Title: Special Guest Talk - 'From nonlinear optics to high intensity laser physics'

Speakers: Donna Strickland

Collection: The Day of Discovery

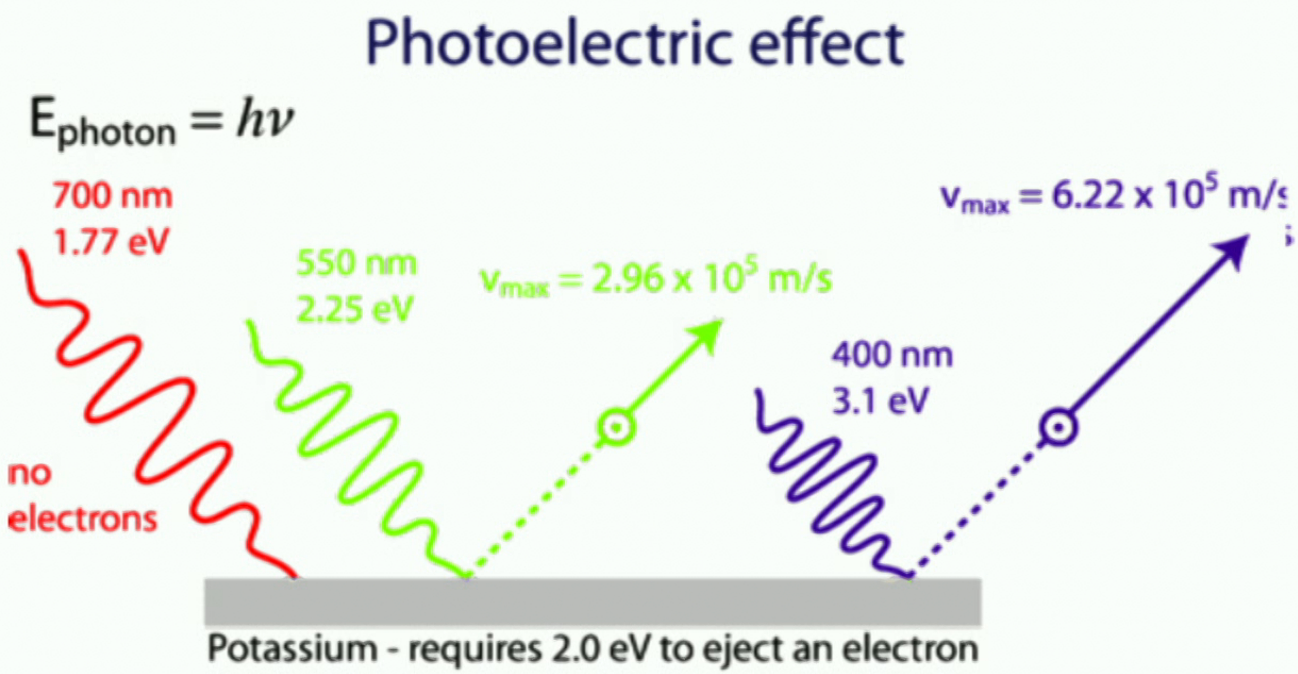
Date: October 20, 2022 - 4:10 PM

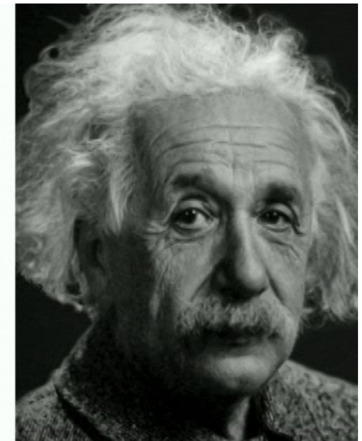
URL: https://pirsa.org/22100071

From Linear Optics to Nonlinear Optics to High Intensity Laser Physics

Donna Strickland

PHOTOELECTRIC EFFECT – linear optics

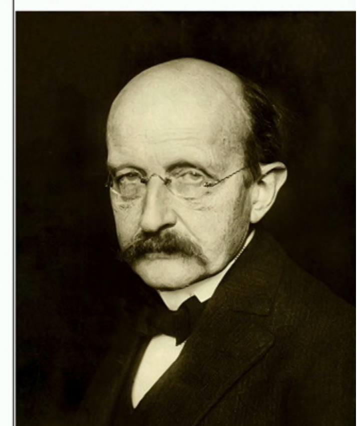




ALBERT EINSTEIN

Photo courtesy AFP

1905

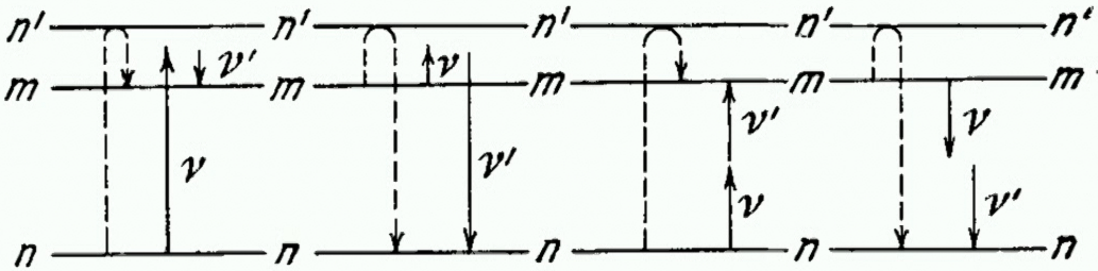


Max Planck

1900

CK-12 Foundation

MULTIPHOTON PHYSICS

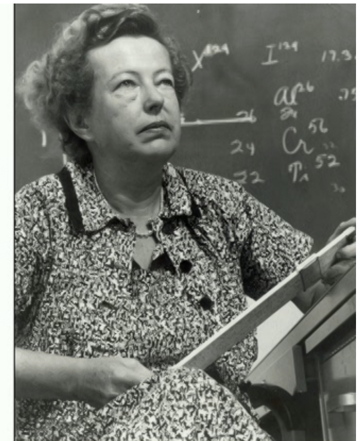


Die punktierten Linien bedeuten das Verhalten des Atoms, aufwärts-gerichtete Pfeile absorbierte, abwärtsgerichtete emittierte Lichtquanten

Figg. 1—4

The dotted lines indicate the behavior of the atoms, upward-directed arrows absorbed, down-facing emitted quantum of light

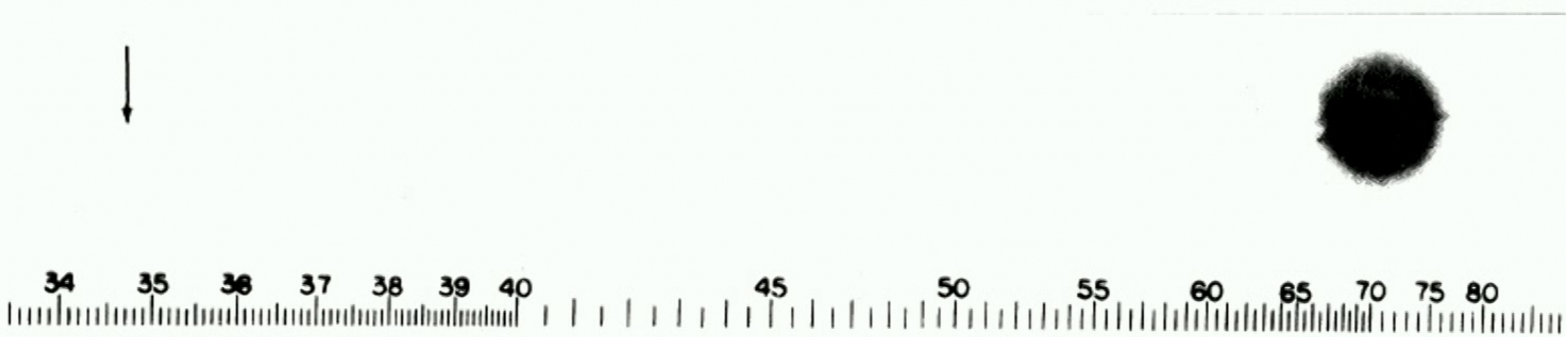
Göppert-Mayer, M. (1931), Über Elementarakte mit zwei Quantensprüngen. Ann. Phys., 401: 273-294. doi:10.1002/andp.19314010303



MARIA GOEPPERT MAYER

1931

NONLINEAR OPTICAL INTERACTION



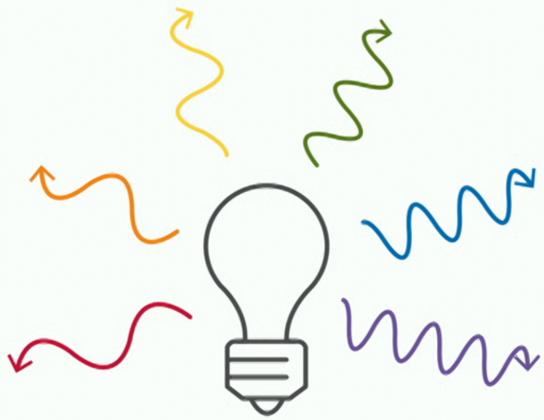
P.A. Franken, A. E. Hill, C.W Peters and G. Weinreich, PRL 7, 118 (1961)

PETER A. FRANKEN

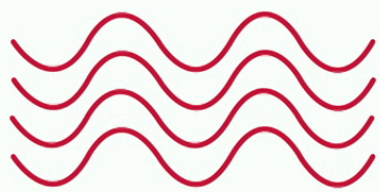
1961

LASER DEMONSTRATION

LIGHT BULB

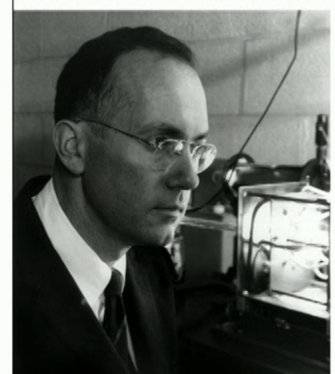


LASER



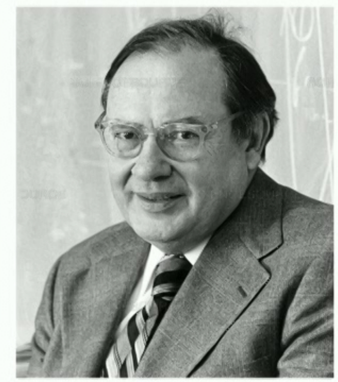
NICOLAY G. BASOV

ALEKSANDR M. PROKHOROV



CHARLES H. TOWNES

Credit: From the Caltech Archives image collection

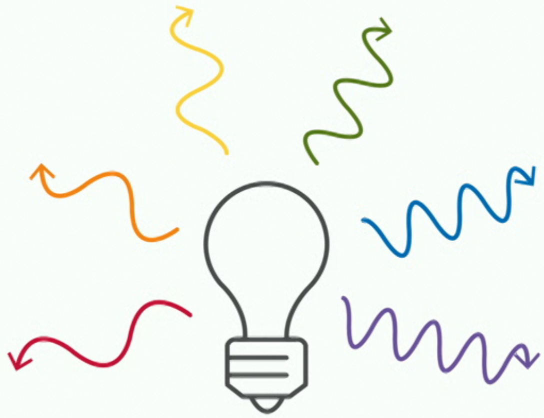


ARTHUR L. SCHAWLOW

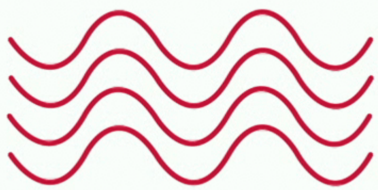
Credit: Emilio Segrè Visual Archives/American Institute of Physics/Science Source

LASER DEMONSTRATION

LIGHT BULB



LASER

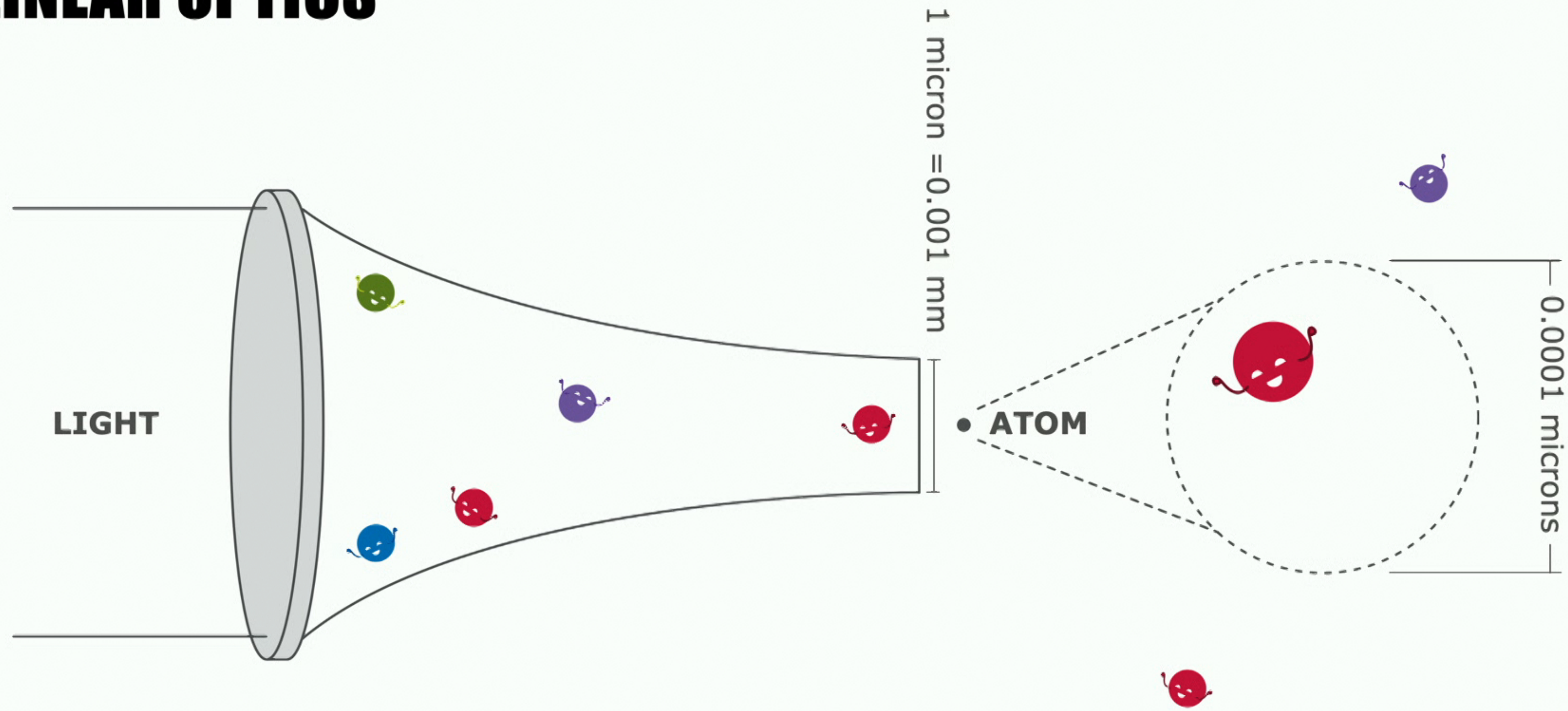


THEODORE H. MAIMAN

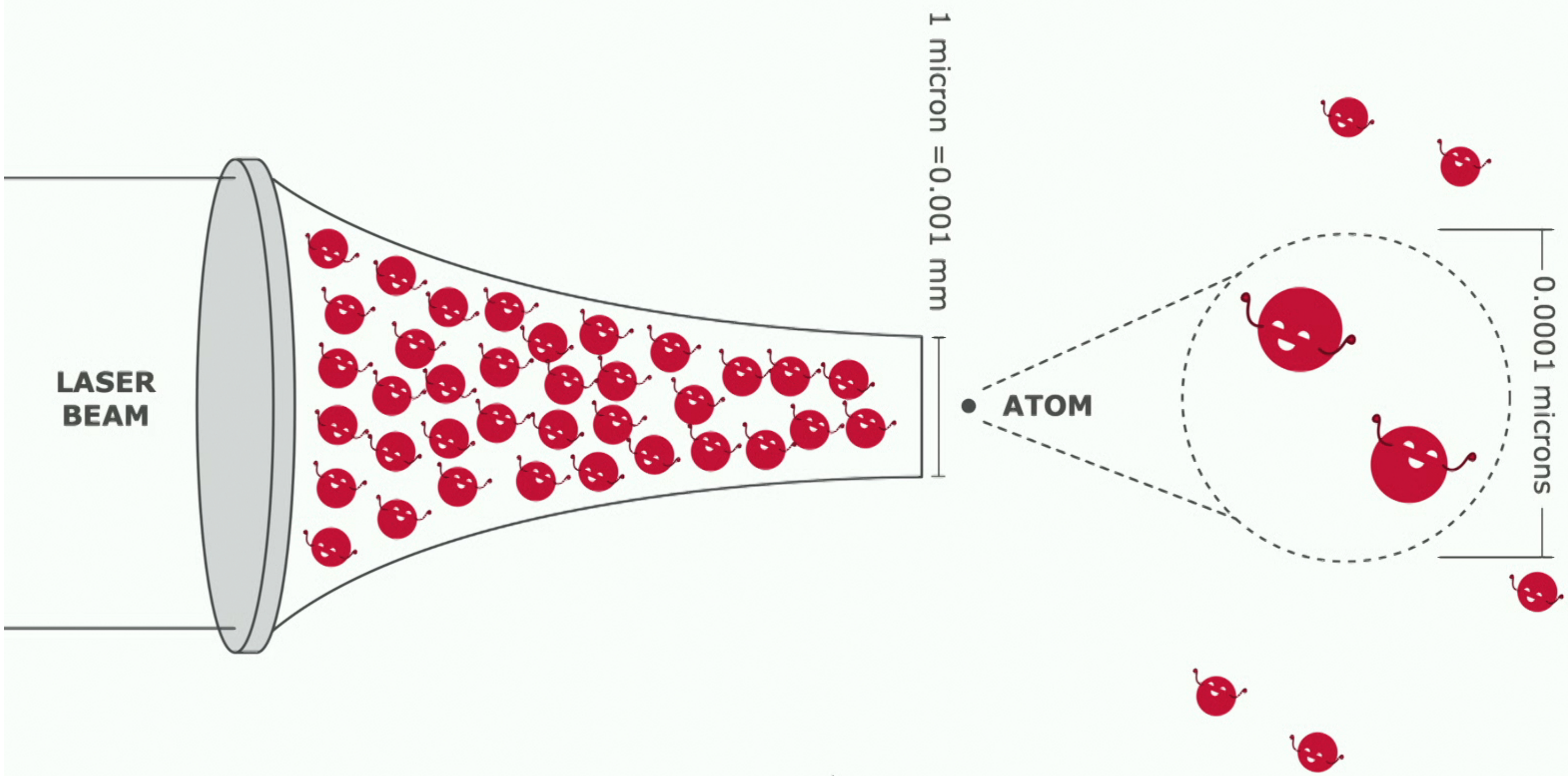
Credit: American Institute of Physics

1960

LINEAR OPTICS



LASER MADE NONLINEAR OPTICS POSSIBLE



NICOLAAS BLOEMBERGEN

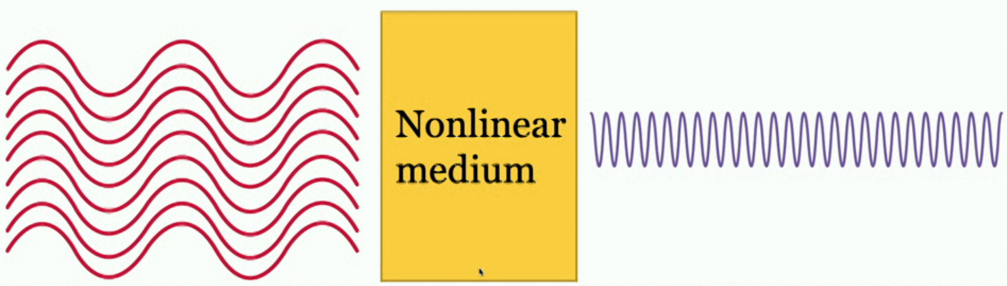
Credit: Emilio Segrè Visual Archives/American Institute of Physics/Science Photo Library

HIGH ORDER HARMONIC GENERATION

TABLE I. Conversion efficiency and limiting power density for some higher-order nonlinear processes.

Process	Species and path	Limiting P/A (W/cm^2)	Conversion efficiency (%)
$3\times 5320\,\text{Å} \rightarrow 1773\,\text{Å}$	Xe[a], $5p$–$6s$–$5p$–$6s$–$6p$–$8d$–c	1.94×10^{12}	0.084
$5\times 5320\,\text{Å} \rightarrow 1064\,\text{Å}$	As above	As above	0.051
$5\times 1182\,\text{Å} \rightarrow 236\,\text{Å}$	Li^{+}[b], $1s$–$2p$–$1s$–$2p$–$3s$–$2p$–$3s$–$4p$–c	1.68×10^{15}	0.002
$7\times 1182\,\text{Å} \rightarrow 169\,\text{Å}$	As above	As above	0.004
$15\times 2660\,\text{Å} \rightarrow 177\,\text{Å}$	Li^{+}[c], $(1s$–$2p)^7$–$(2p$–$3s)^7$–$3p$–$4d$–c	3.47×10^{15}	4×10^{-7}

[a] $5p=5p^6[^1S]0$; $6s=6s[1\frac{1}{2}]^0 1$; $6p=6p[2\frac{1}{2}]2$; $8d=8d[2\frac{1}{2}]^0 3$; c = continuum.
[b] $1s=1s^2[^1S]0$; $2p=2p[^1P^0]1$; $3s=3s[^1S]0$; $4p=4p[^1P^0]1$; c = continuum.
[c] $3p=3p[^1P^0]1$, others as in b.



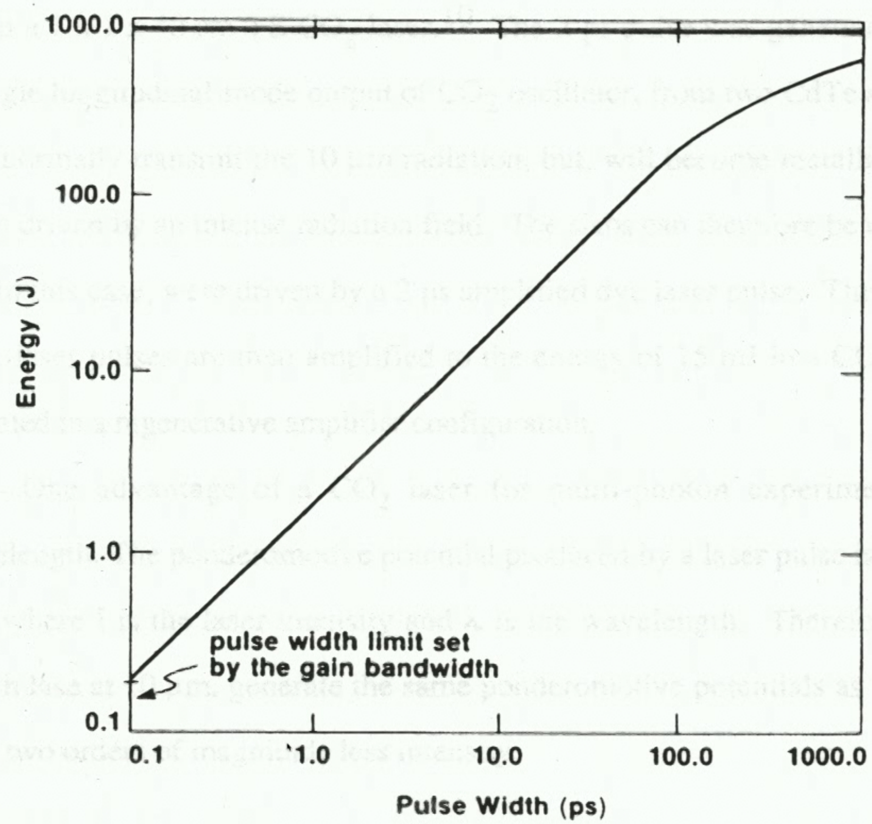
"Generation of Vacuum-Ultraviolet and Soft–X-Ray Radiation Using High-Order Nonlinear Optical Polarizabilities" S.E. Harris, Phys. Rev. Lett. **31**, 341 (1973)

STEPHEN E. HARRIS

Credit: Ed Souza/Stanford News Service

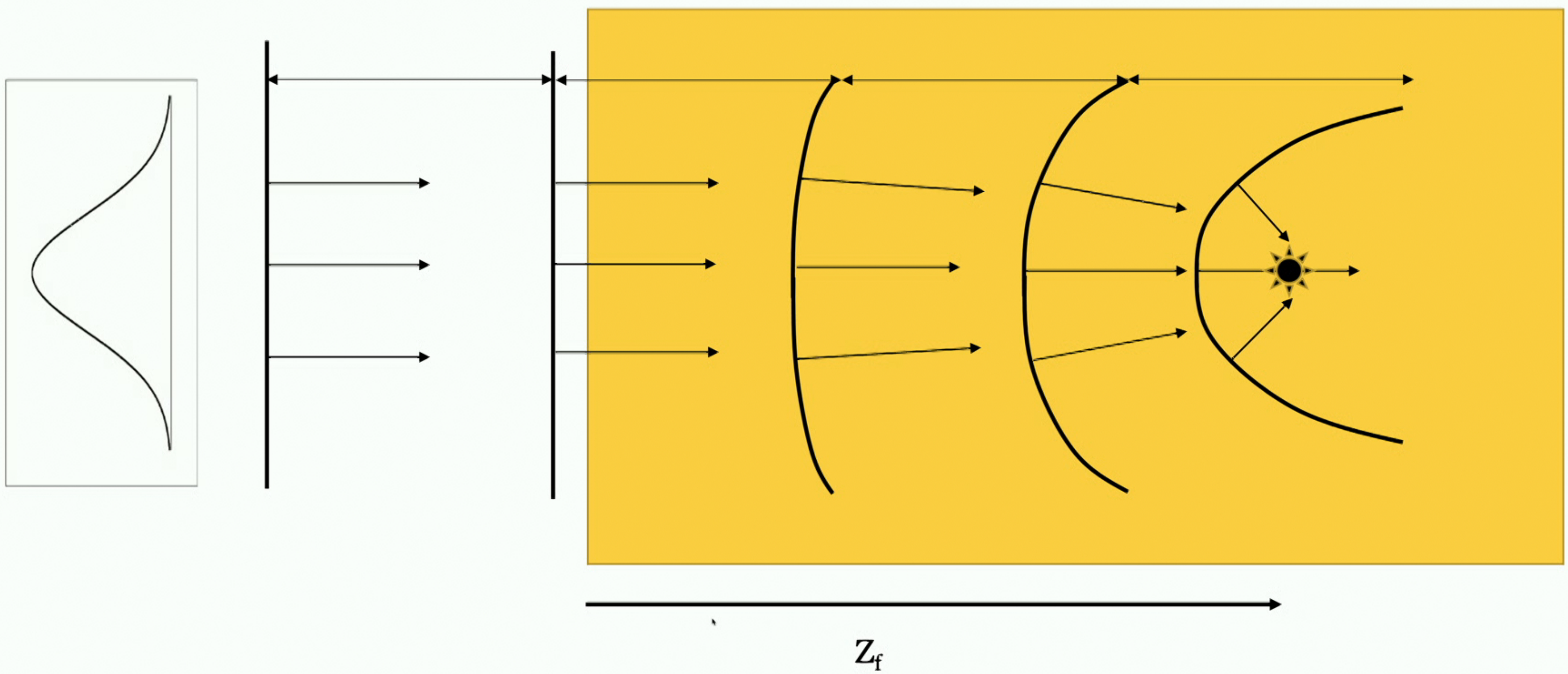

OMEGA LASER

PULSE WIDTH LIMITATION TO AMPLIFICATION



Self-focusing

$$n(r) = n_0 + \gamma I(r)$$



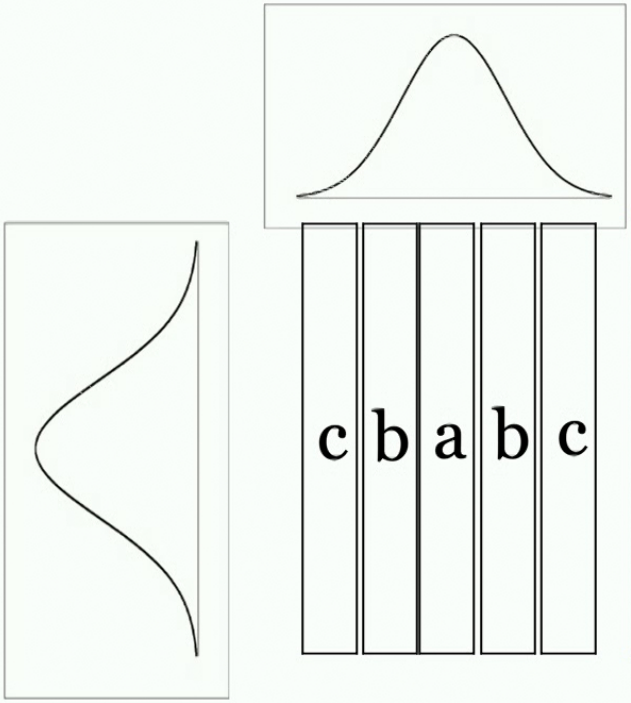
Moving Focus Model of Self-focusing

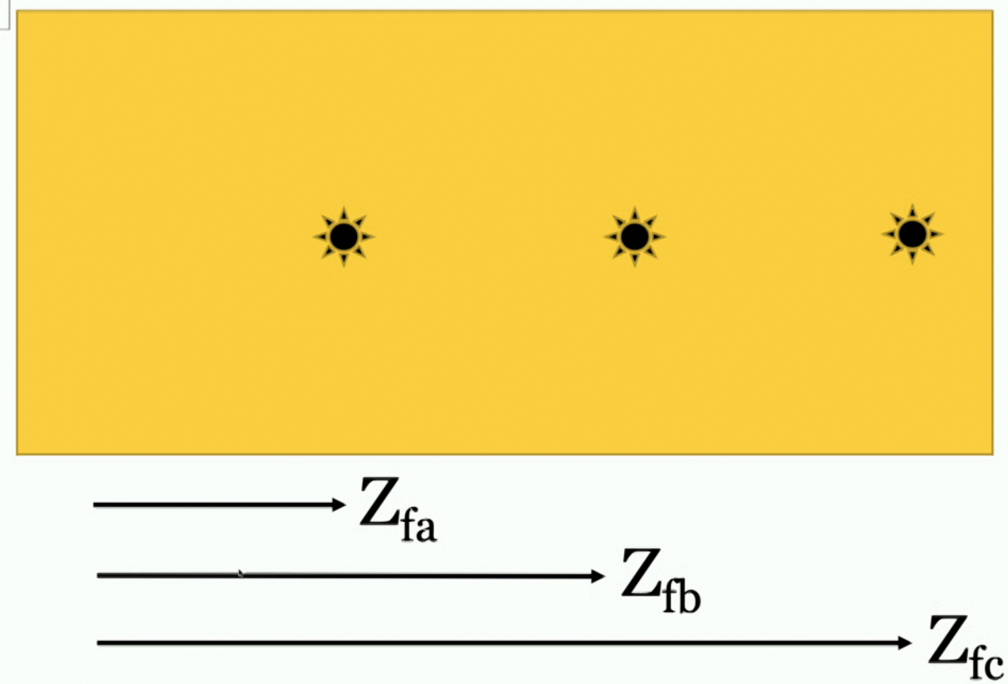
Michael
Ming-tak Loy

Yuen-Ron
Shen

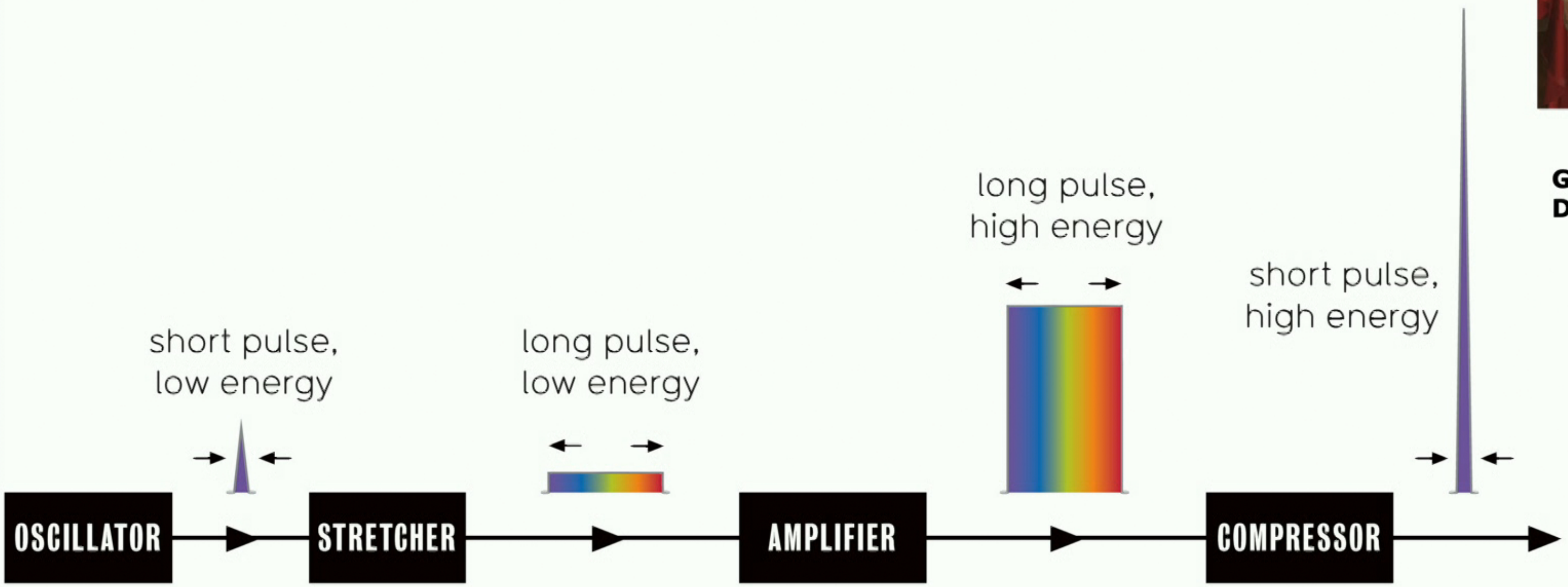
1973

$$n(r,t) = n_0 + \gamma I(r,t)$$

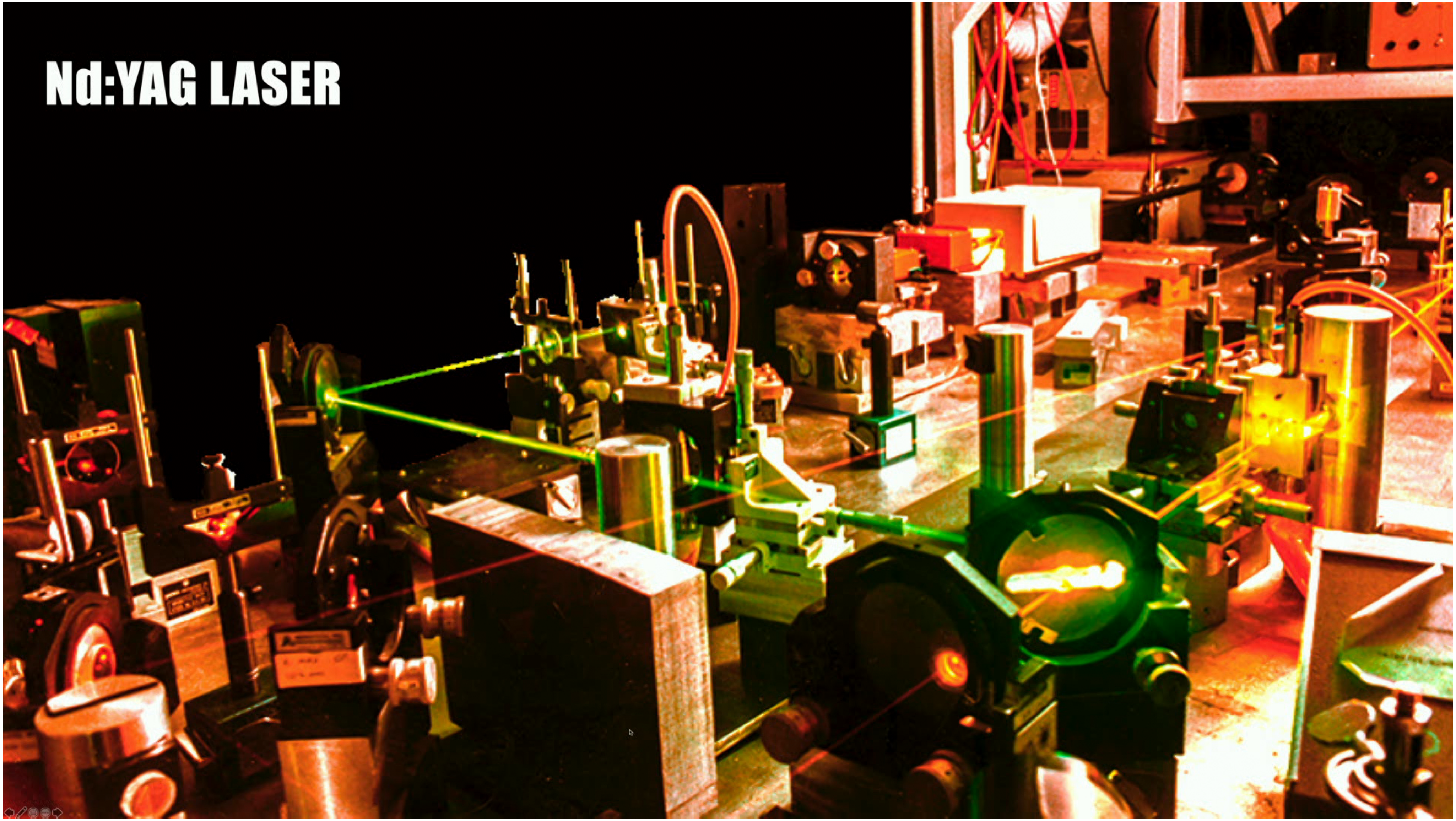


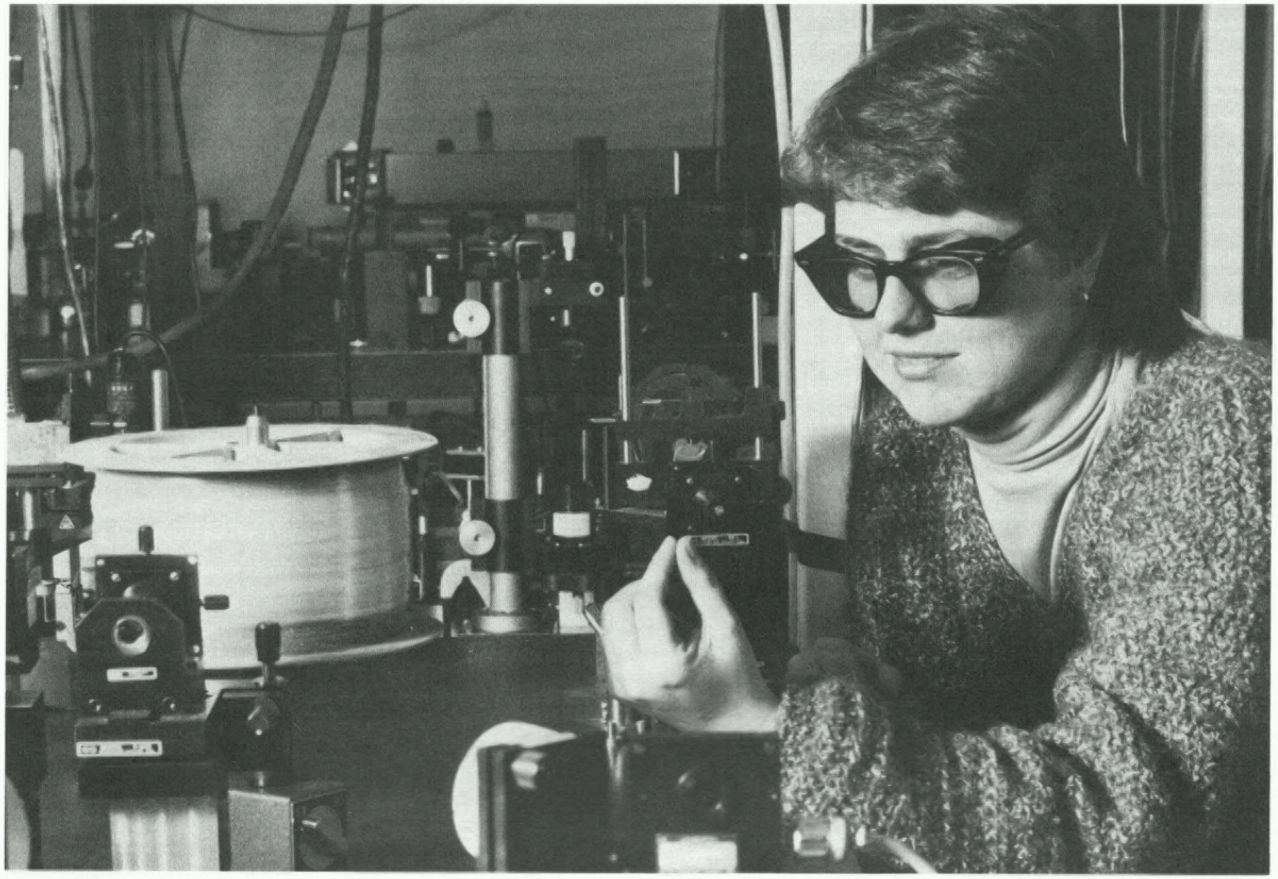


CHIRPED PULSE AMPLIFICATION (CPA)

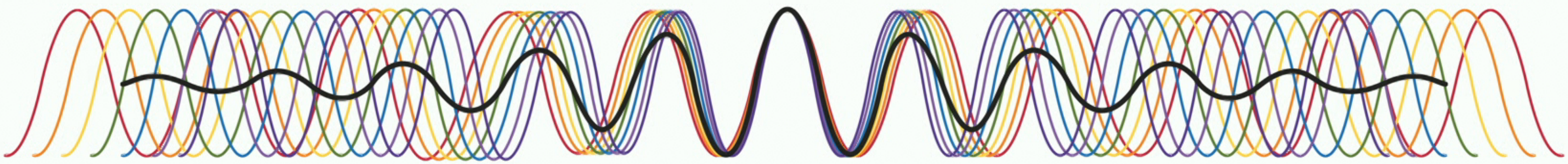


GÉRARD MOUROU AND DONNA STRICKLAND

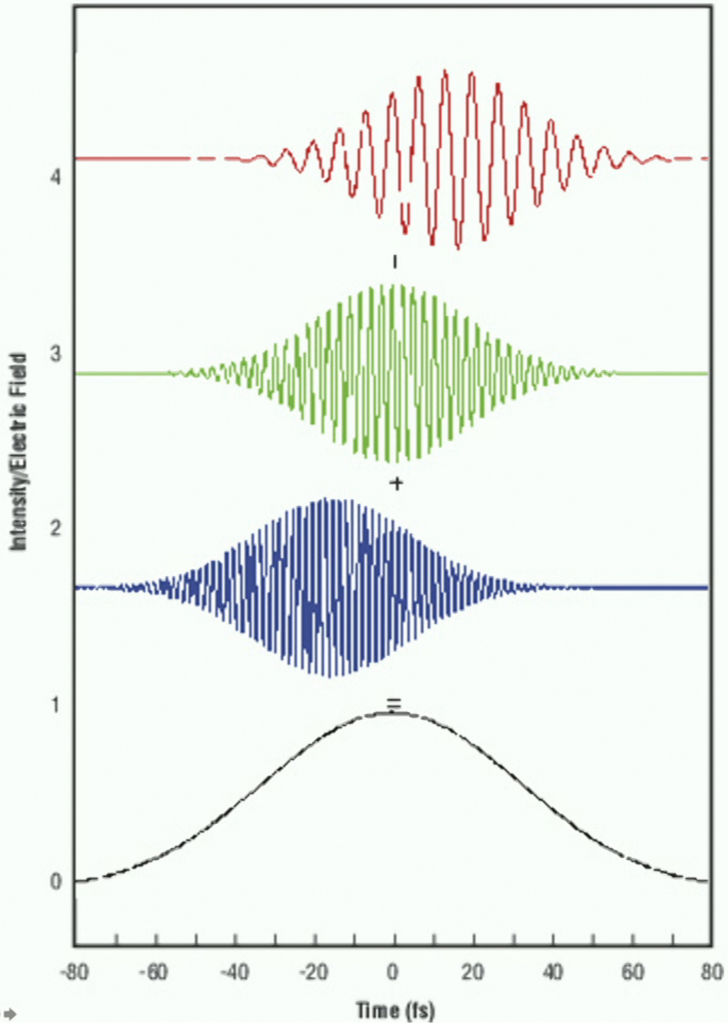

Nd:YAG LASER



YOU NEED A LOT OF COLOR TO MAKE A SHORT PULSE



SECOND ORDER DISPERSION – PULSE CHIRP



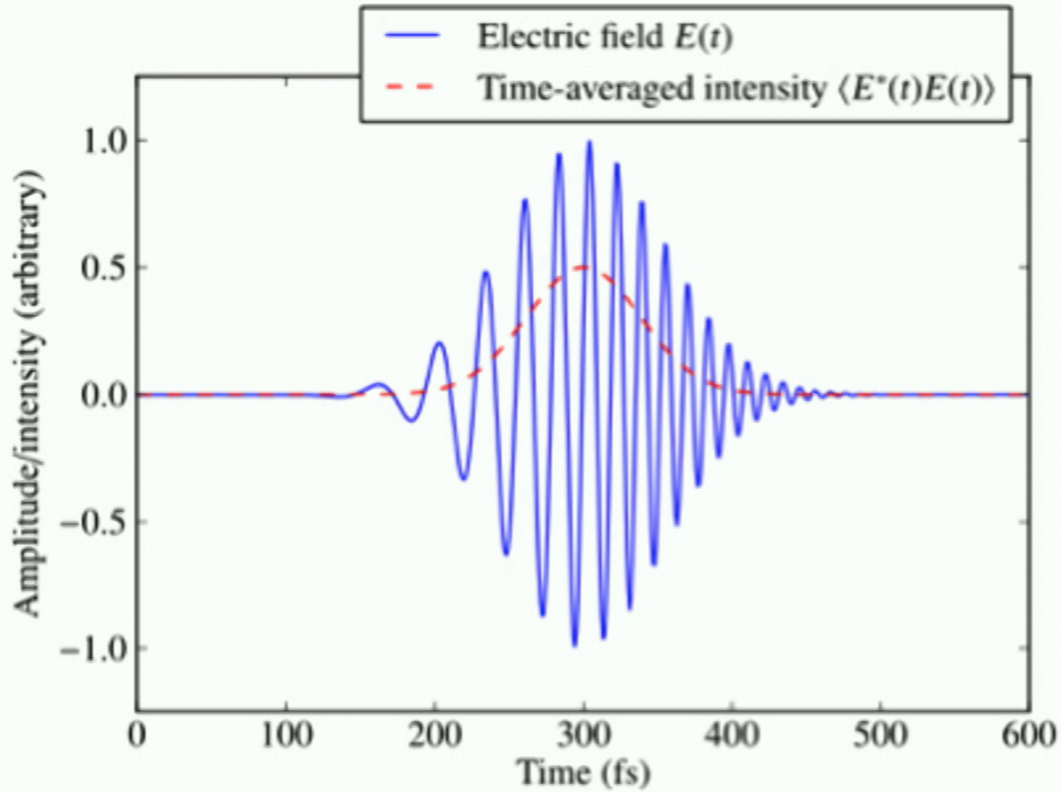
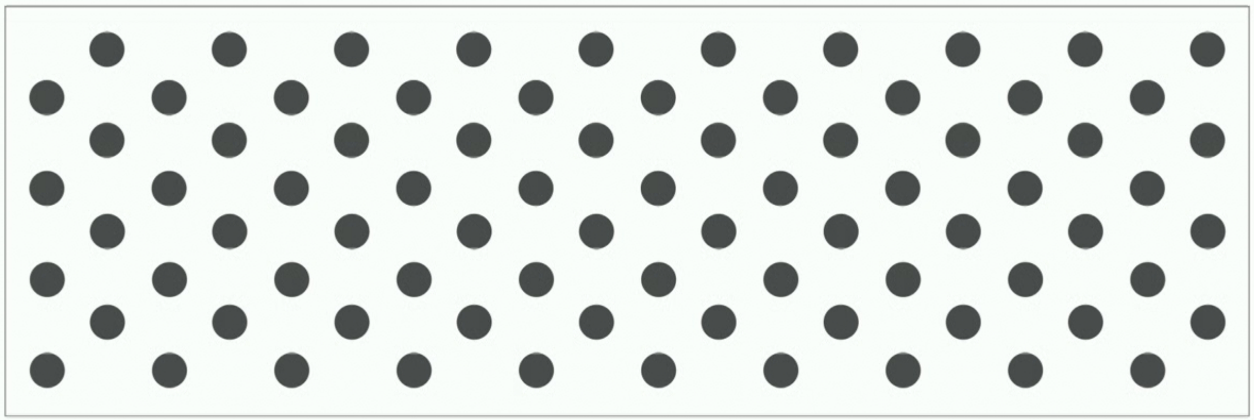
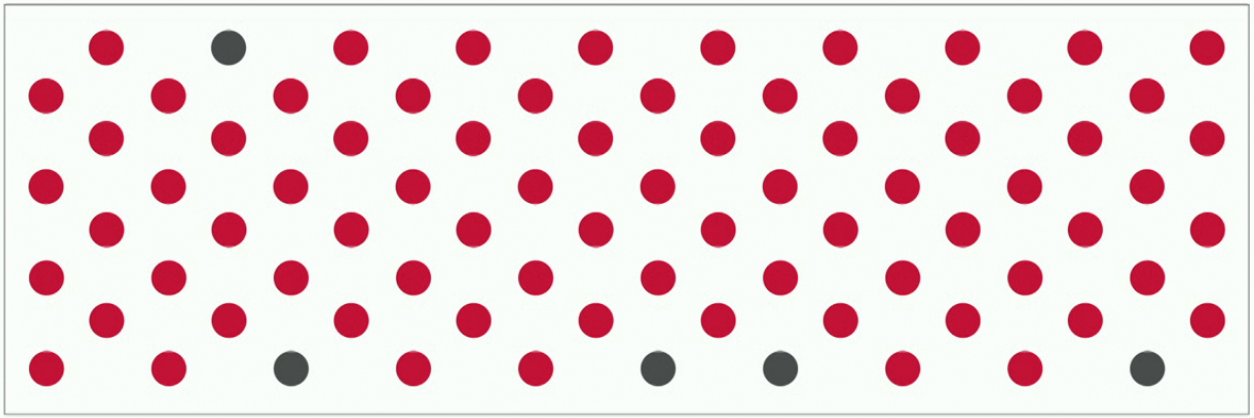


Figure 1. Ultrashort laser pulse. Source: Zueignung / CC BY-SA 3.0

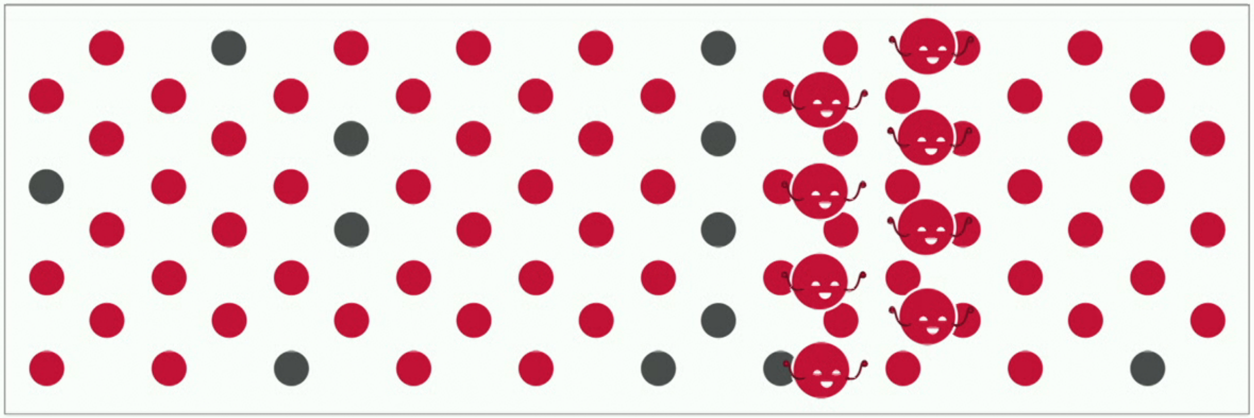
LASER AMPLIFICATION



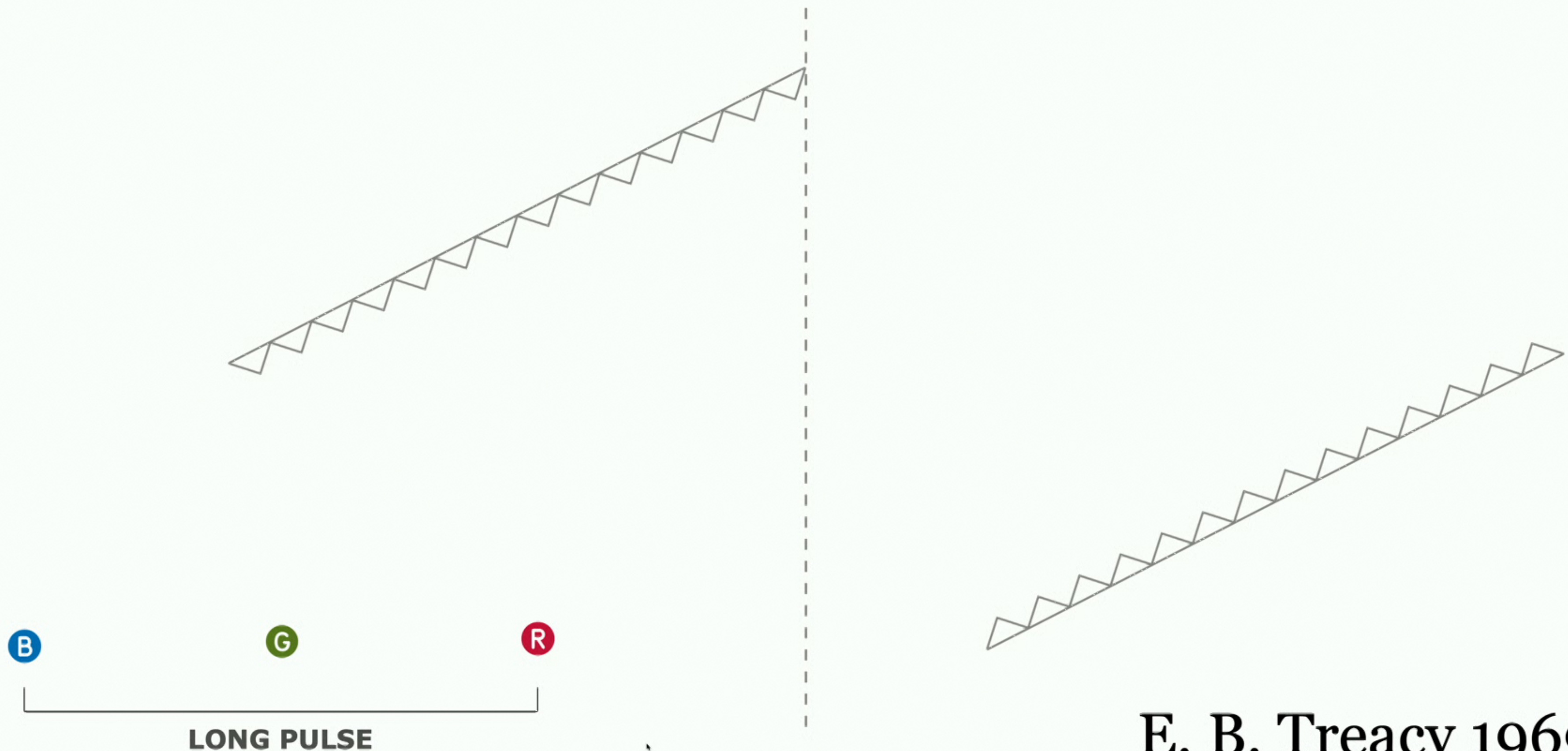
LASER AMPLIFICATION



LASER AMPLIFICATION

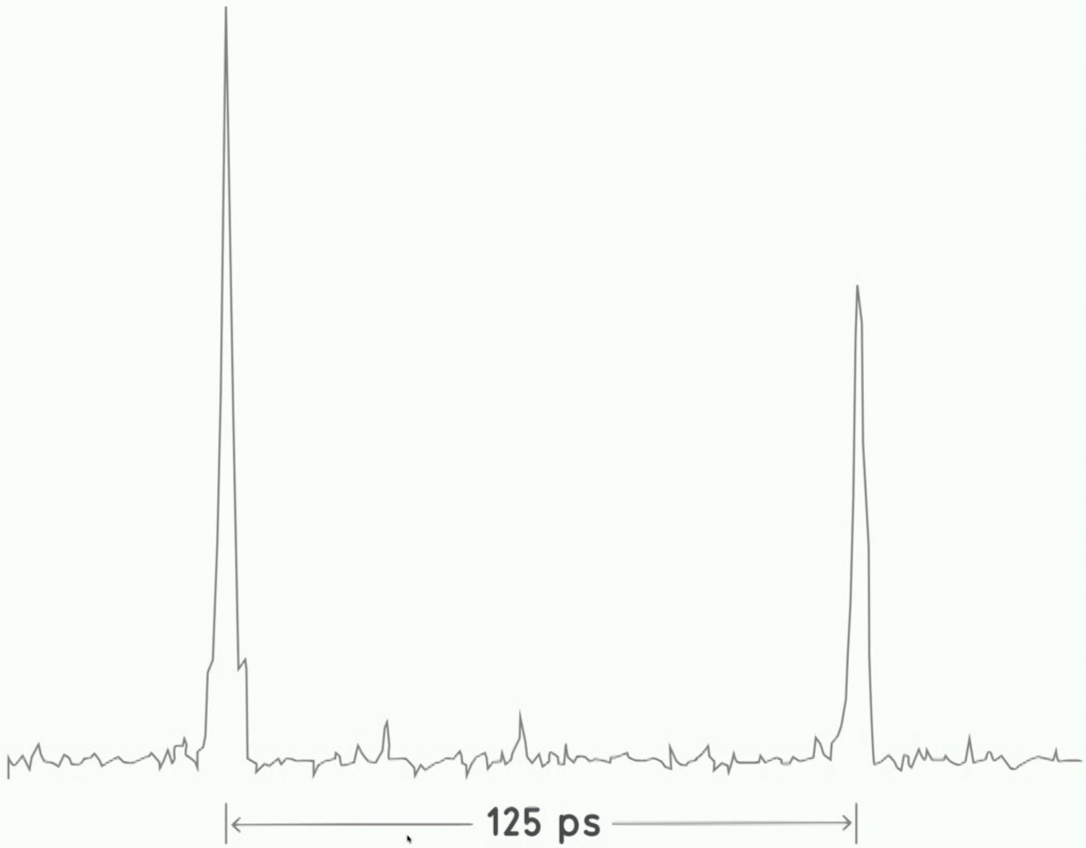


PULSE COMPRESSION

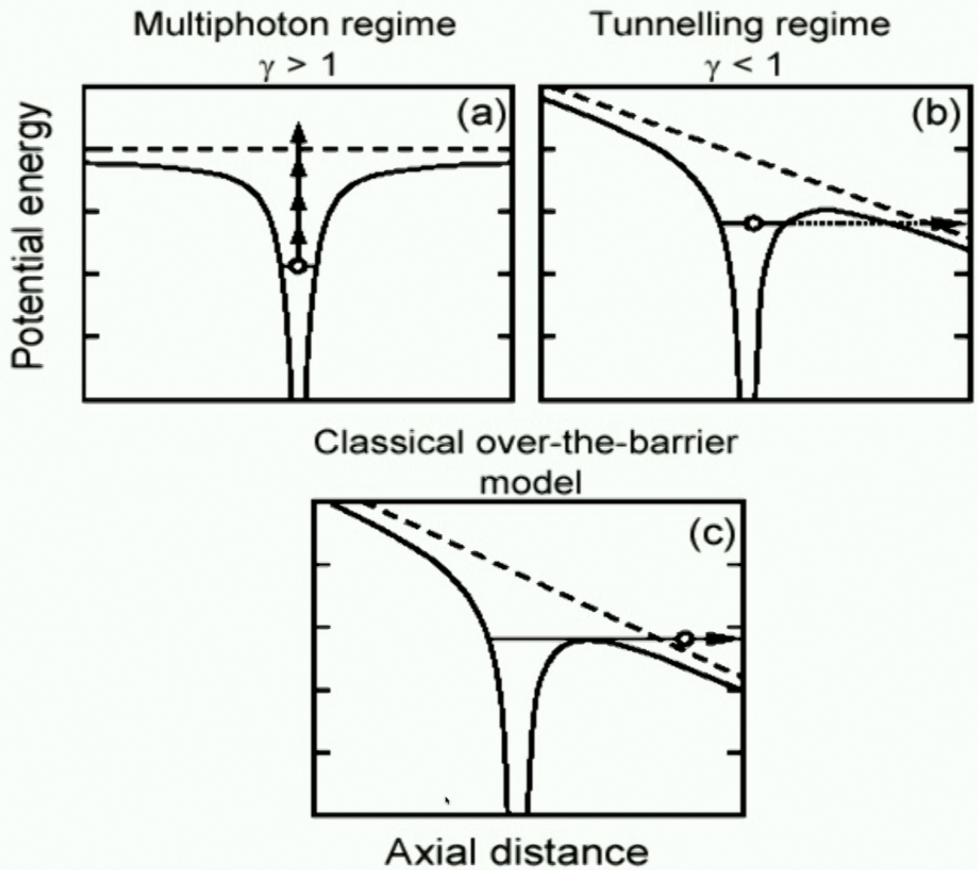


E. B. Treacy 1969

MEASUREMENT SHOWING CPA WORKED



MULTIPHOTON IONIZATION VERSUS TUNNEL IONIZATION



ULTRA-HIGH INTENSITY ROADMAP