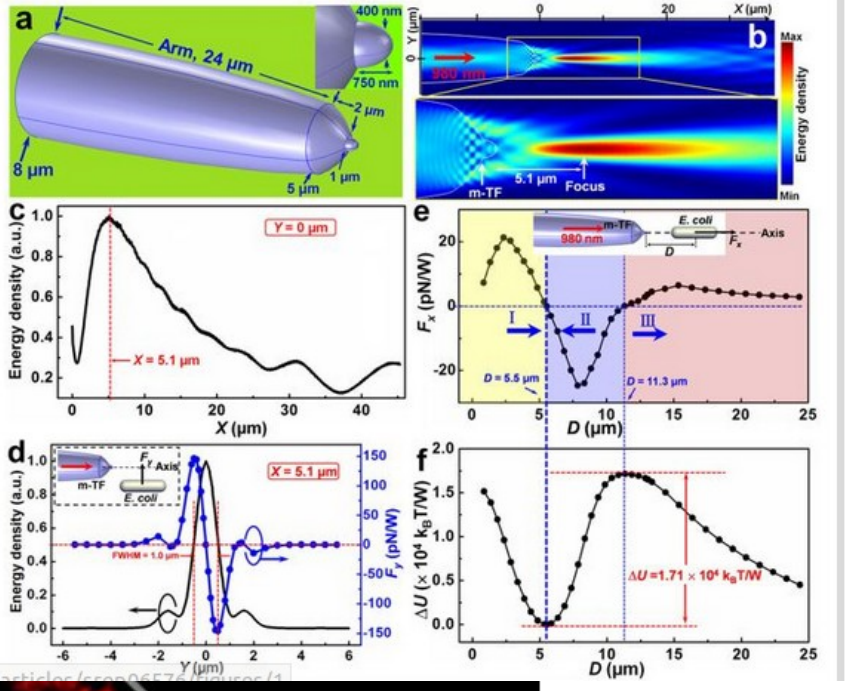
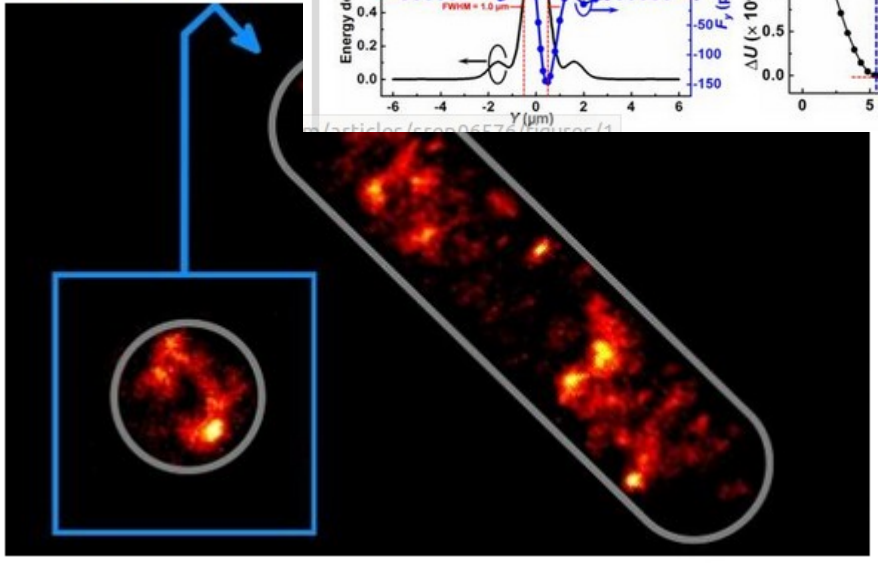
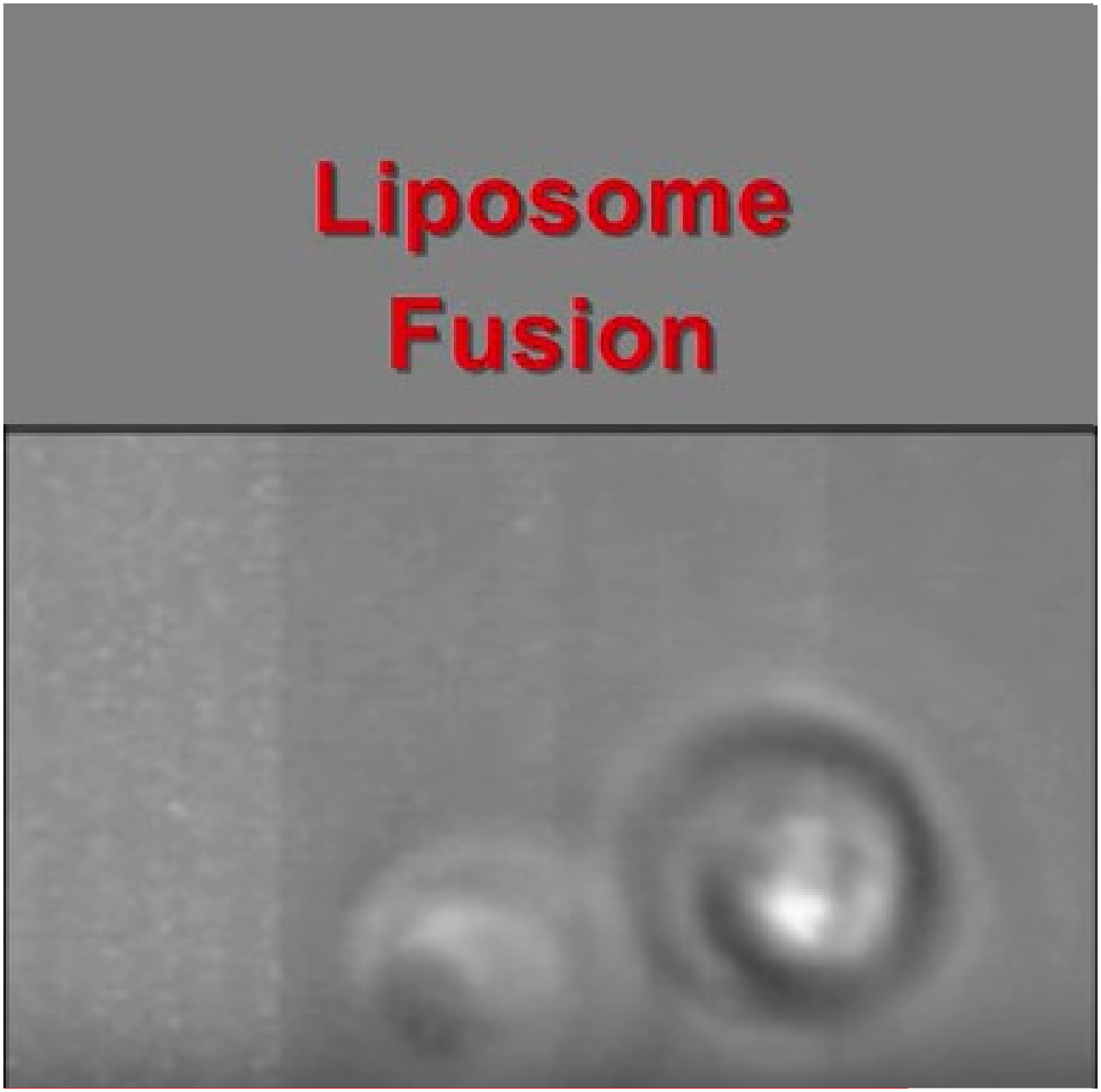
Non-contact fiber-optical trapping of motile bacteria: dynamics observation and energy es

Figure 1: Model of the modified tapered fiber and numerical results.







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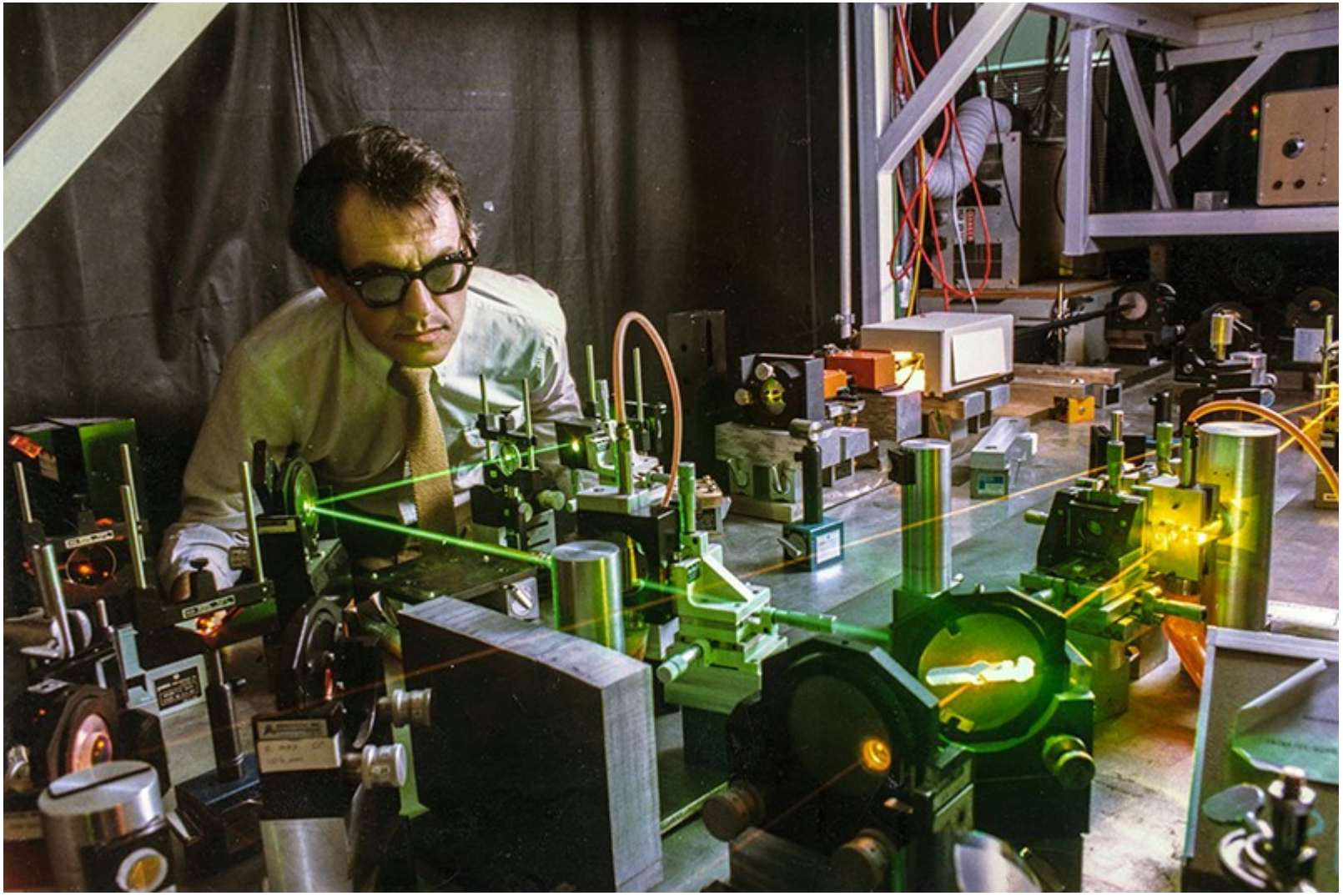
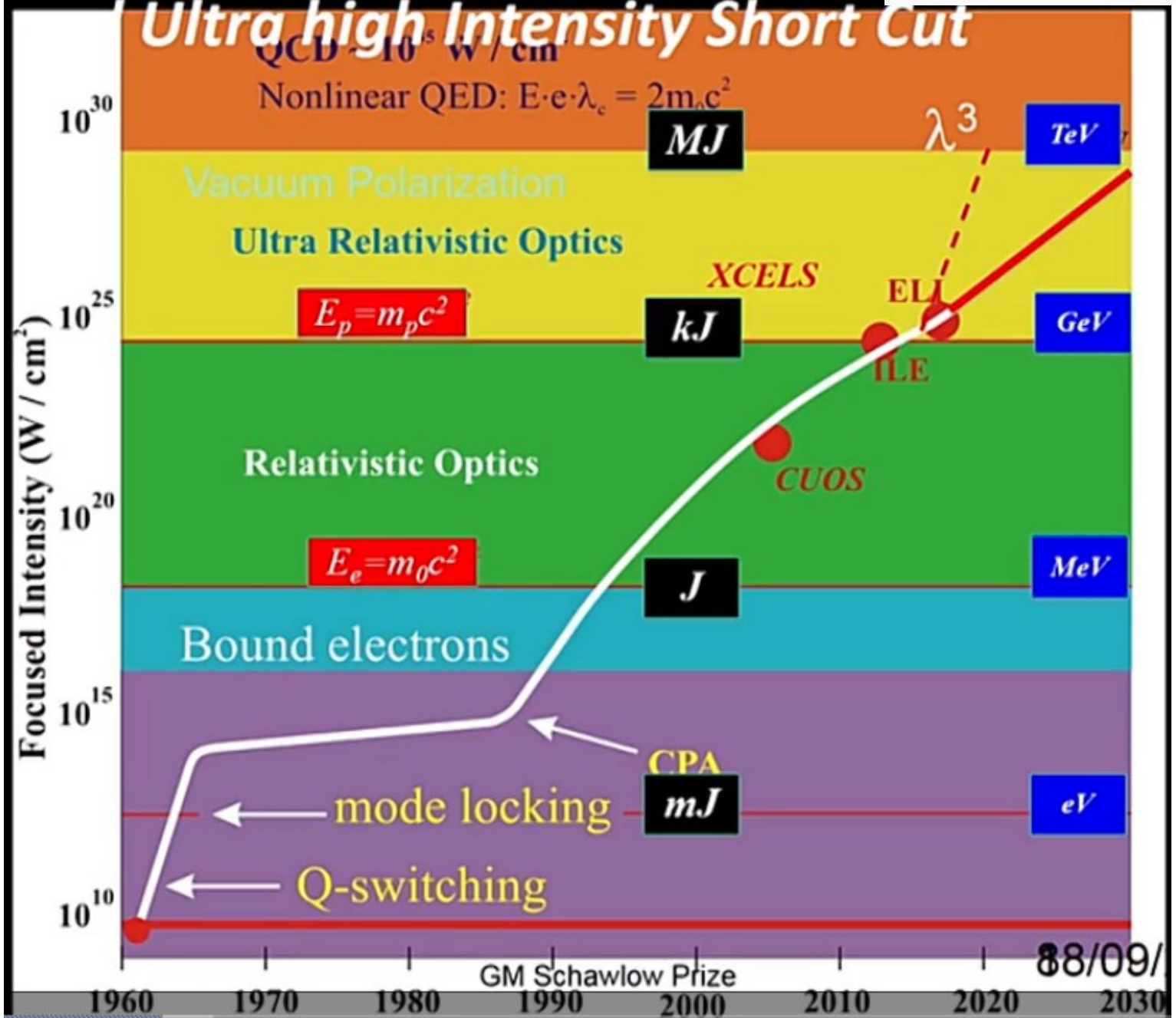


Gérard Mourou, in a 1987 photograph from the Laboratory for Laser Energetics. Mourou's work at Rochester has helped shape the direction of research in high-powered lasers. (University of Rochester photo)

www.rochester.edu/newscenter/rochesters-breakthrough-in-laser-science-earns-nobel-prize-340302/

Extreme Light Road Map

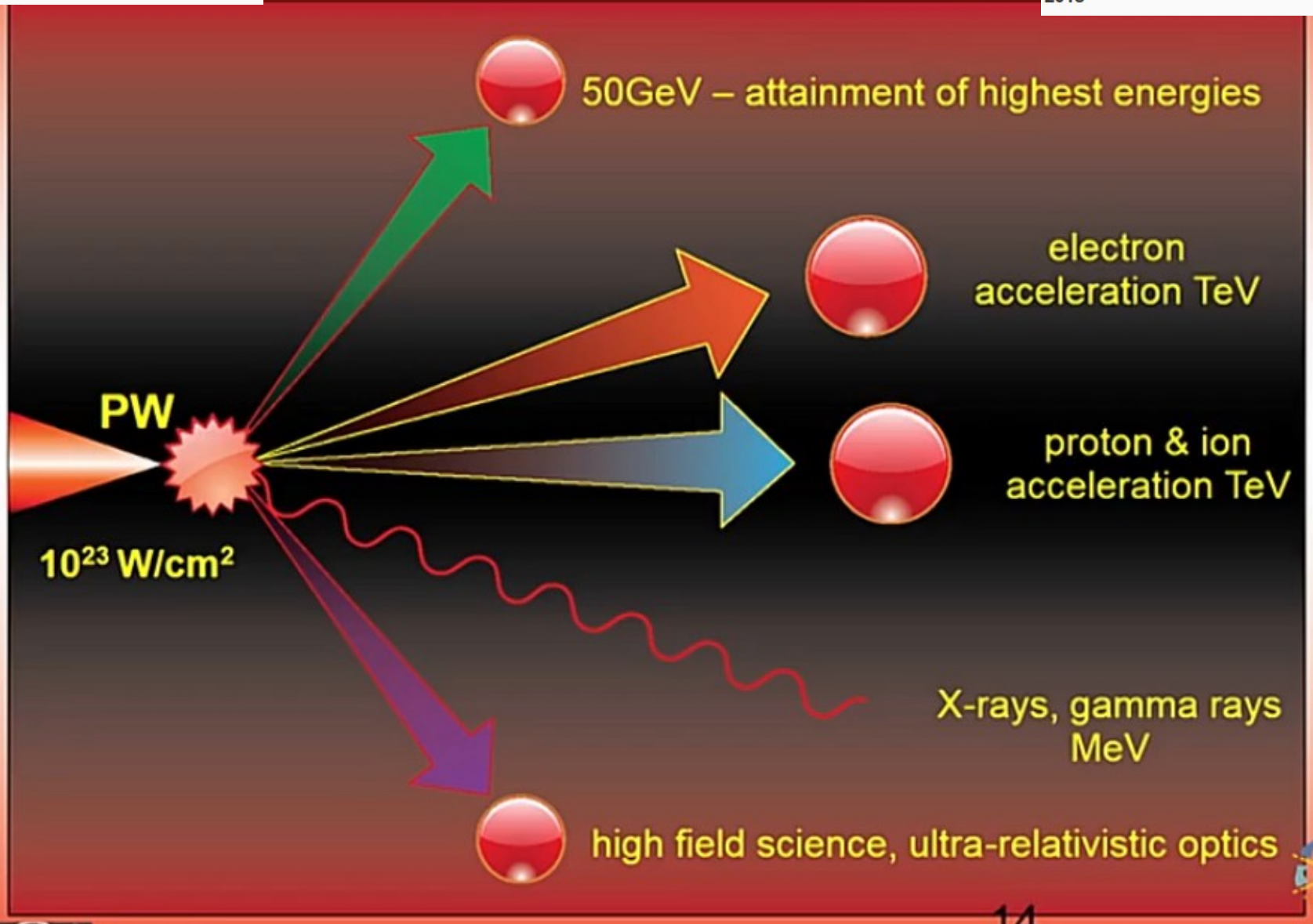
Chirped Pulse Amplification to ELI and Beyond talk by Gerard Mourou at FiO+LS 2018



Extreme Light: Universal Source of Radiations and Particles

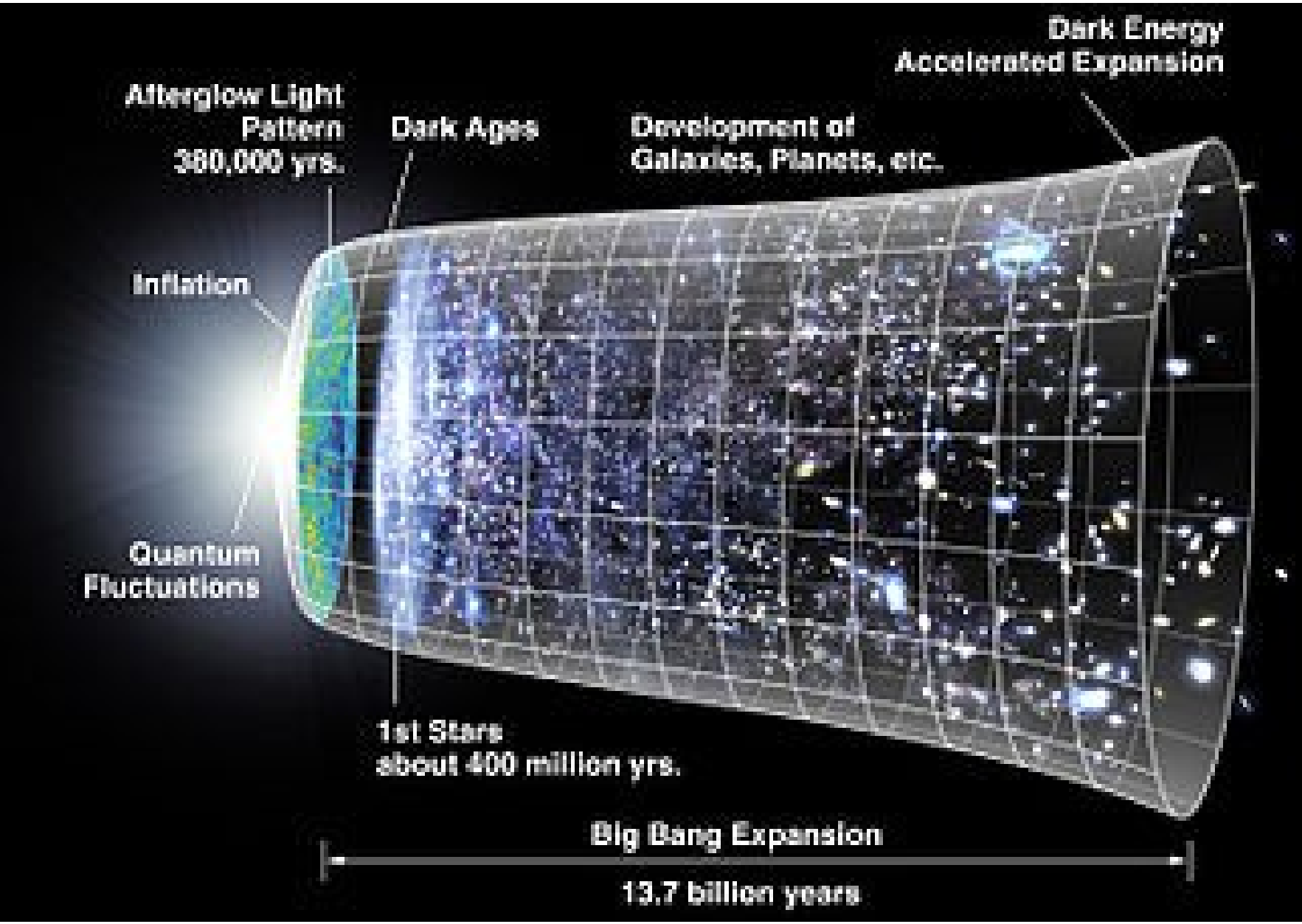
OSA FRONTIERS IN OPTICS
LASER SCIENCE APS/DLS

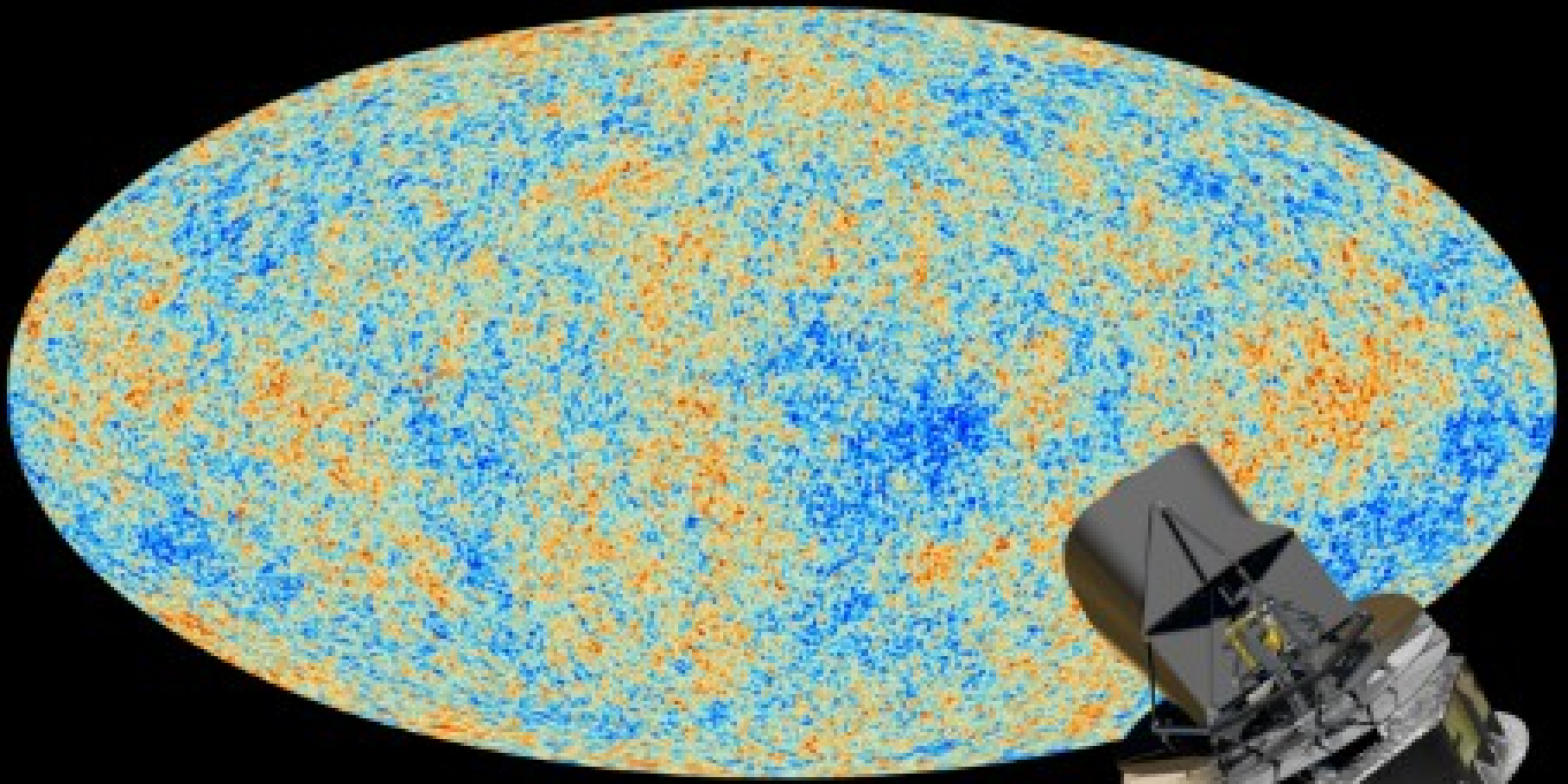
Chirped Pulse Amplification to ELI and Beyond talk by Gerard Mourou at FiO+LS 2018



IZEST

International Year of Light


Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
380,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years

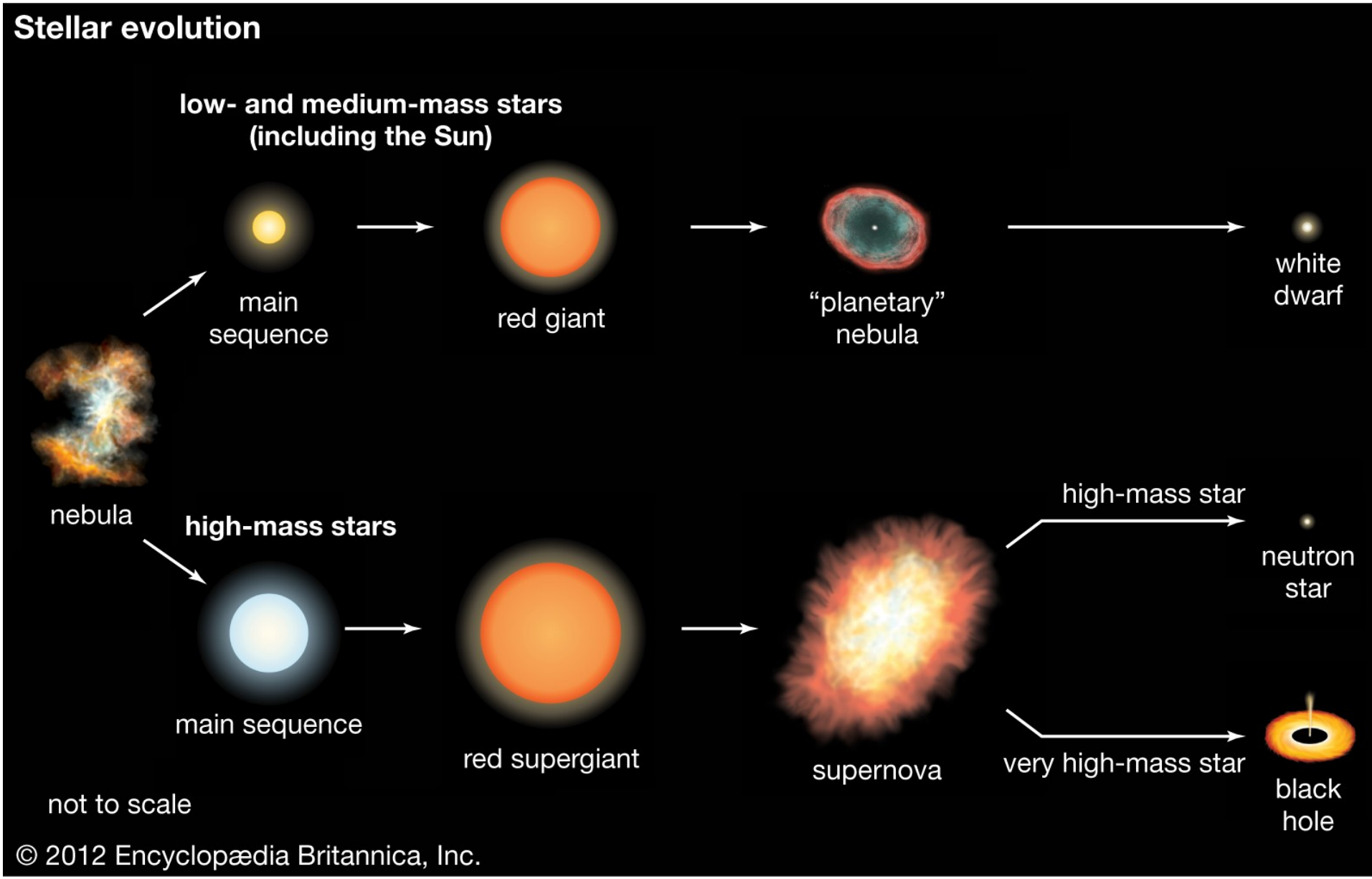


Microwave background radiation

Planck space observatory

The Sound of the Big Bang

John G. Cramer
Professor of Physics
University of Washington



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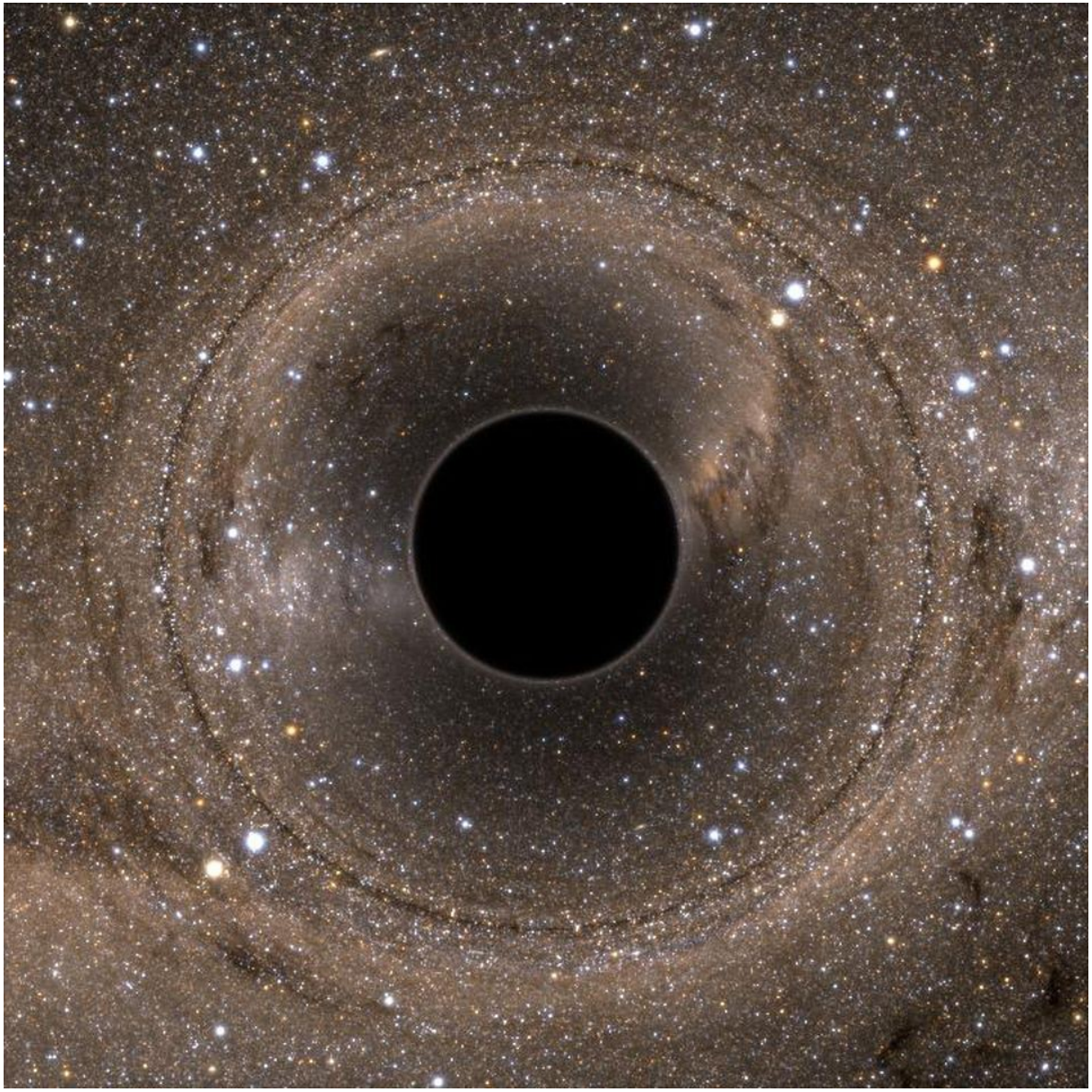

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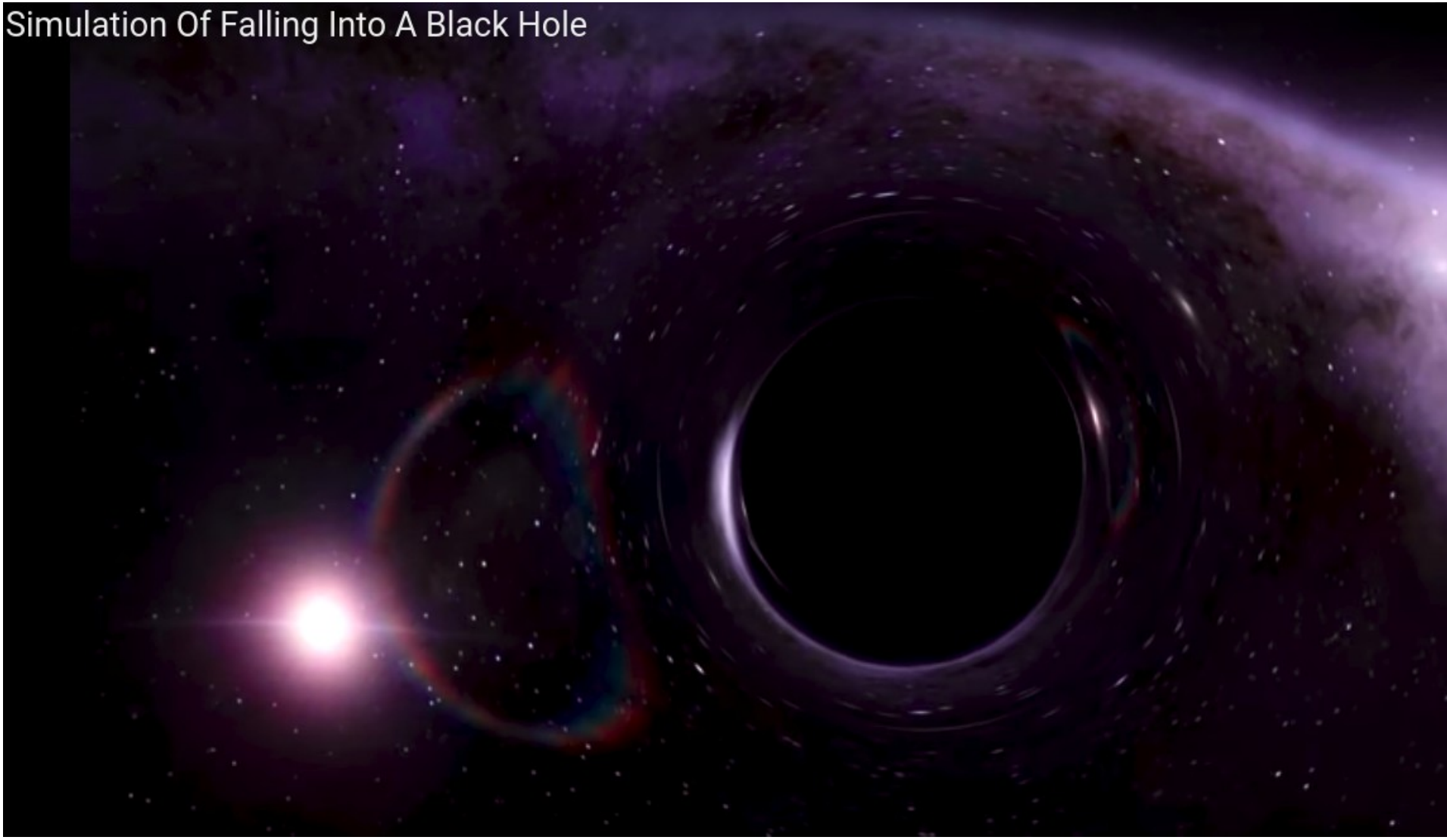

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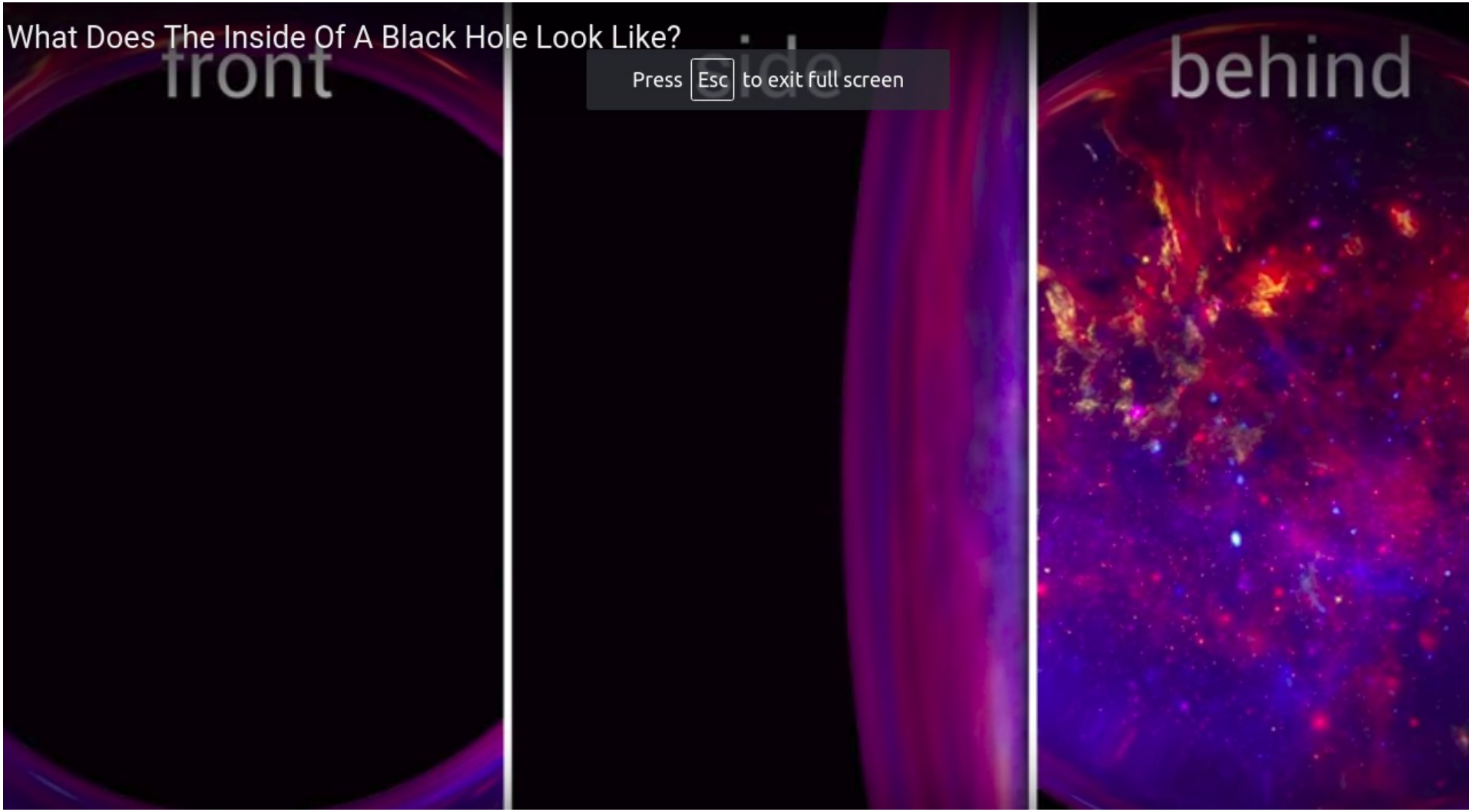
What Does The Inside Of A Black Hole Look



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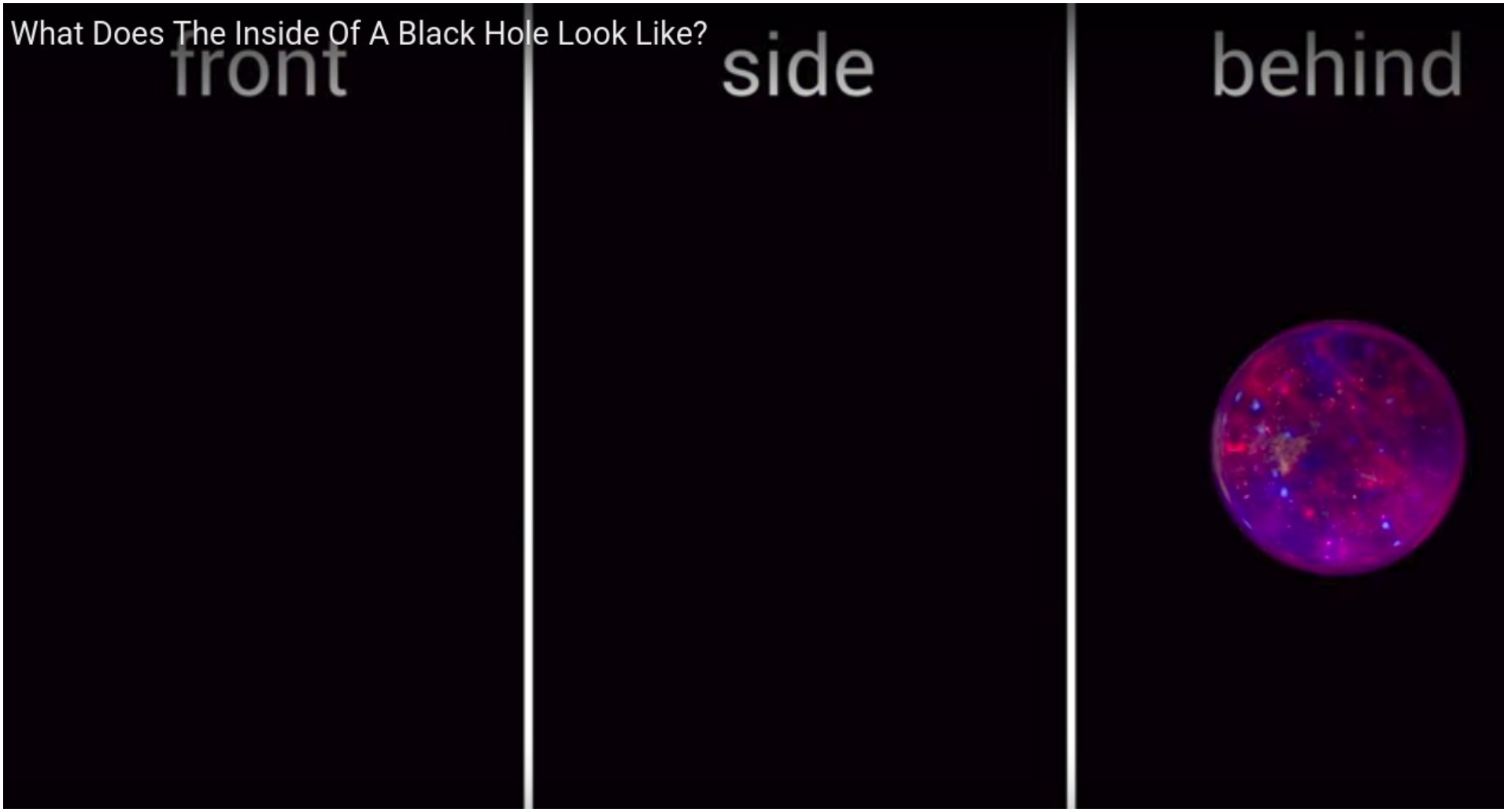

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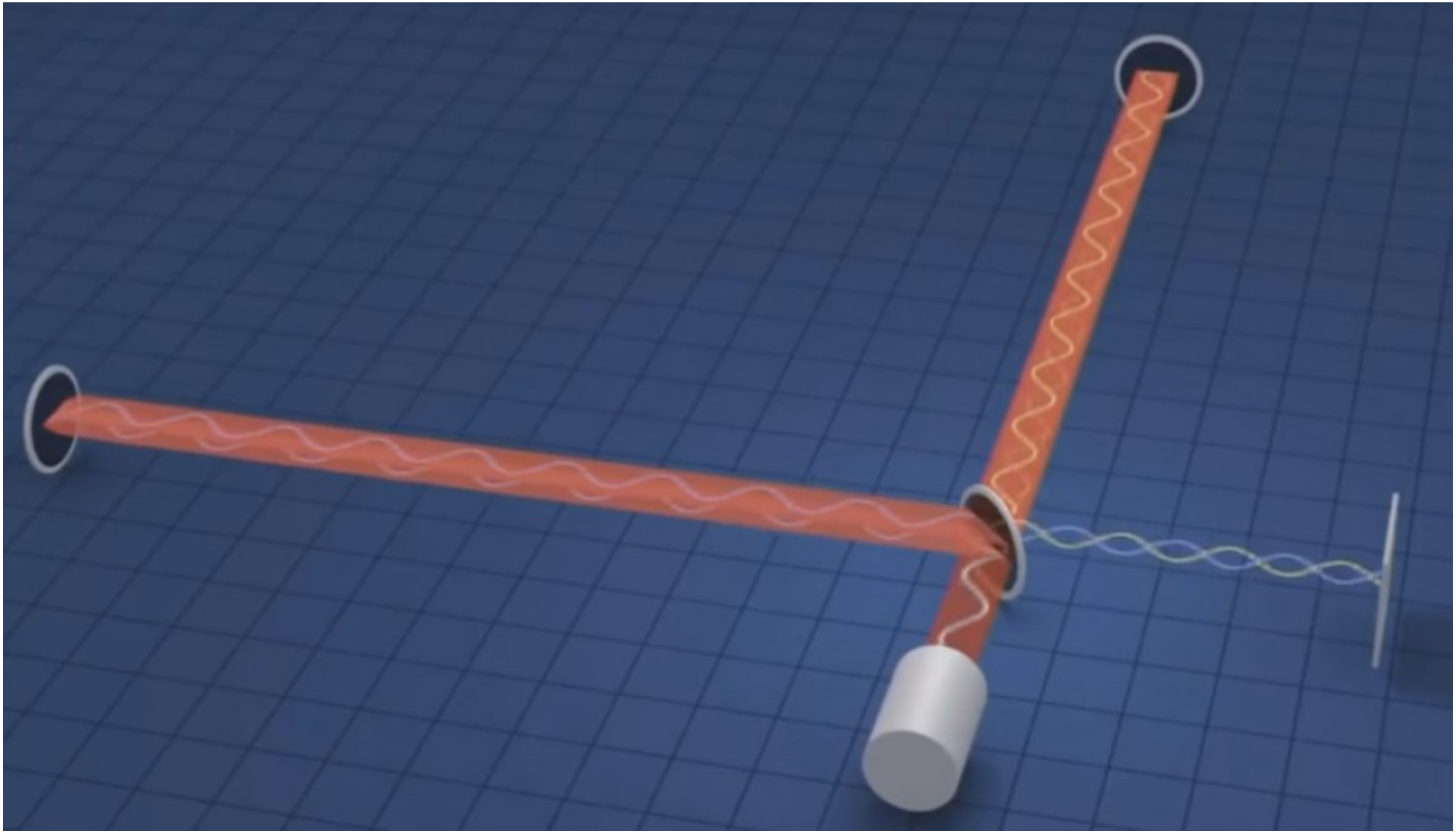

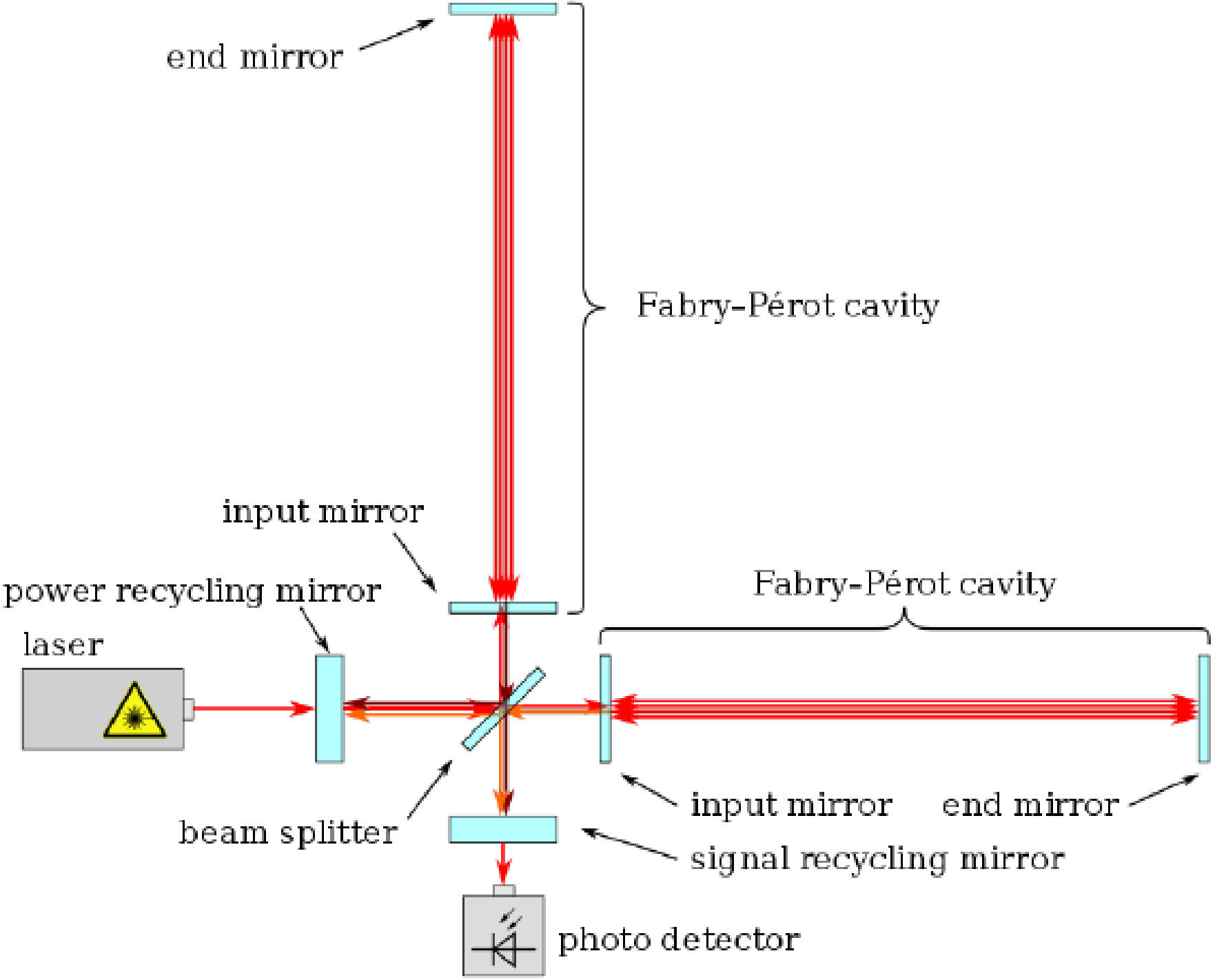
end mirror
Fabry-Pérot cavity
input mirror
power recycling mirror
laser
Fabry-Pérot cavity
beam splitter
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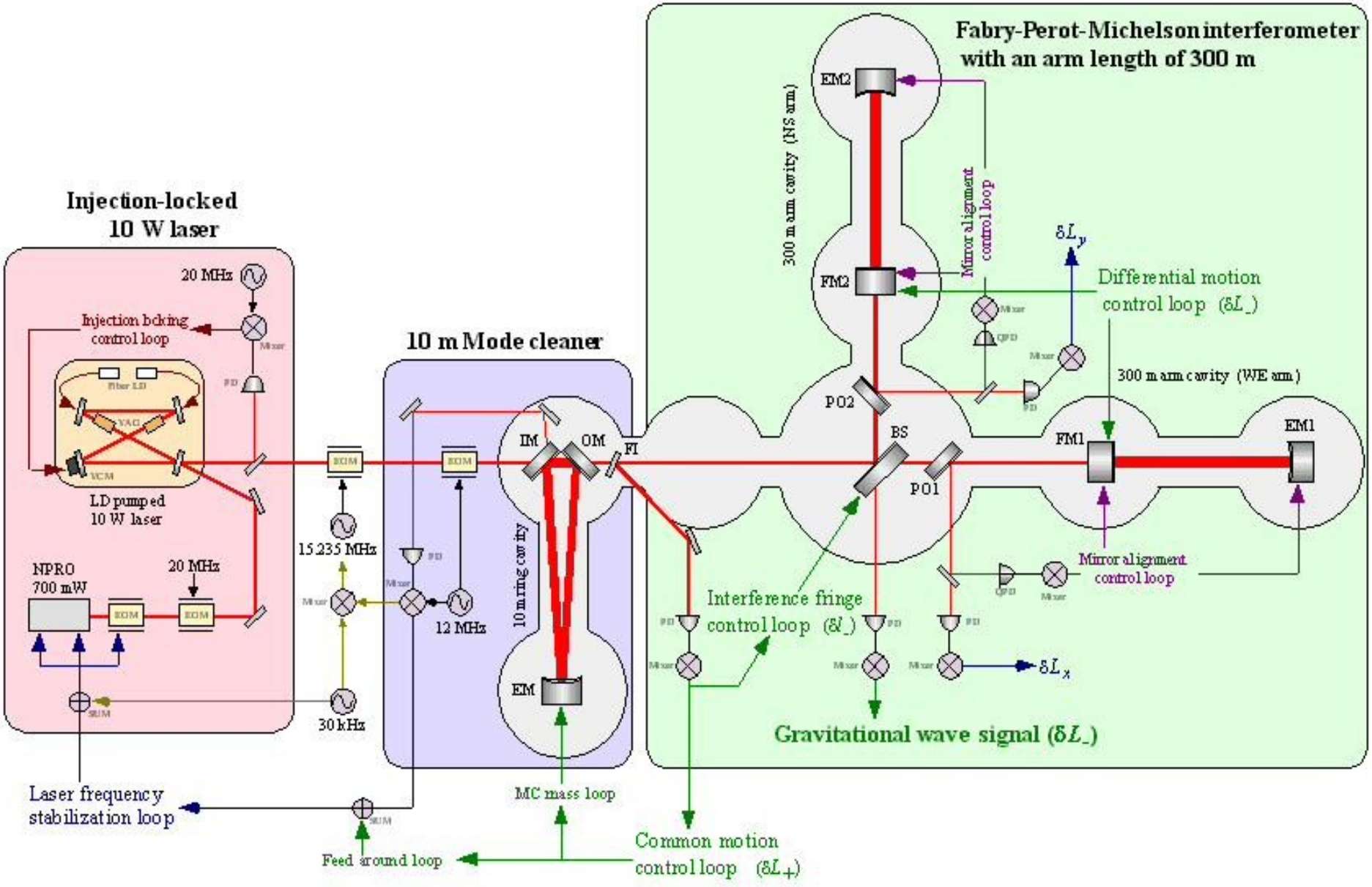
signal recycling mirror
photo detector

Спроби виявлення гравітаційних хвиль: лазерні інтерферометри



Laser Interferometer Gravitational-wave Observatory – LIGO (США)

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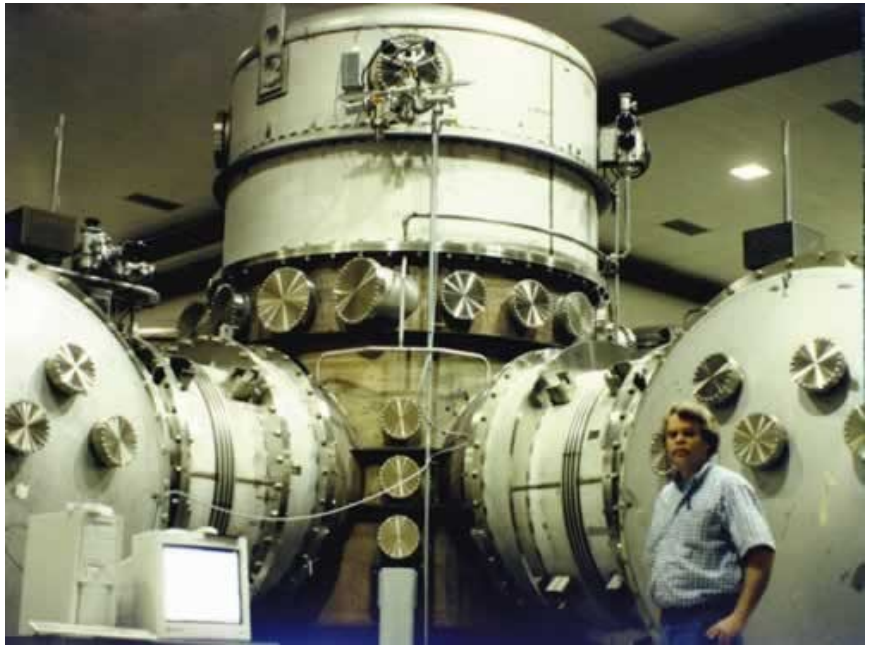

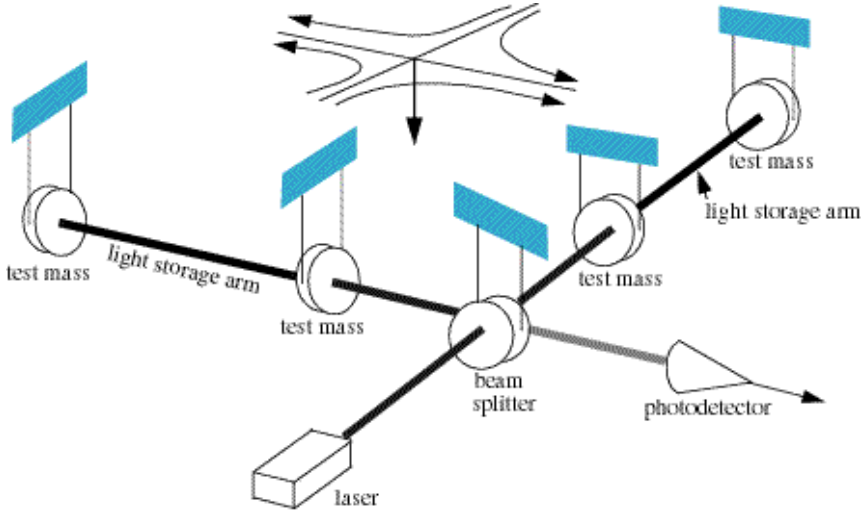

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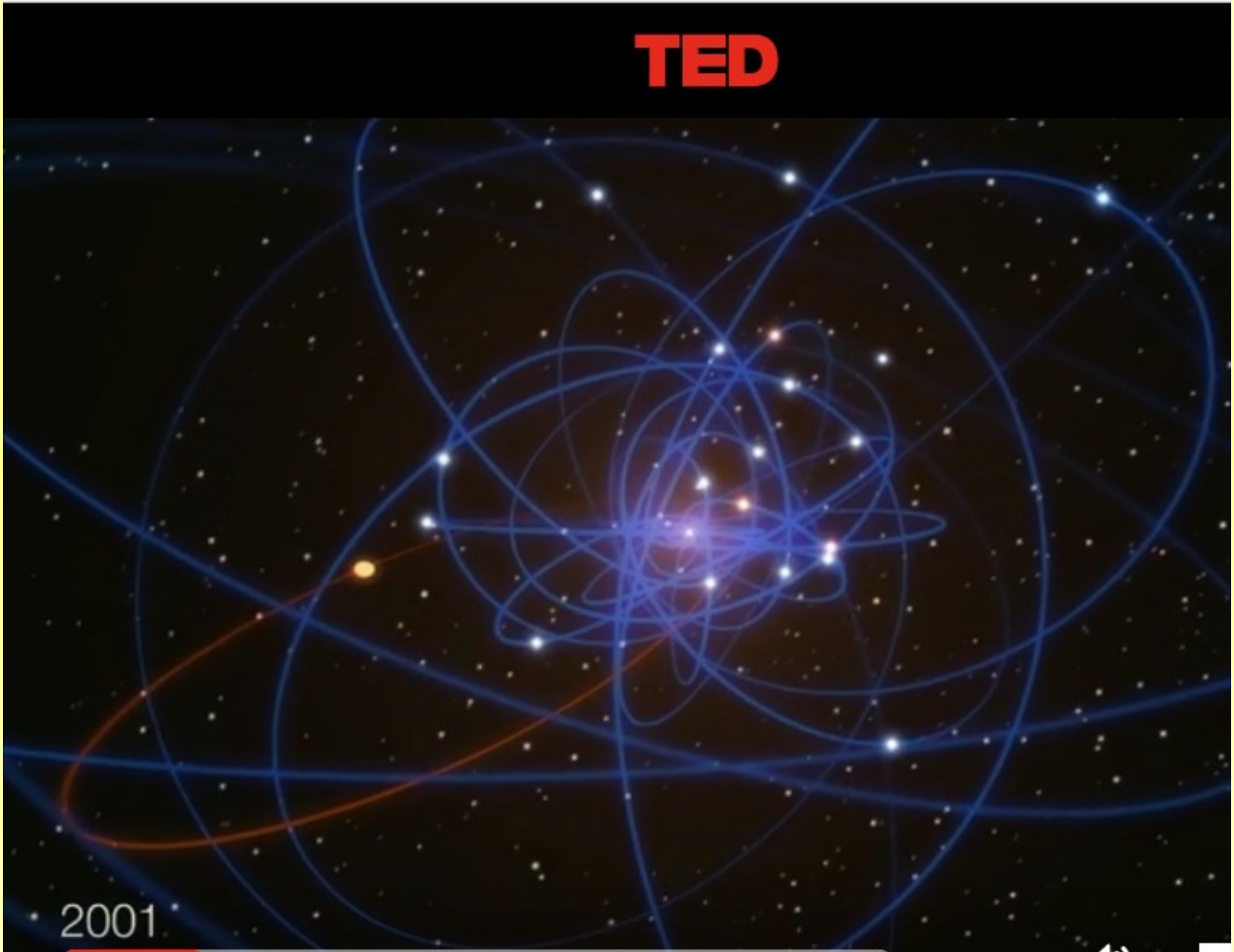
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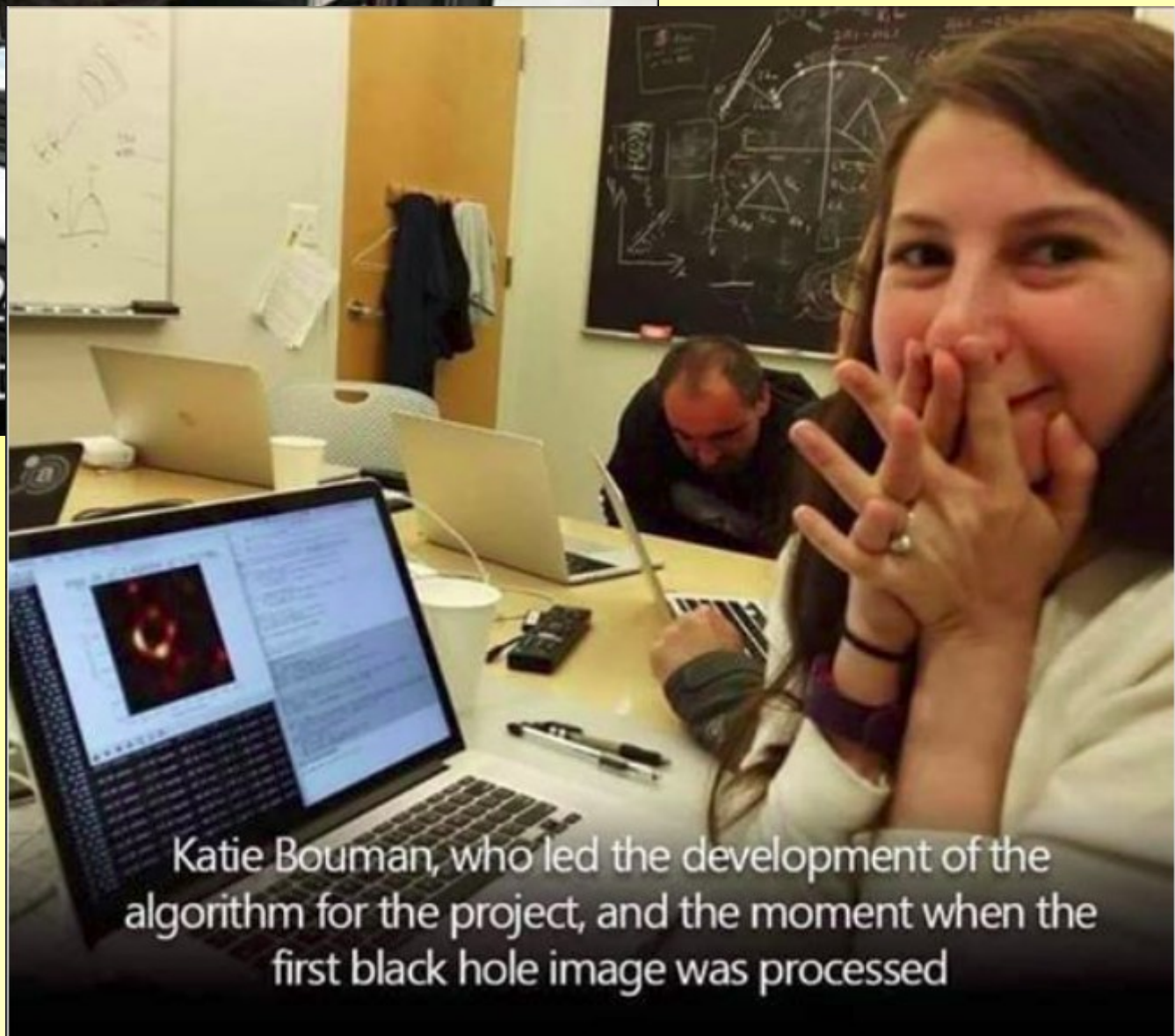
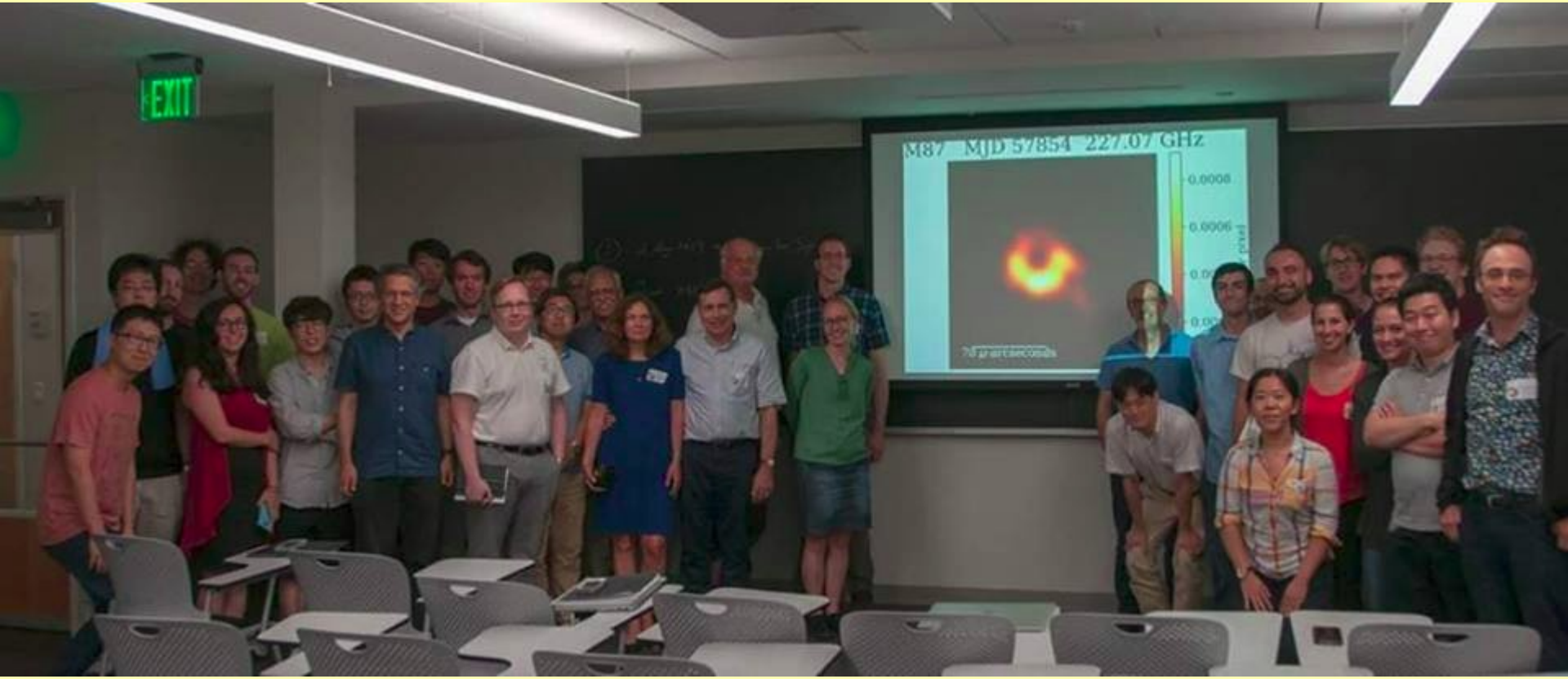

Katie Bouman, who led the development of the algorithm for the project, and the moment when the first black hole image was processed



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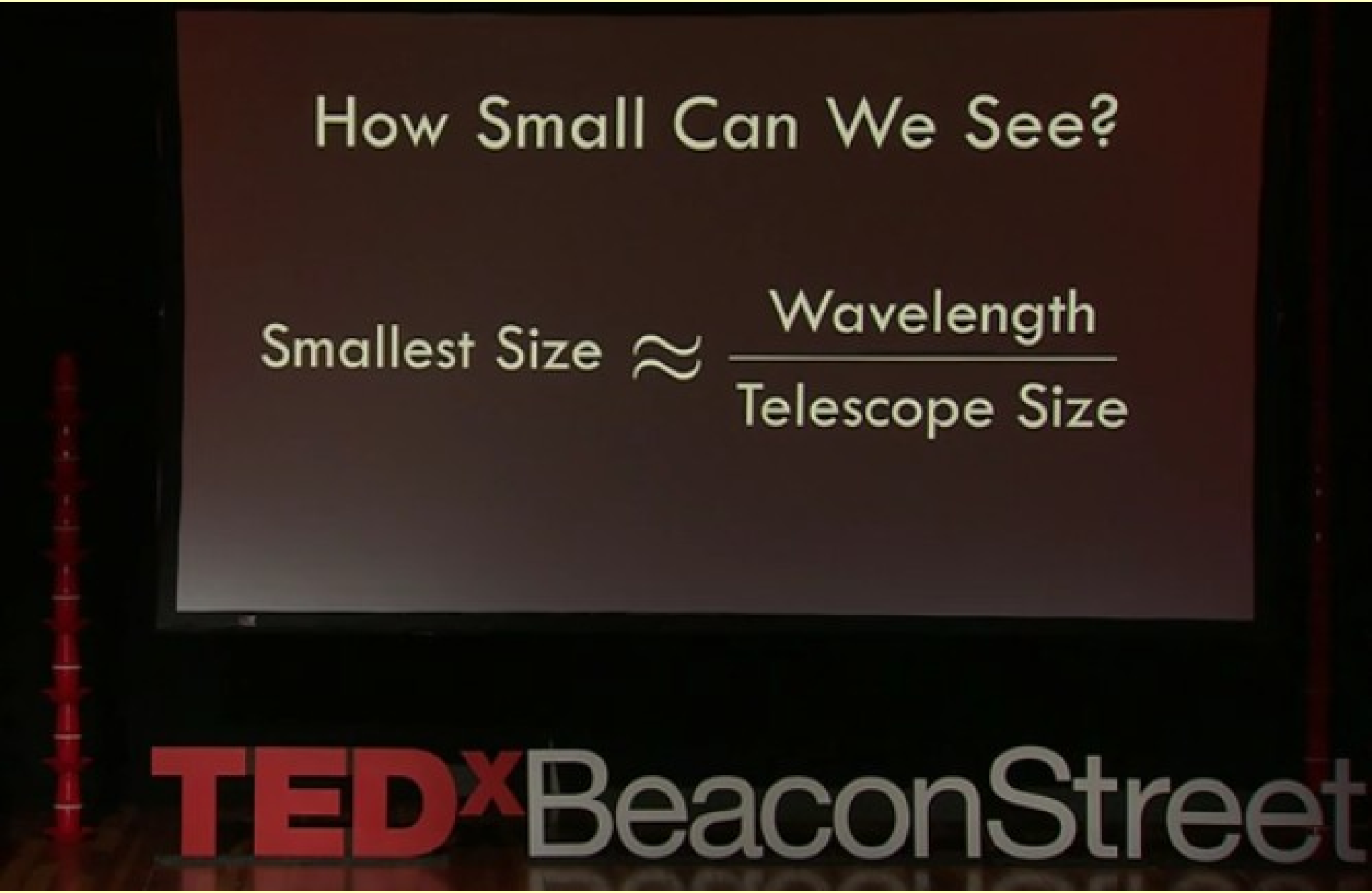

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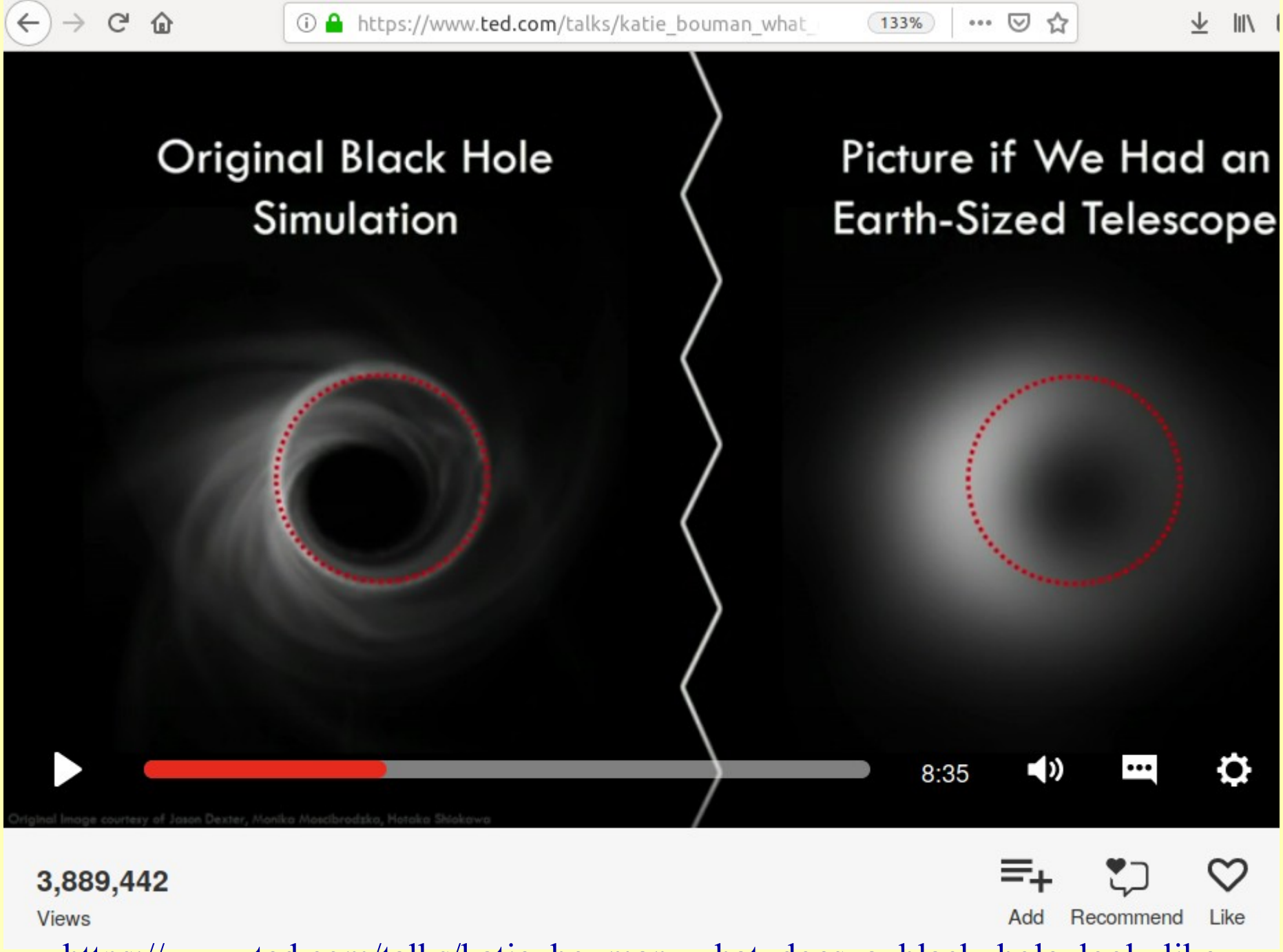

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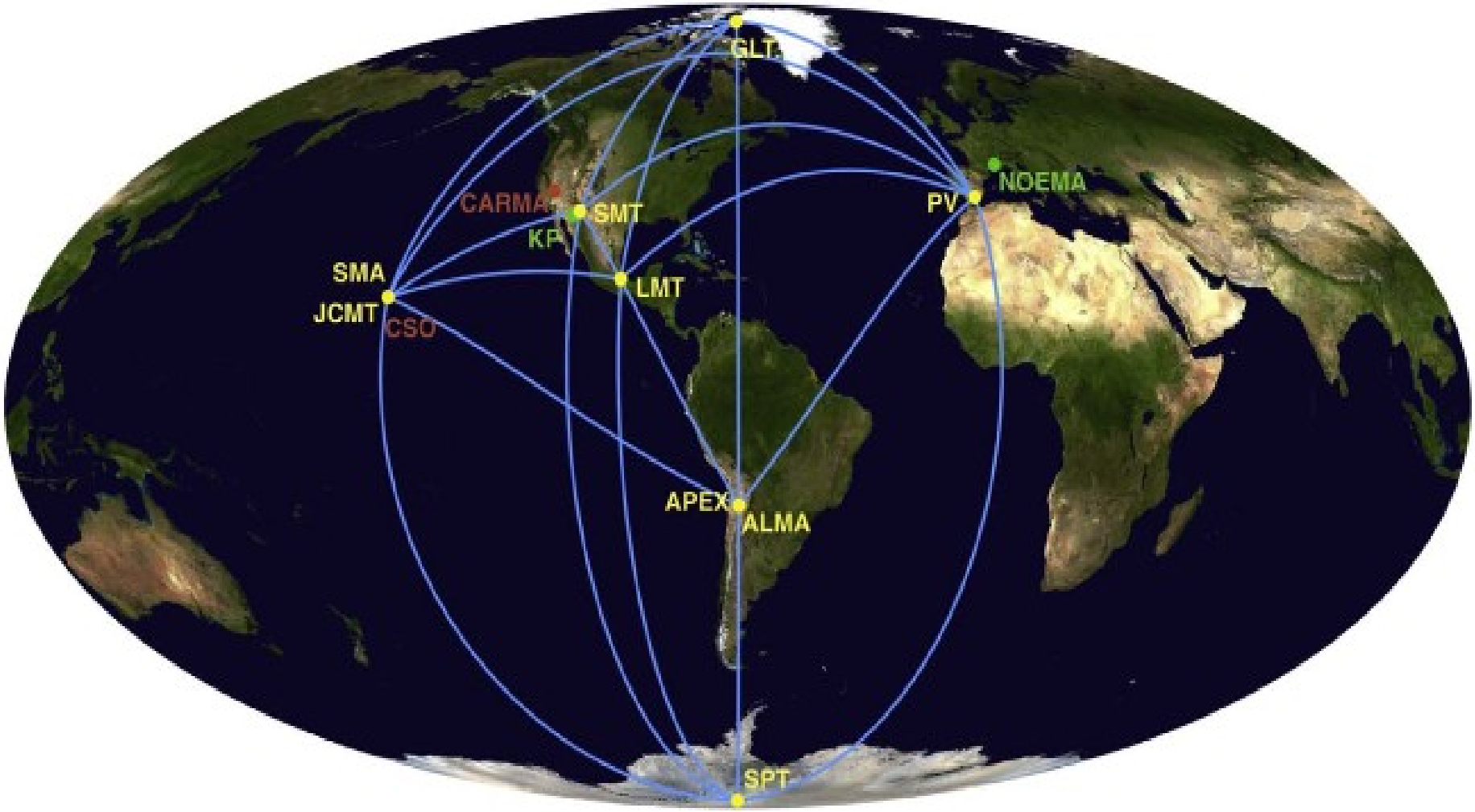
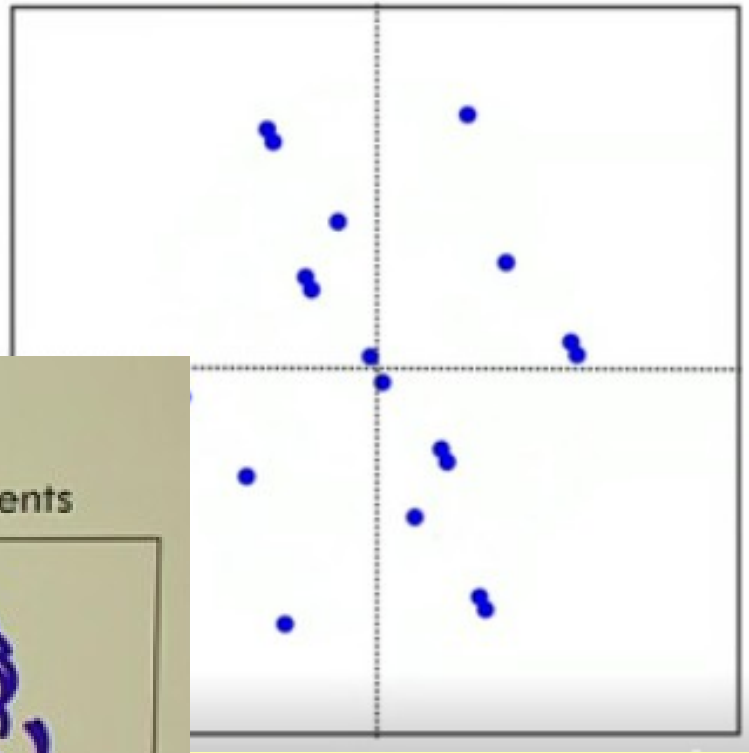


Figure 1. Eight stations of the EHT 2017 campaign over six geographic locations as viewed from the equatorial plane. Solid baselines represent mutual visibility on M87* (+12° declination). The dashed baselines were used for the calibration source 3C279 (see Papers III and IV).

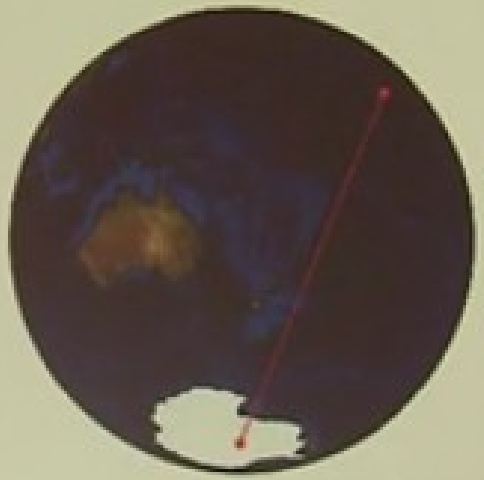
https://iopscience-event-horizon.s3.amazonaws.com/article/10.3847/2041-8213/ab0c96/The_Event_Horizon_Telescope_Collaboration_2019_ApJL_875_L2.pdf

The Event Horizon Telescope

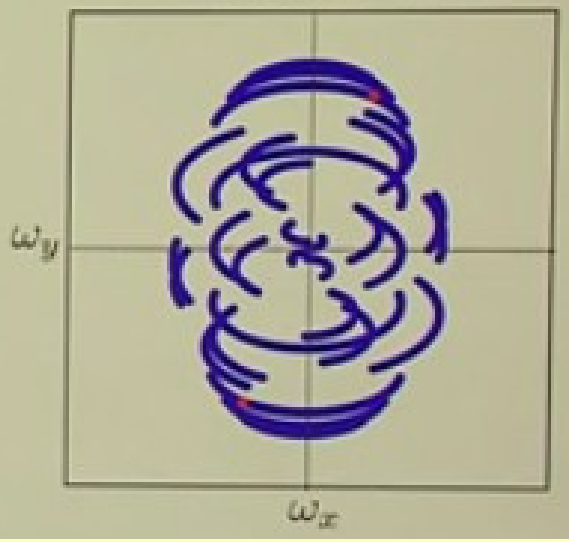
Measurements



The Event Horizon Telescope



Measurements



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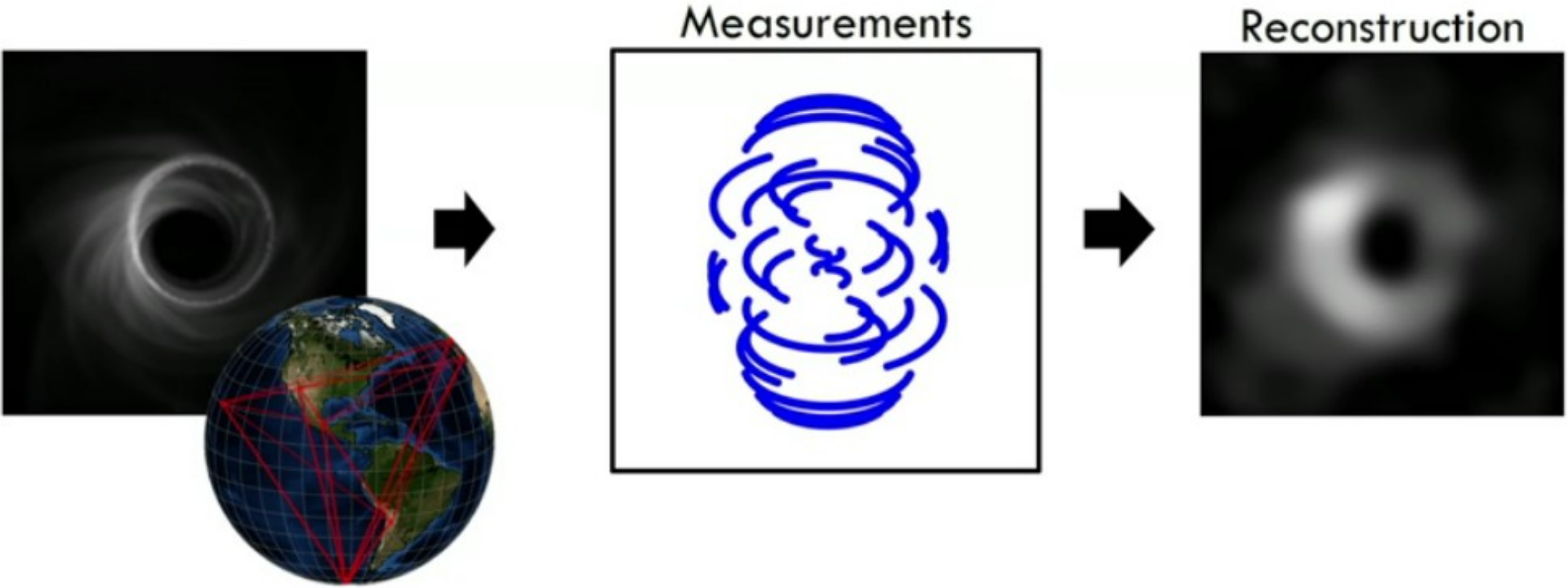
Black Hole in the Center of the Milky Way Galaxy



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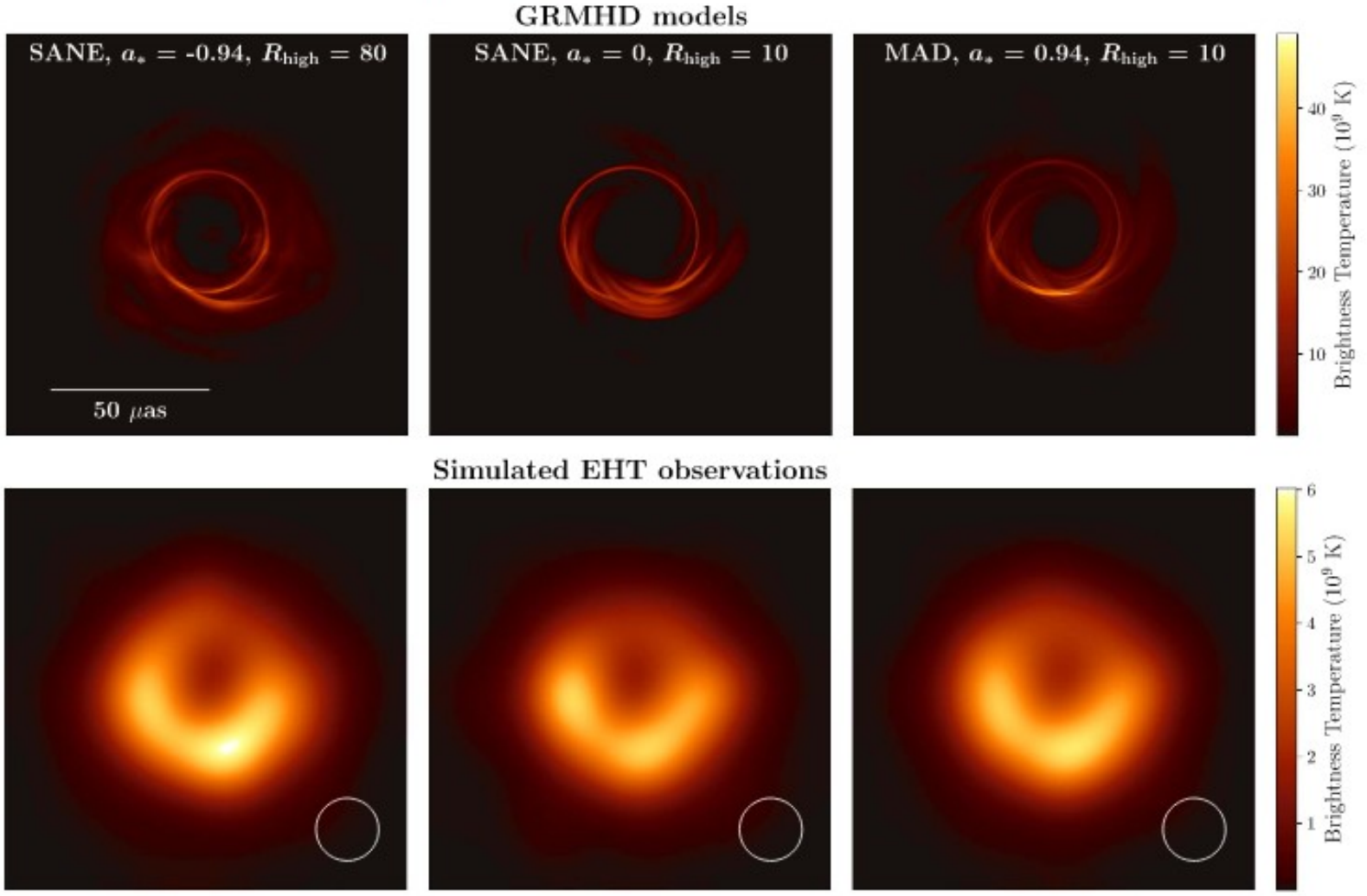
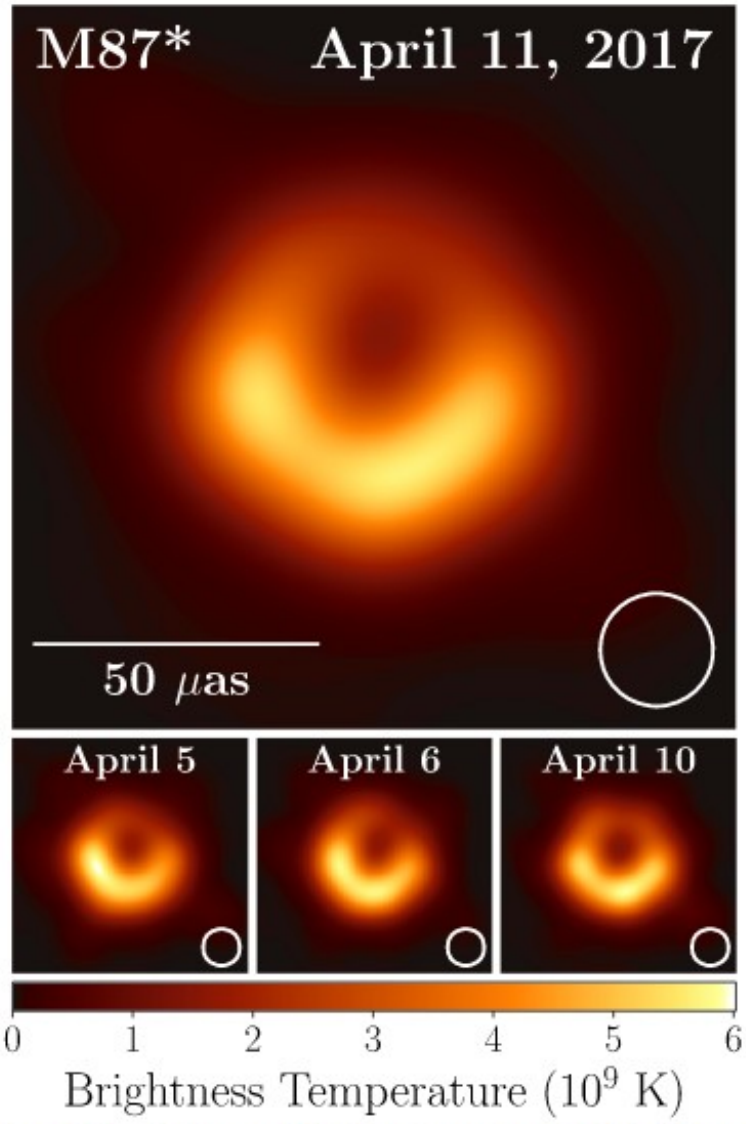


Figure 4. Top: three example models of some of the best-fitting snapshots from the image library of GRMHD simulations for April 11 corresponding to different spin parameters and accretion flows. Bottom: the same theoretical models, processed through a VLBI simulation pipeline with the same schedule, telescope characteristics, and weather parameters as in the April 11 run and imaged in the same way as Figure 3. Note that although the fit to the observations is equally good in the three cases, they refer to radically different physical scenarios; this highlights that a single good fit does not imply that a model is preferred over others (see Paper V).

https://iopscience-event-horizon.s3.amazonaws.com/article/10.3847/2041-8213/ab0ec7/The_Event_Horizon_Telescope_Collaboration_2019_ApJL_875_L1.pdf



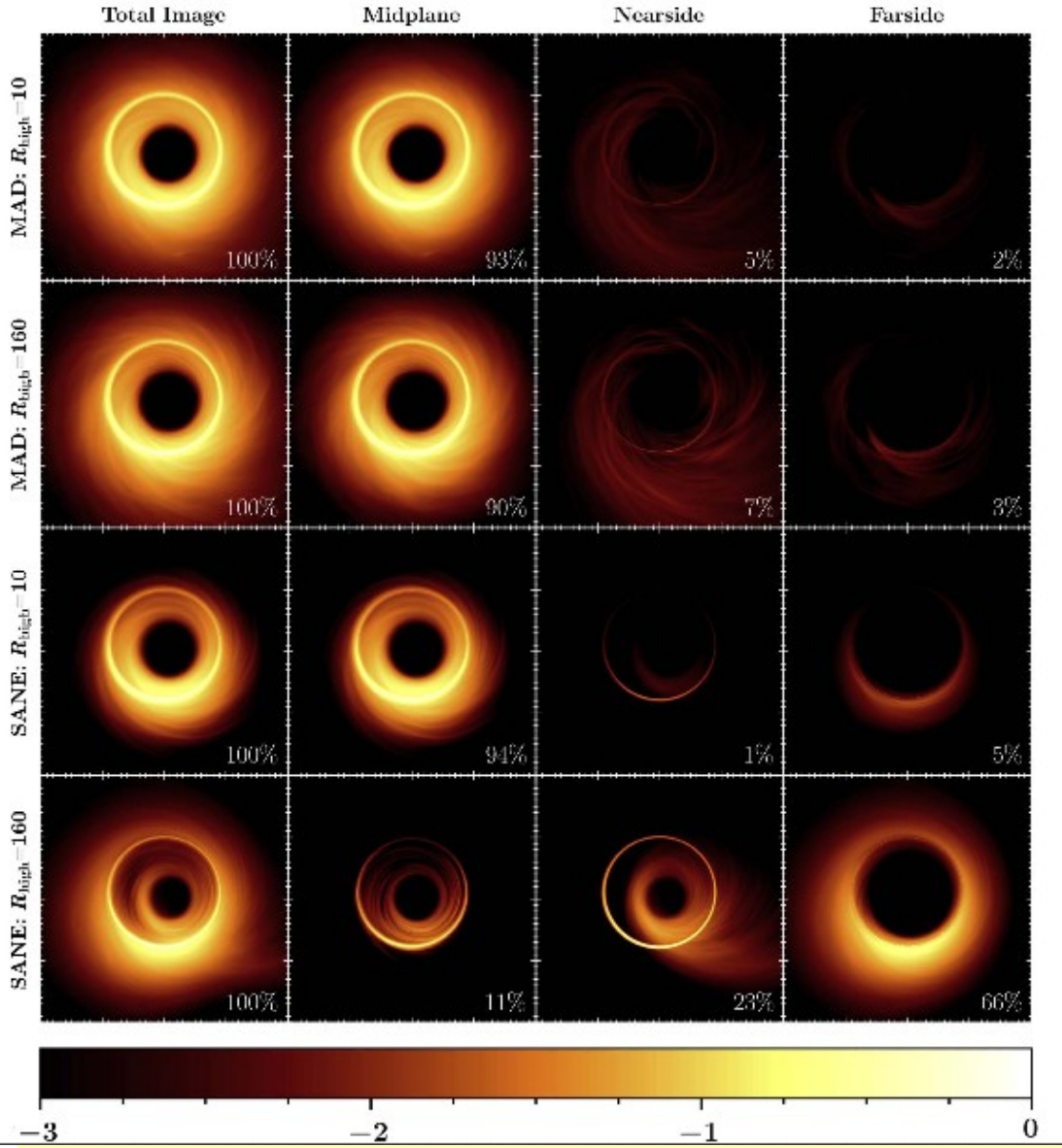


Figure 3. Top: EHT image of M87* from observations on 2017 April 11 as a representative example of the images collected in the 2017 campaign. The

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7.НАУКОВИЙ ПІКНІК

ТЕМА: РУХ

Реєстрація команд та волонтерів: http://bit.ly/Ternopil2019

Міністерство молоді та спорту України

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ТНТ

Використані джерела