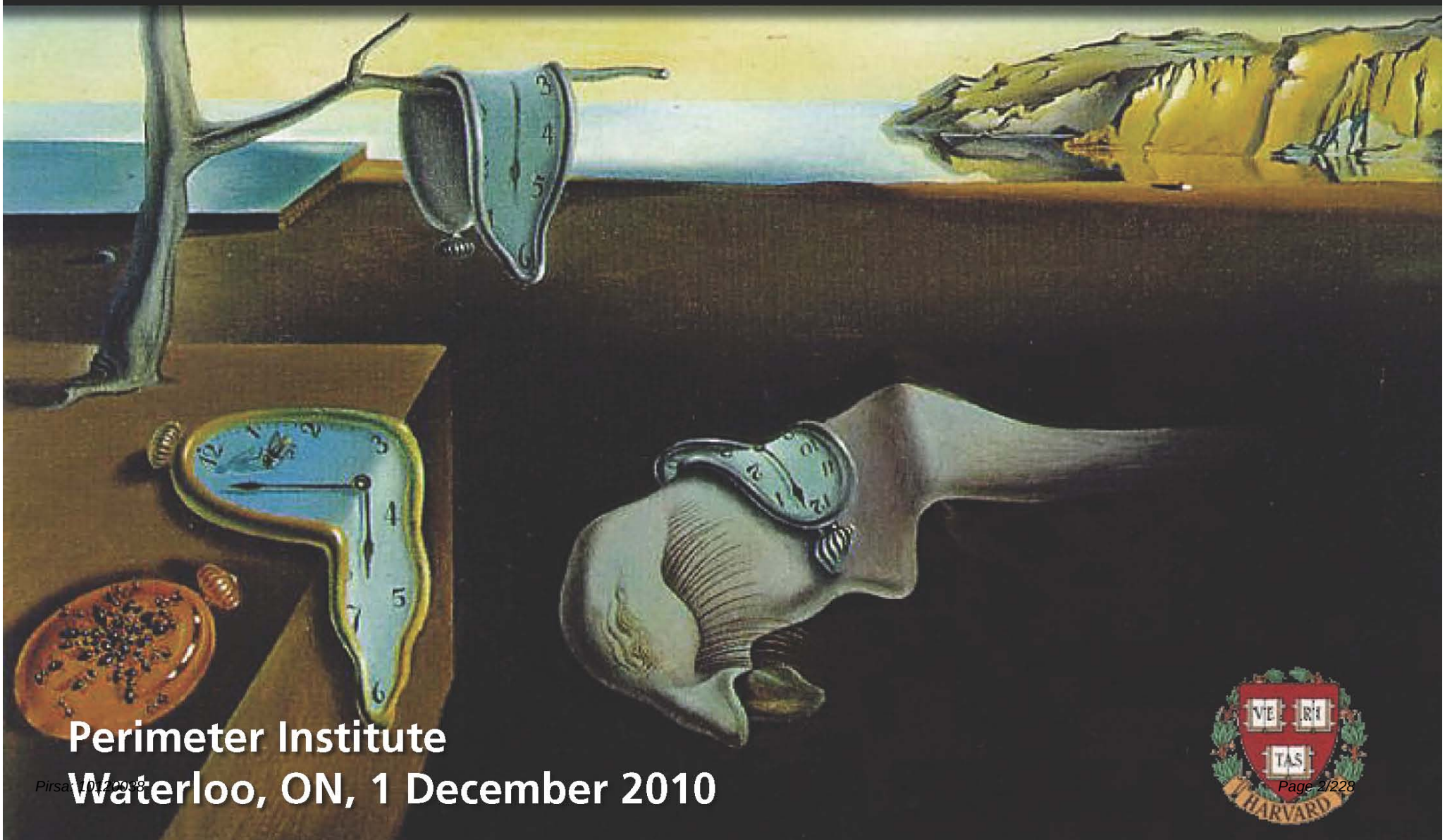
Title: Stopping Time

Date: Dec 01, 2010 07:00 PM

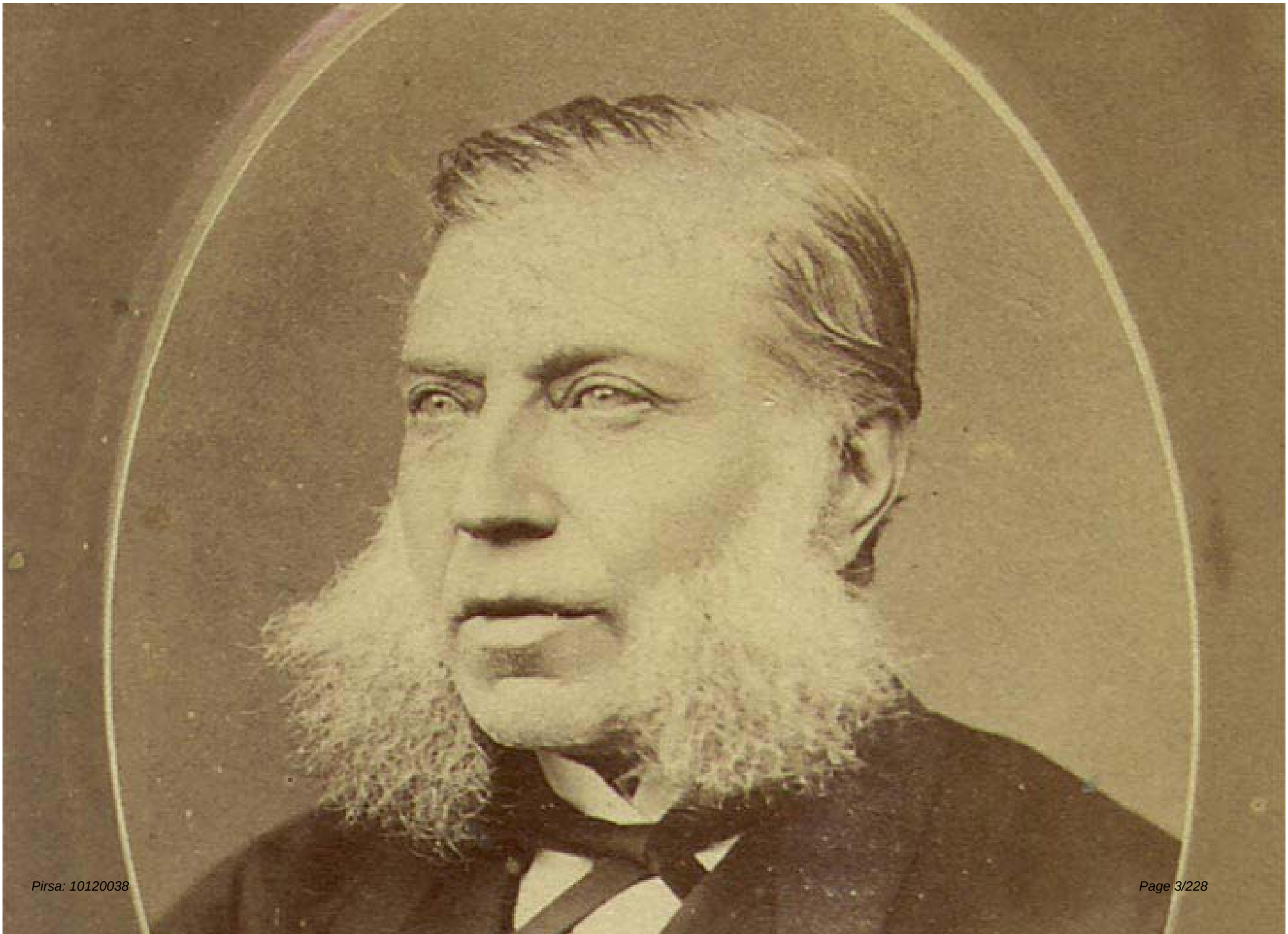
URL: http://pirsa.org/10120038

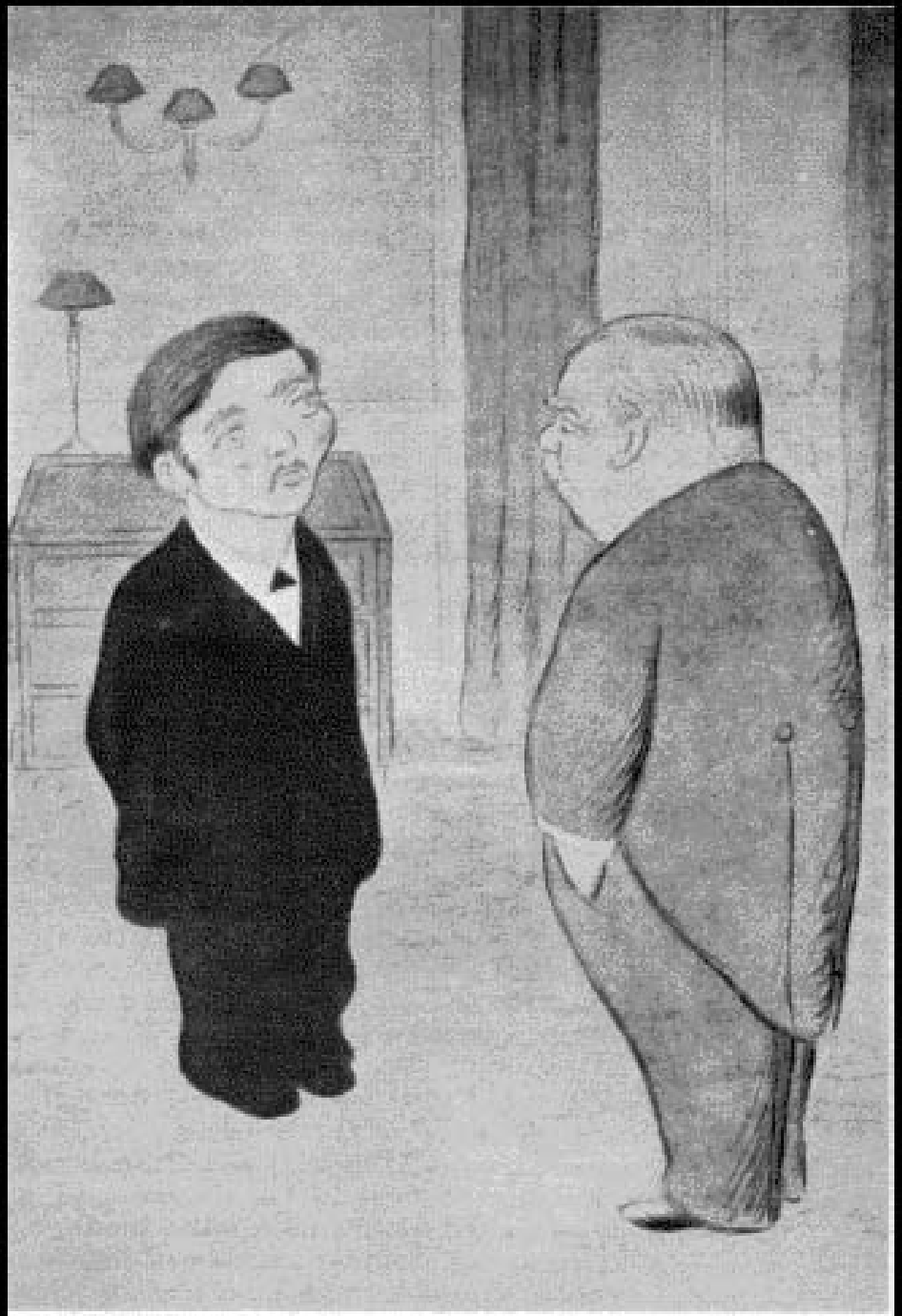
Abstract: Time is of philosophical interest as well as the subject of mathematical and scientific research. Even though it is a concept familiar to most, the passage of time remains one of the greatest enigmas of the universe. The philosopher Augustine once said: "What then is time? If no one asks me, I know what it is. If I wish to explain it to him who asks me, I do not know." The concept time indeed cannot be explained in simple terms. Emotions, life, and death - all are related to our interpretation of the irreversible flow of time. After a discussion of the concept of time, Prof. Mazur will review historical attempts to "stop time", that is, to capture events of very short duration and then present an overview of current research into ultrafast processes using short laser pulses.

Stopping time



Perimeter Institute
Waterloo, ON, 1 December 2010



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- time

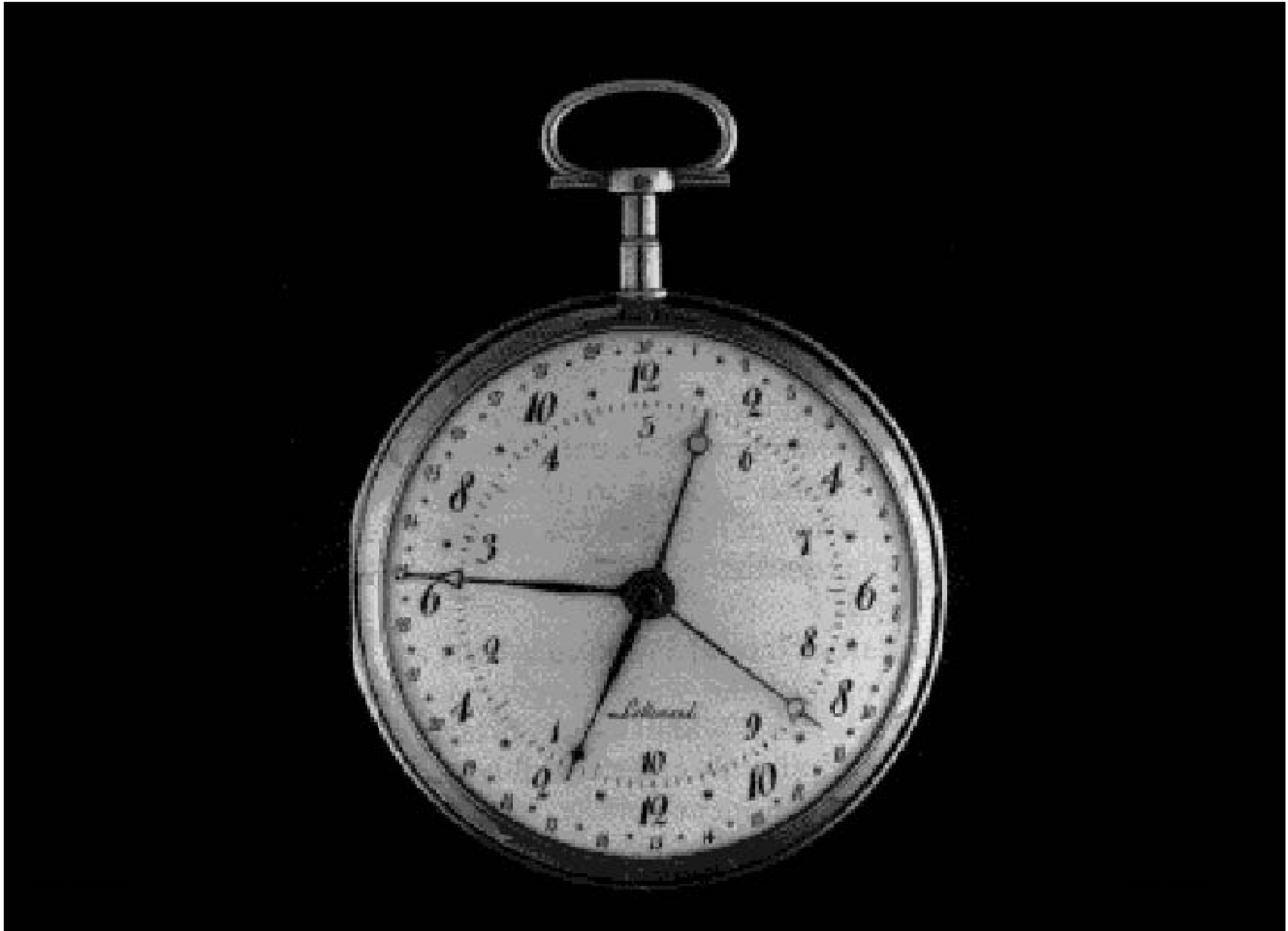
- time
- time

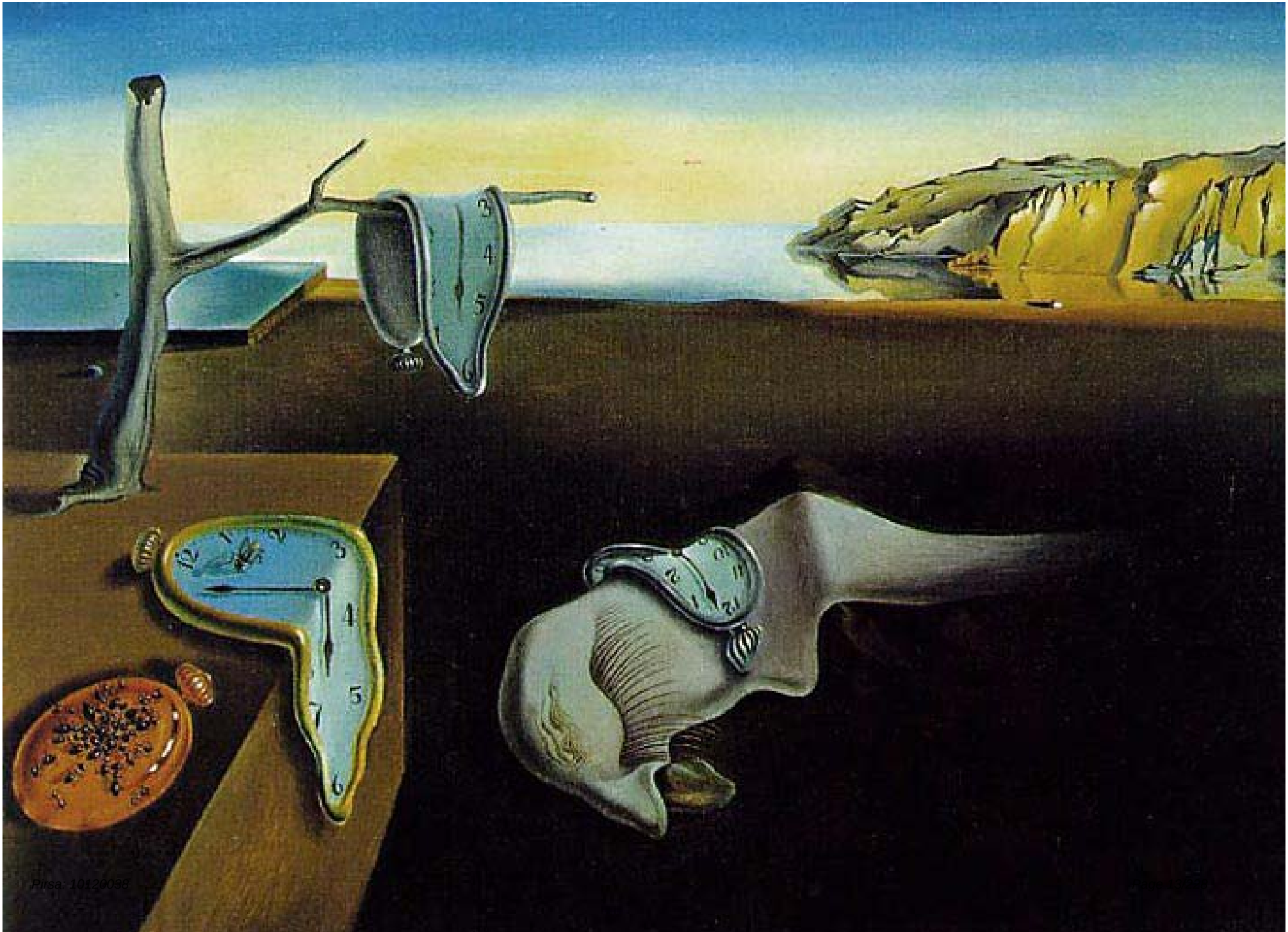
- time
- time
- time

- time: the concept
- time
- time

- time: the concept
- time: stopping it
- time

- time: the concept
- time: stopping it
- time: the new frontier

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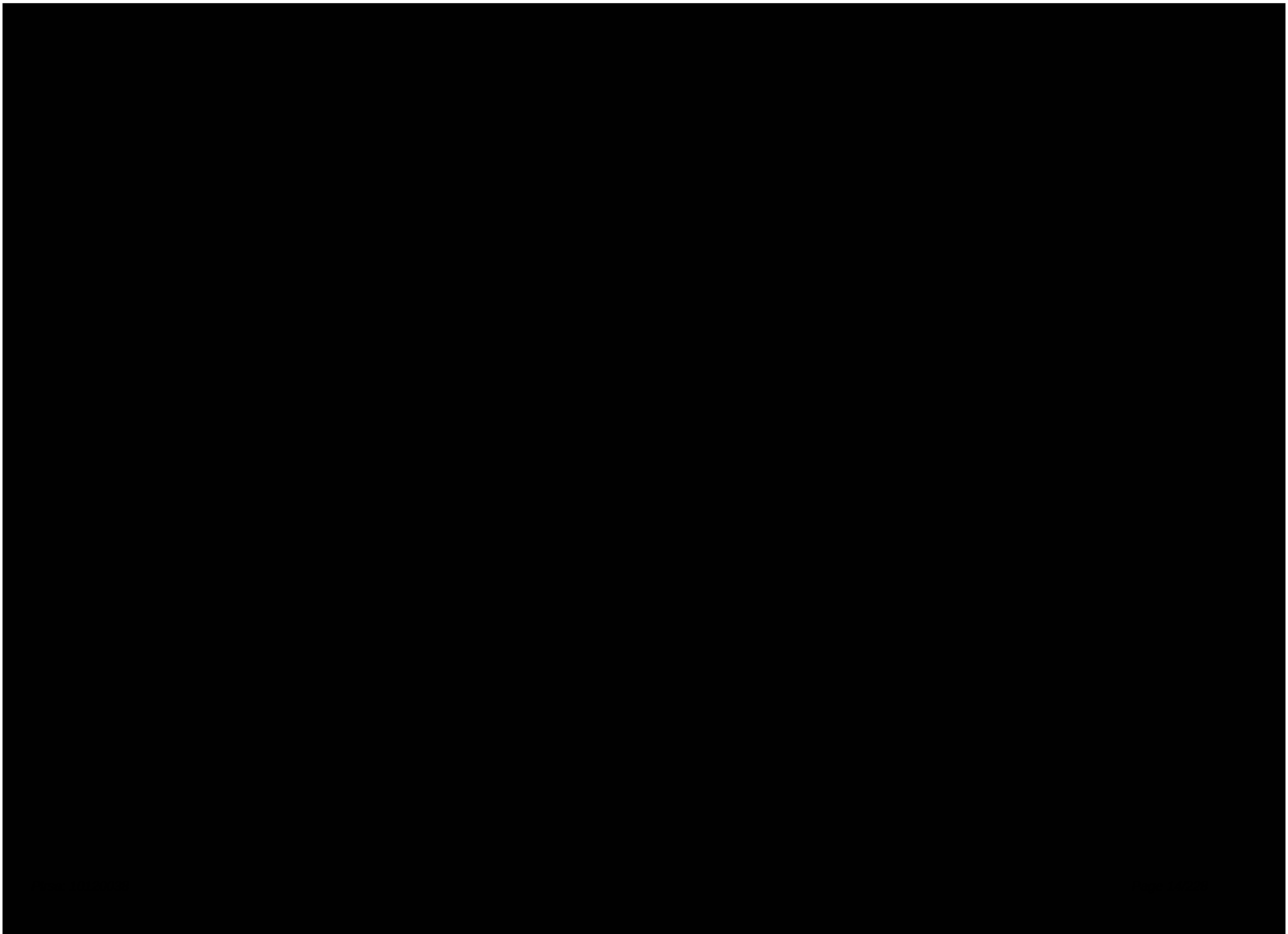
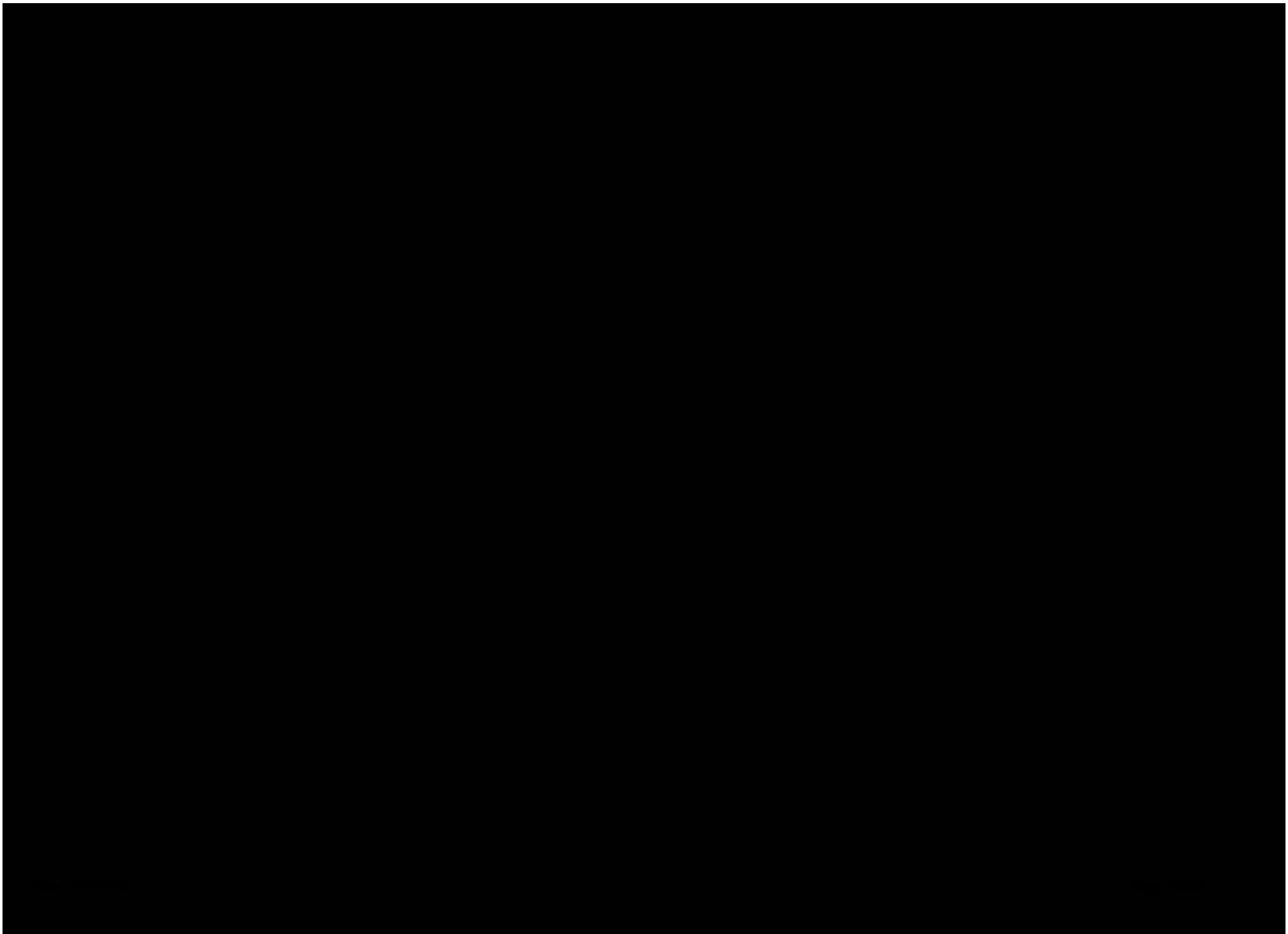




vorher angestellten Versuchen die warme Lufthülle, welche die Kerzenflamme umschließt. Und der

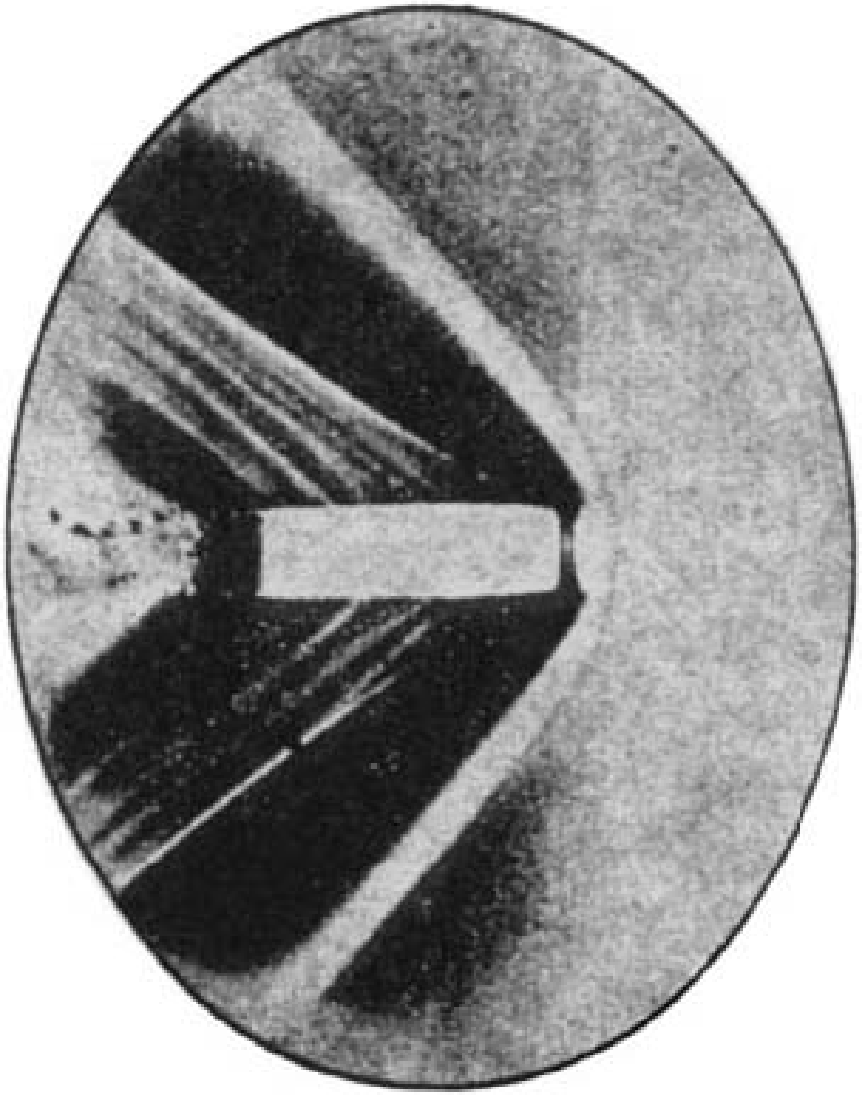
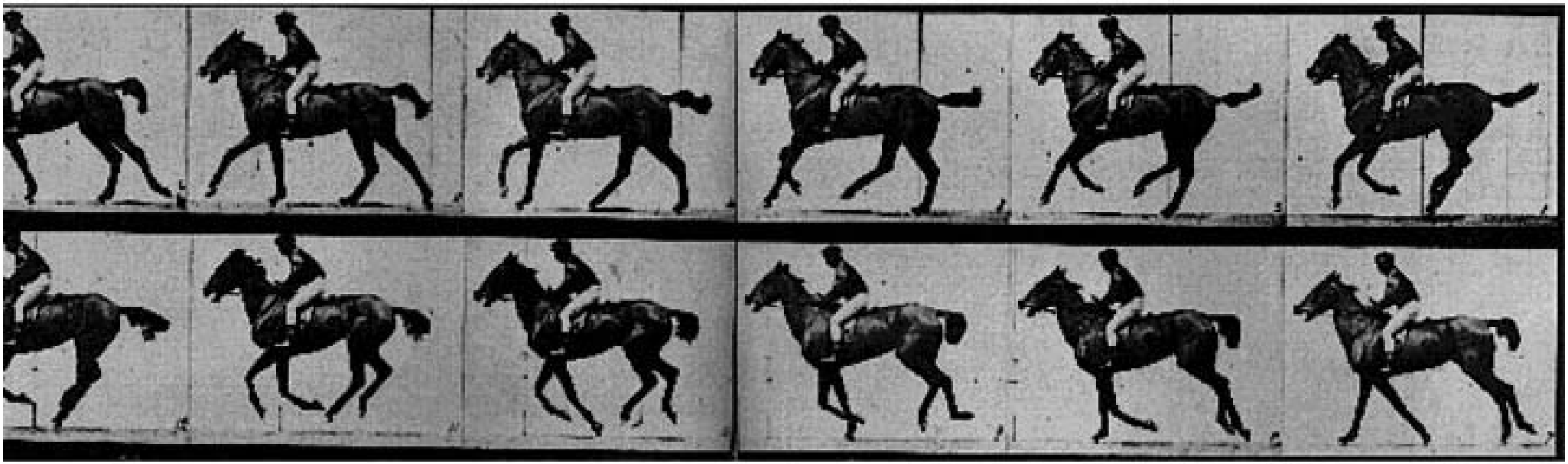
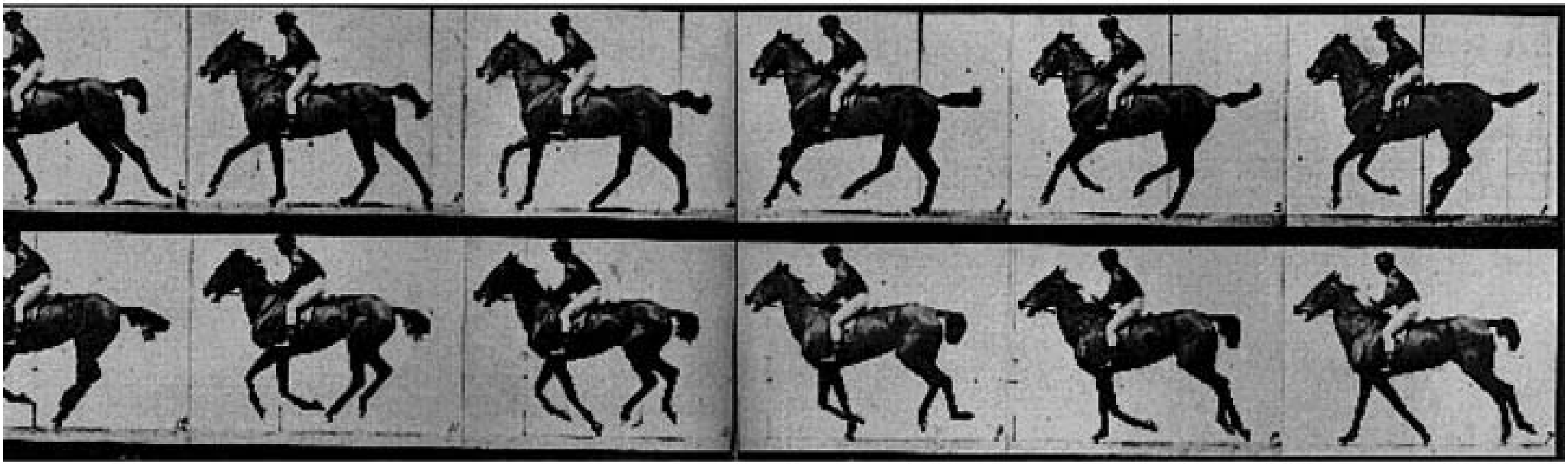
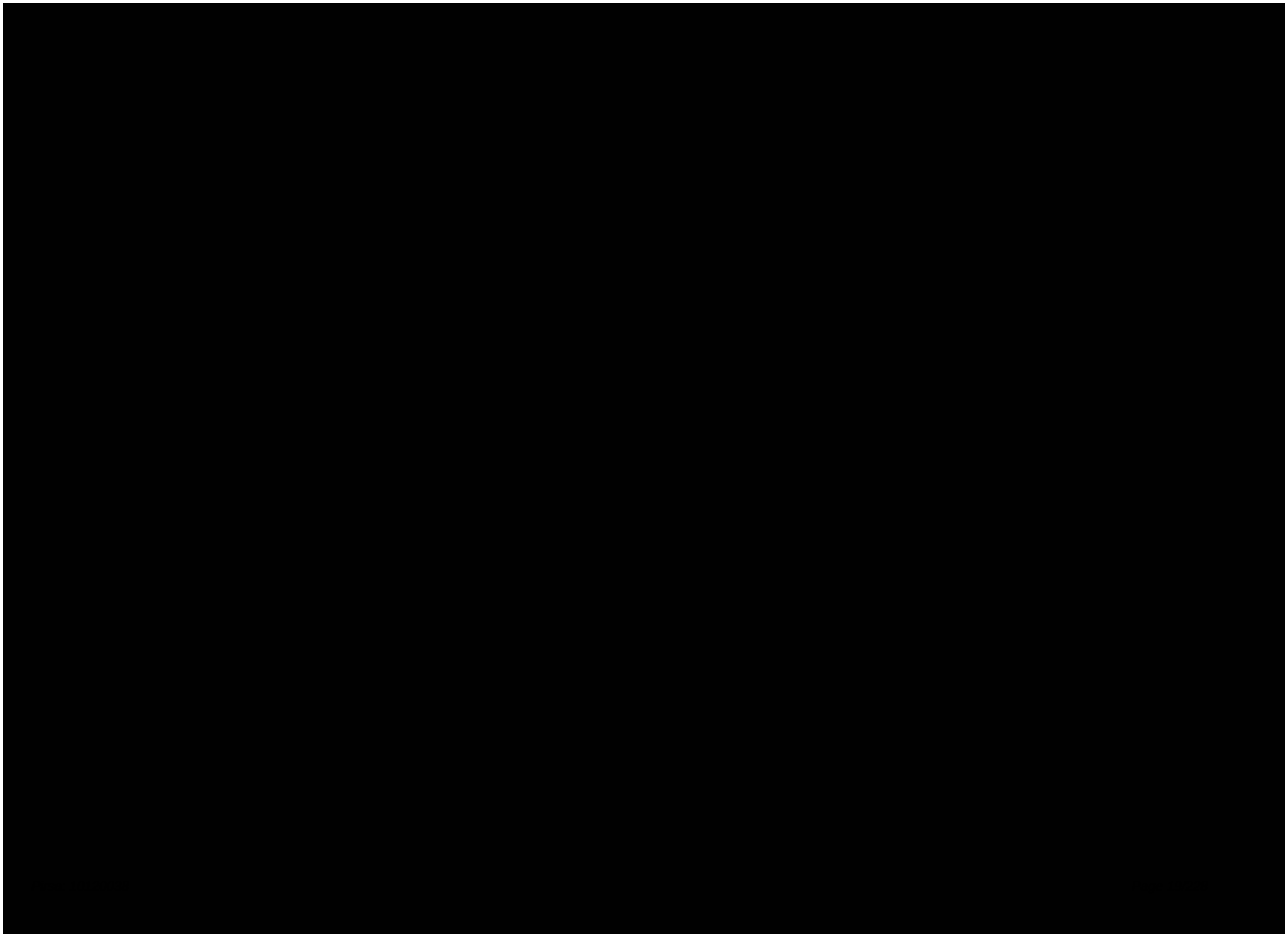


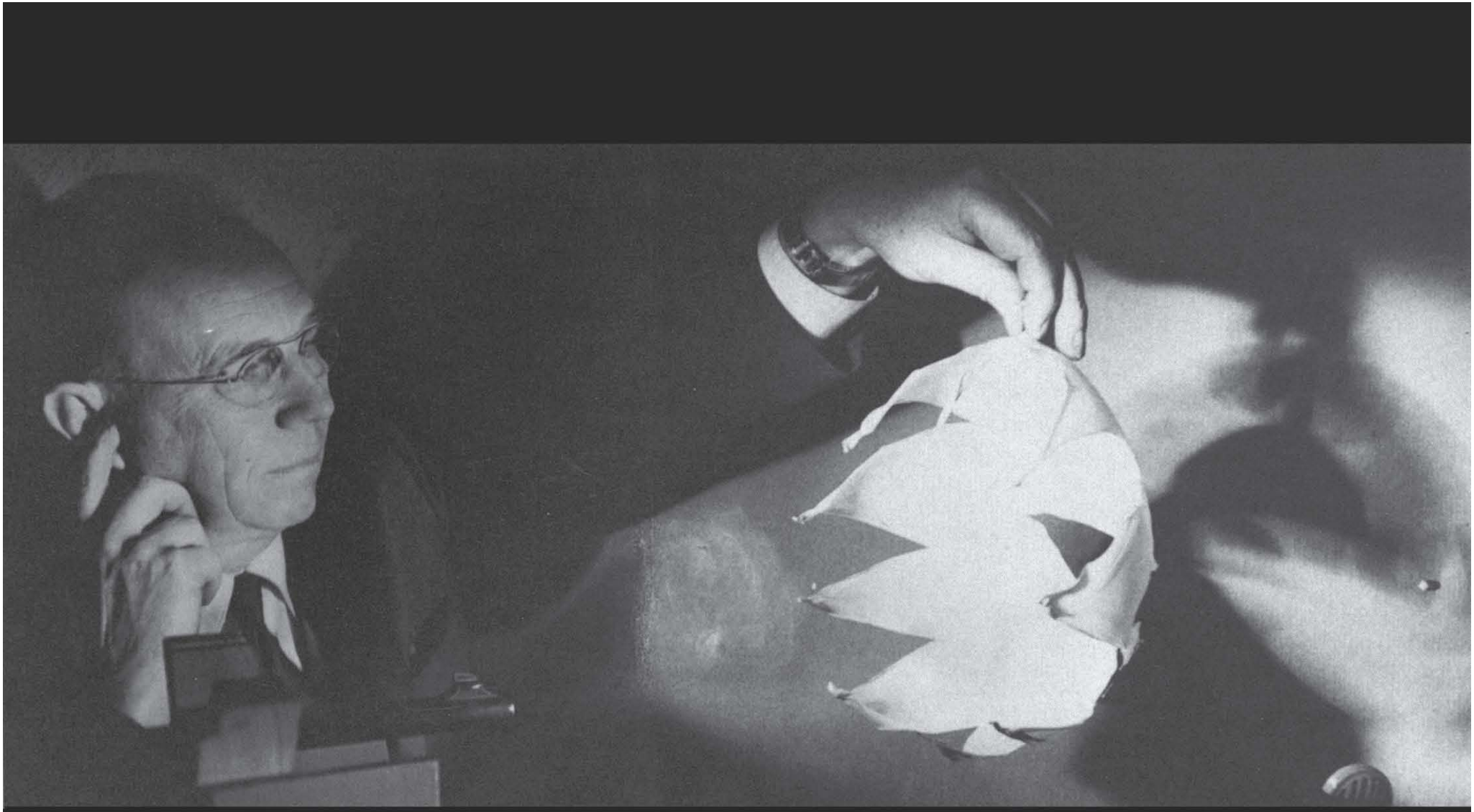
Fig. 52.

Zylinder aus durch Reibung erwärmter Luft, welche

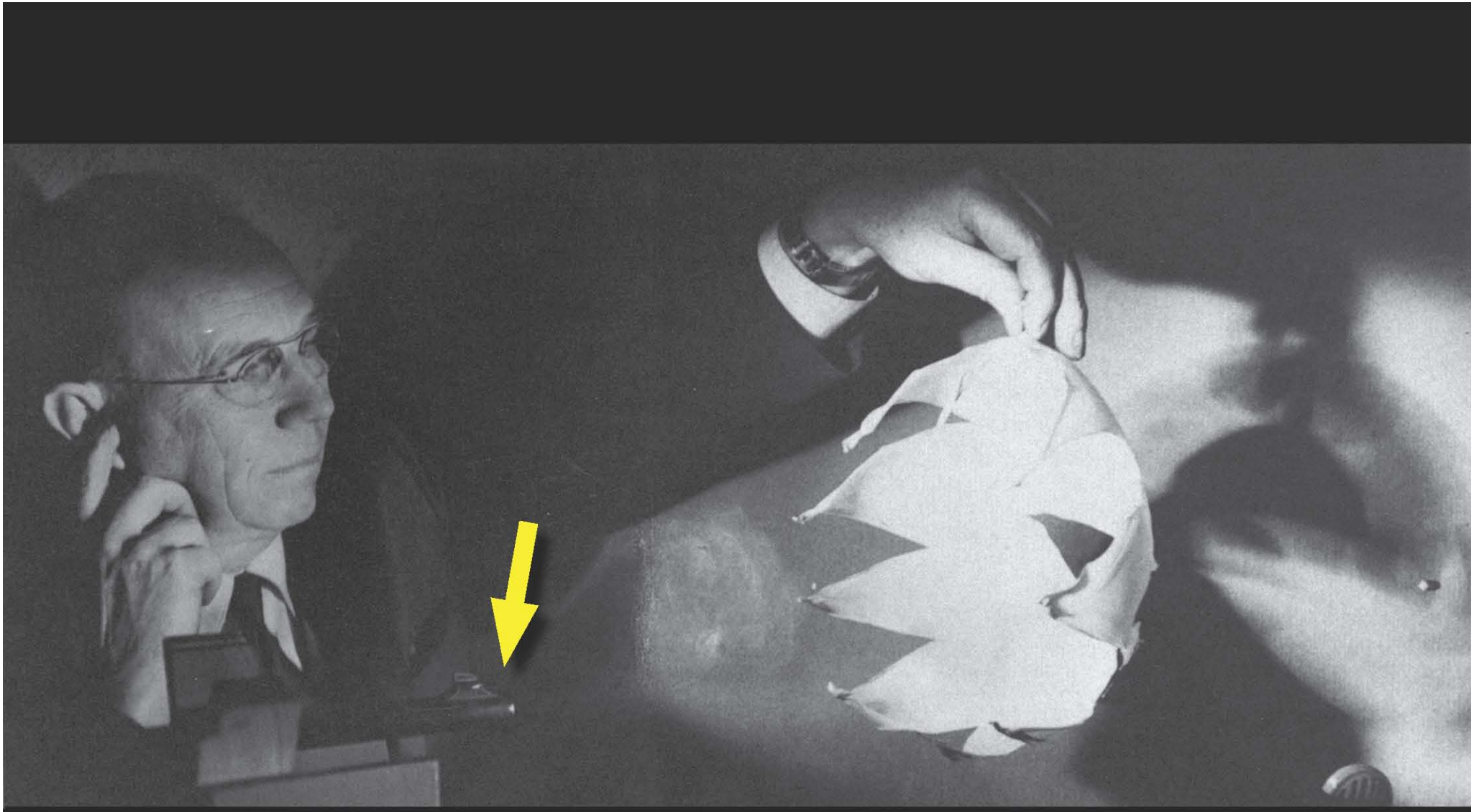




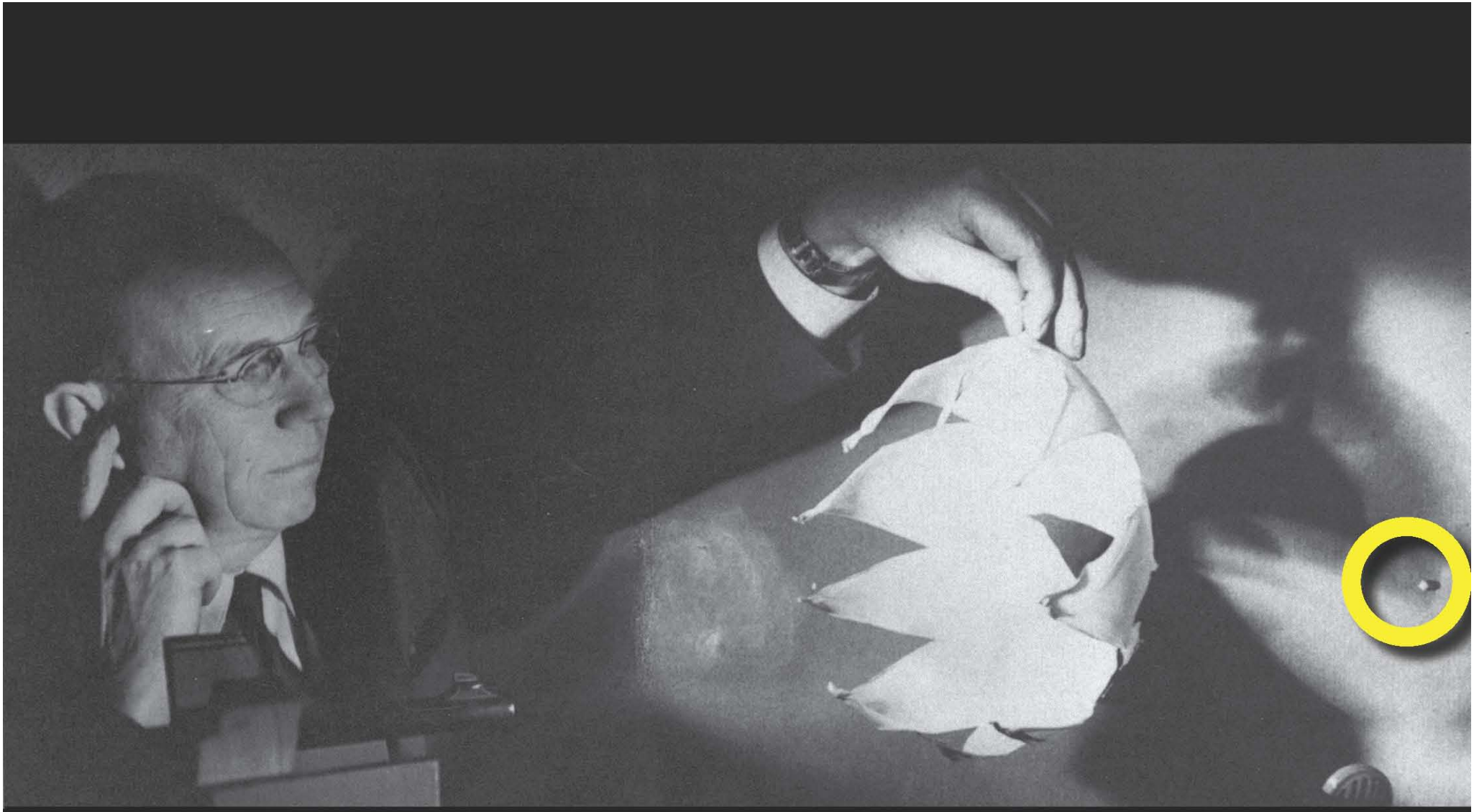




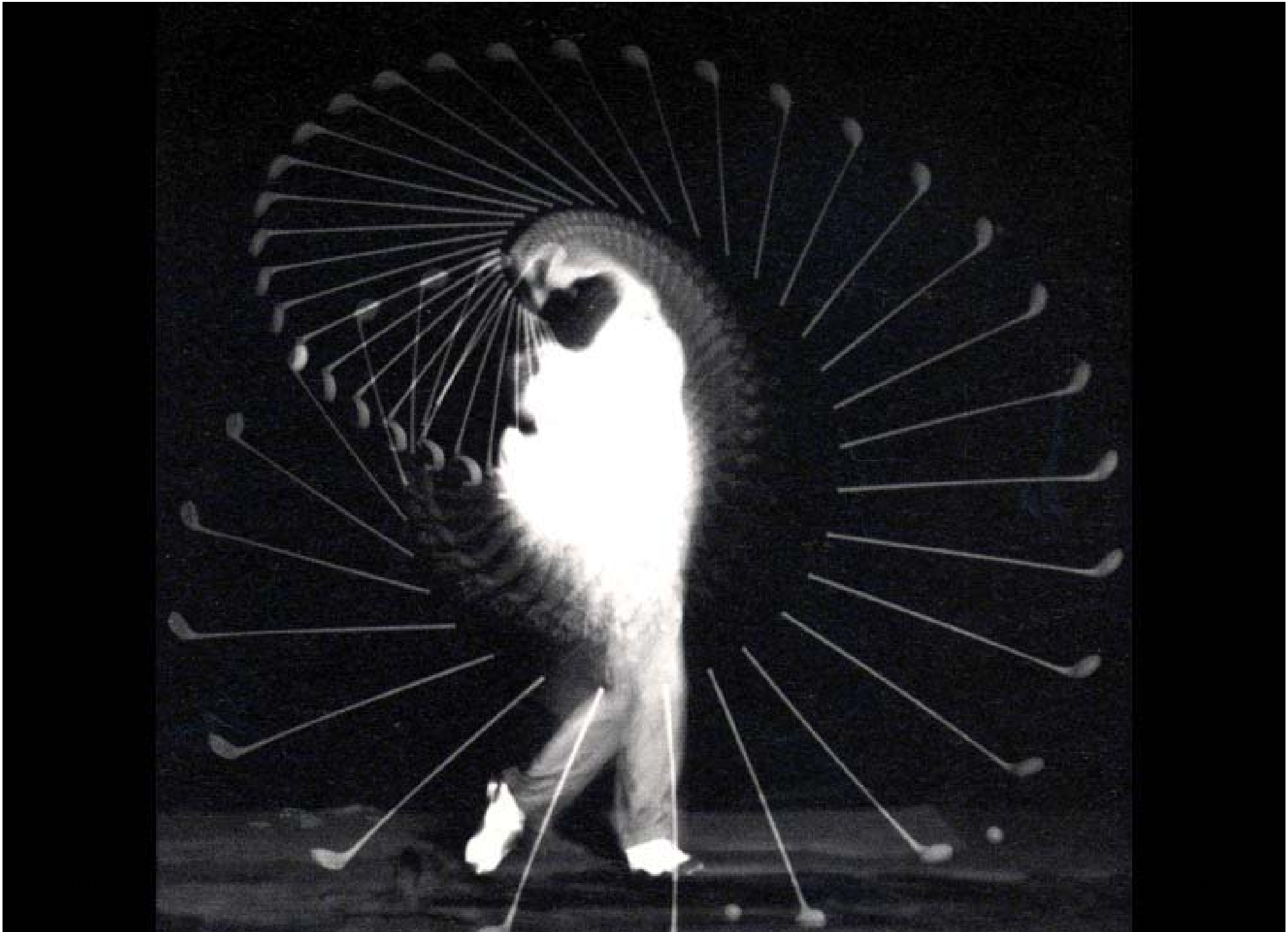
Harold Edgerton (1903 – 1990)

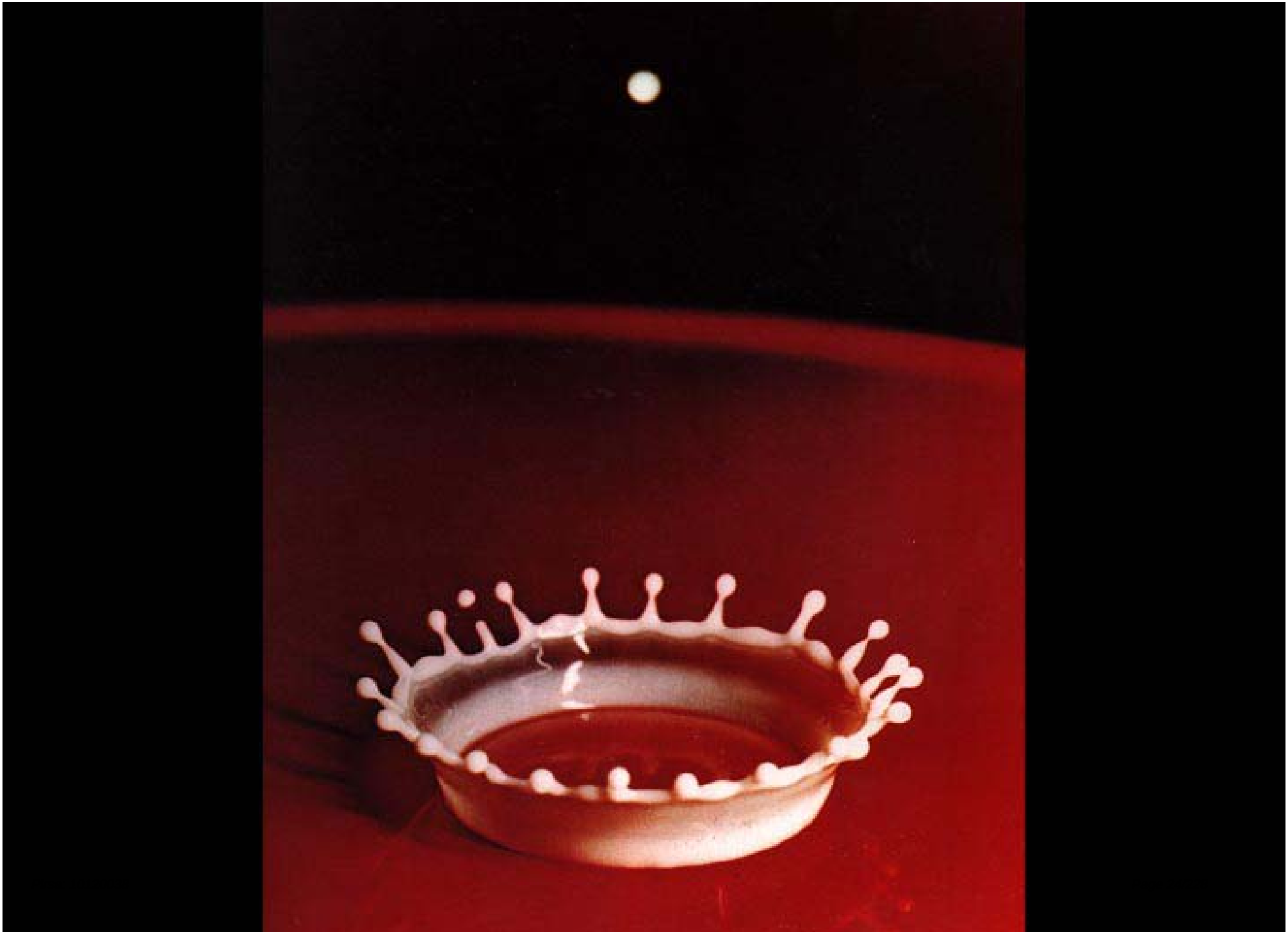


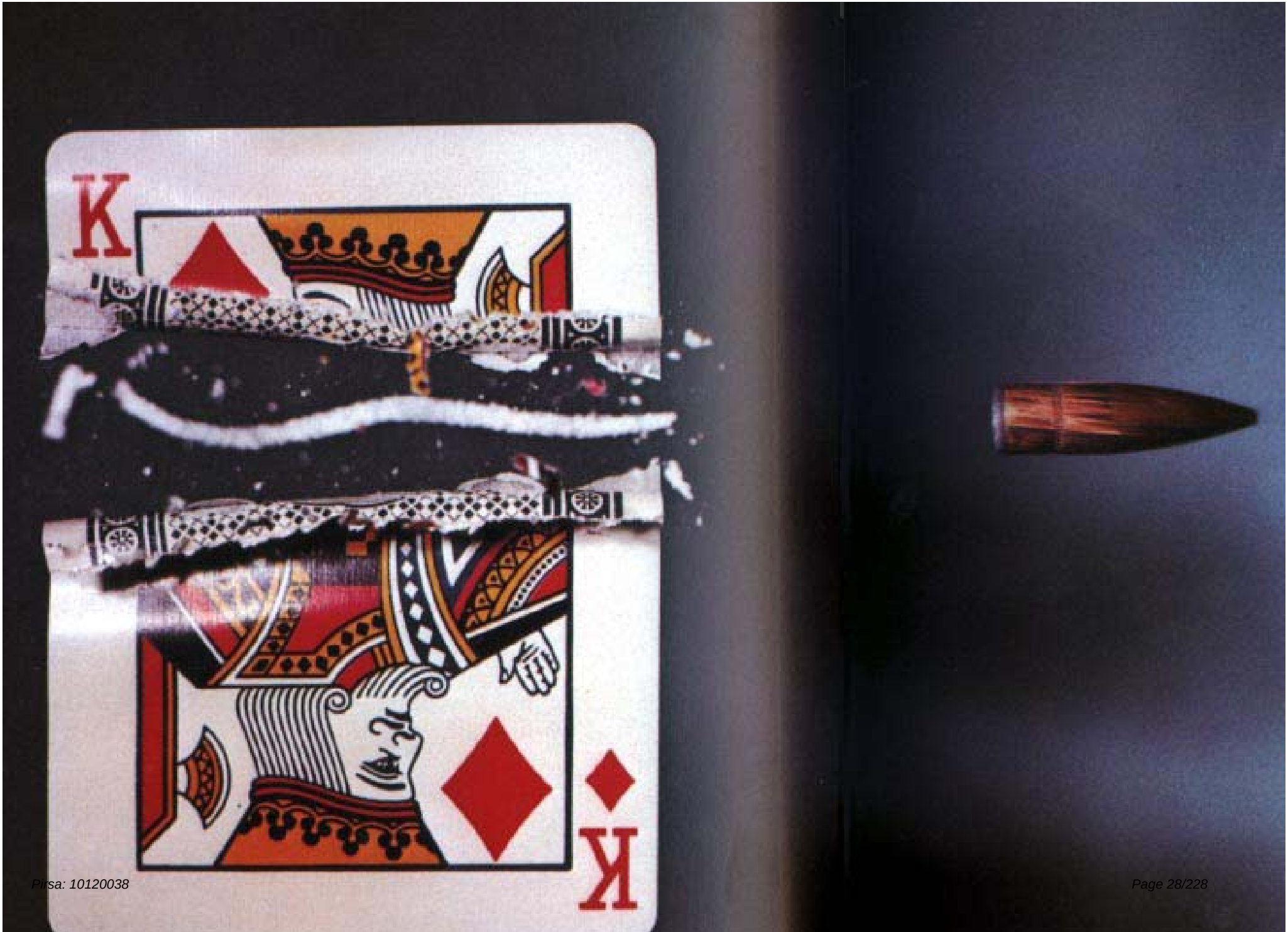
Harold Edgerton (1903 – 1990)



Harold Edgerton (1903 – 1990)



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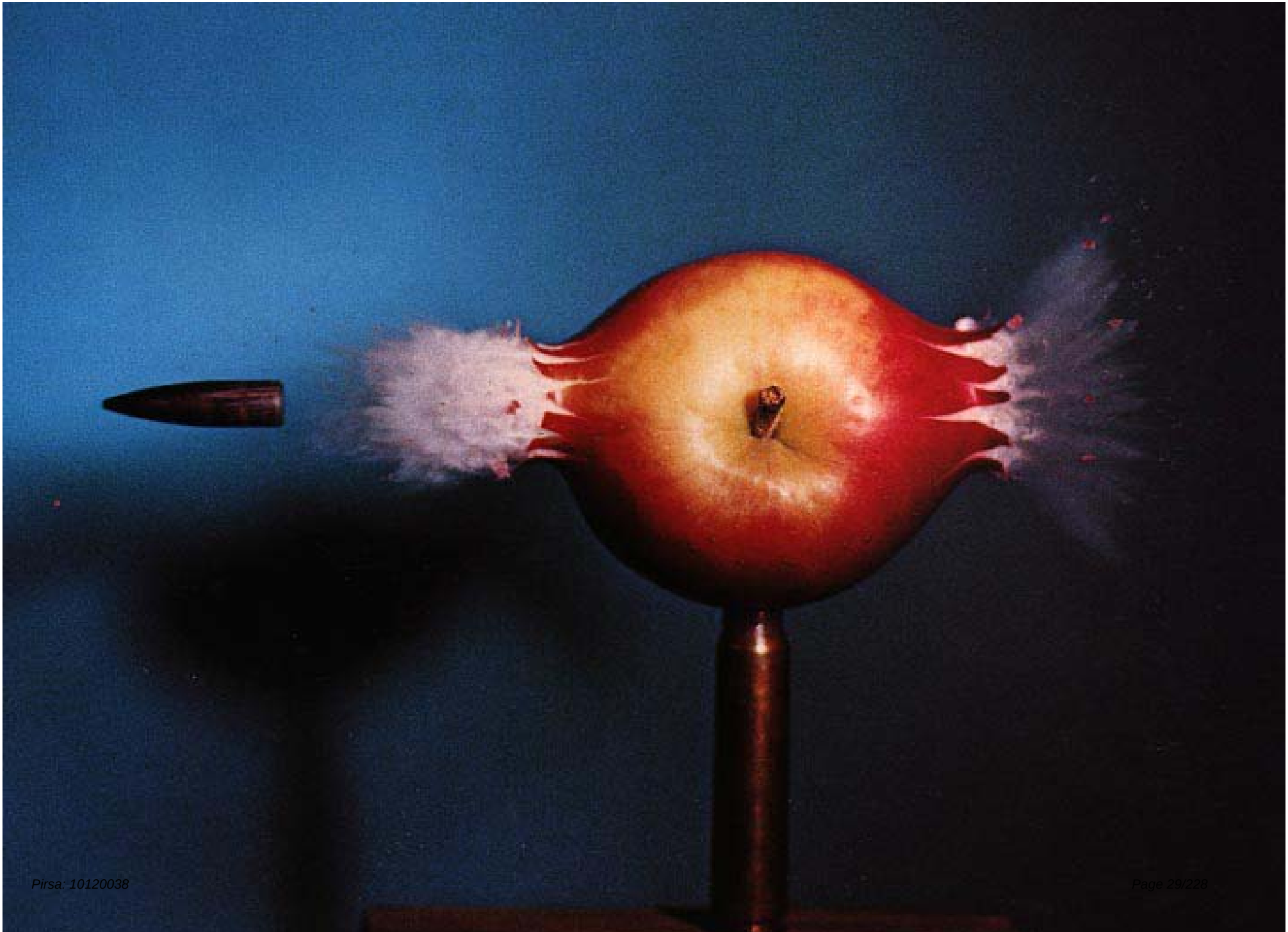
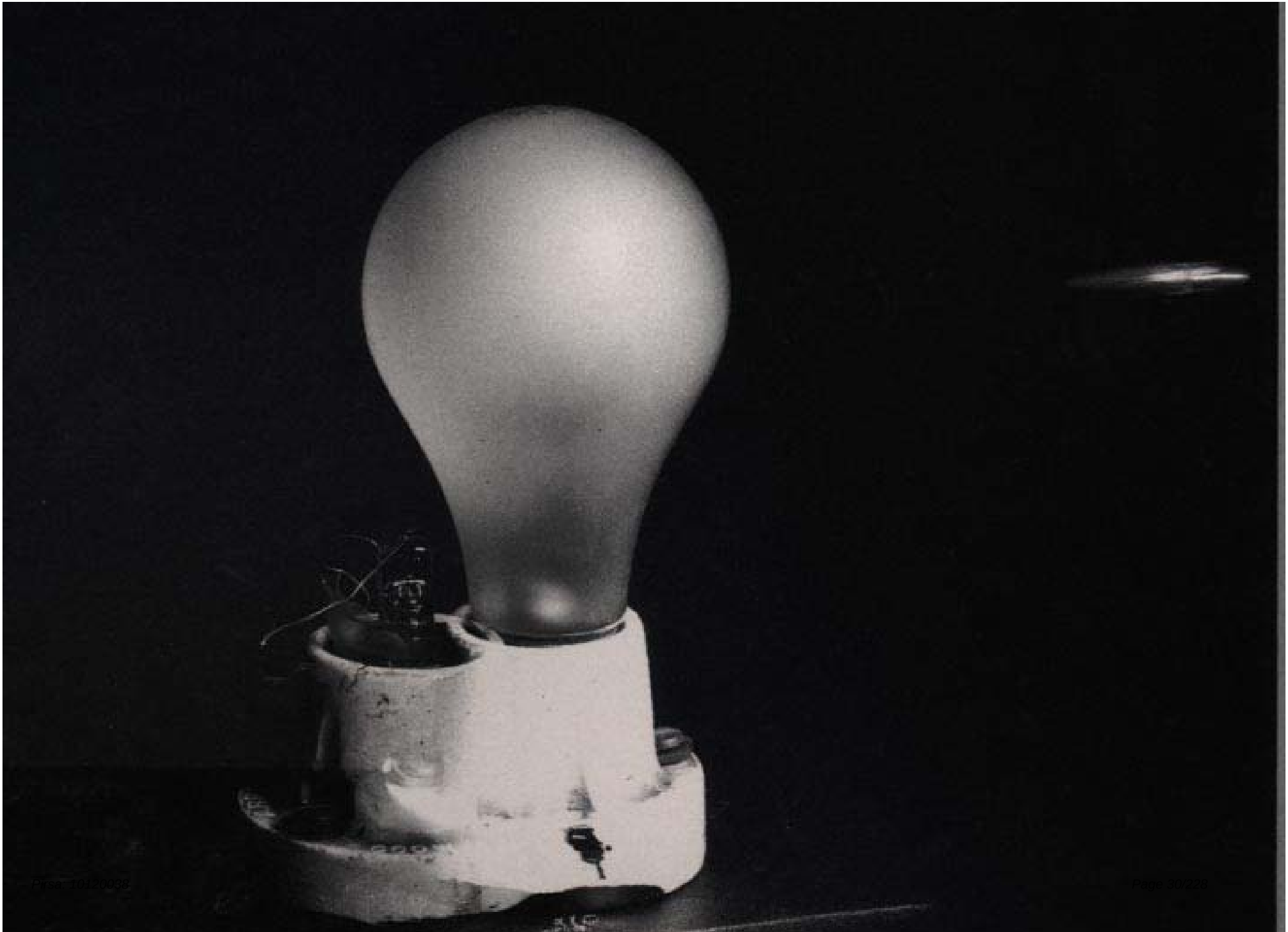
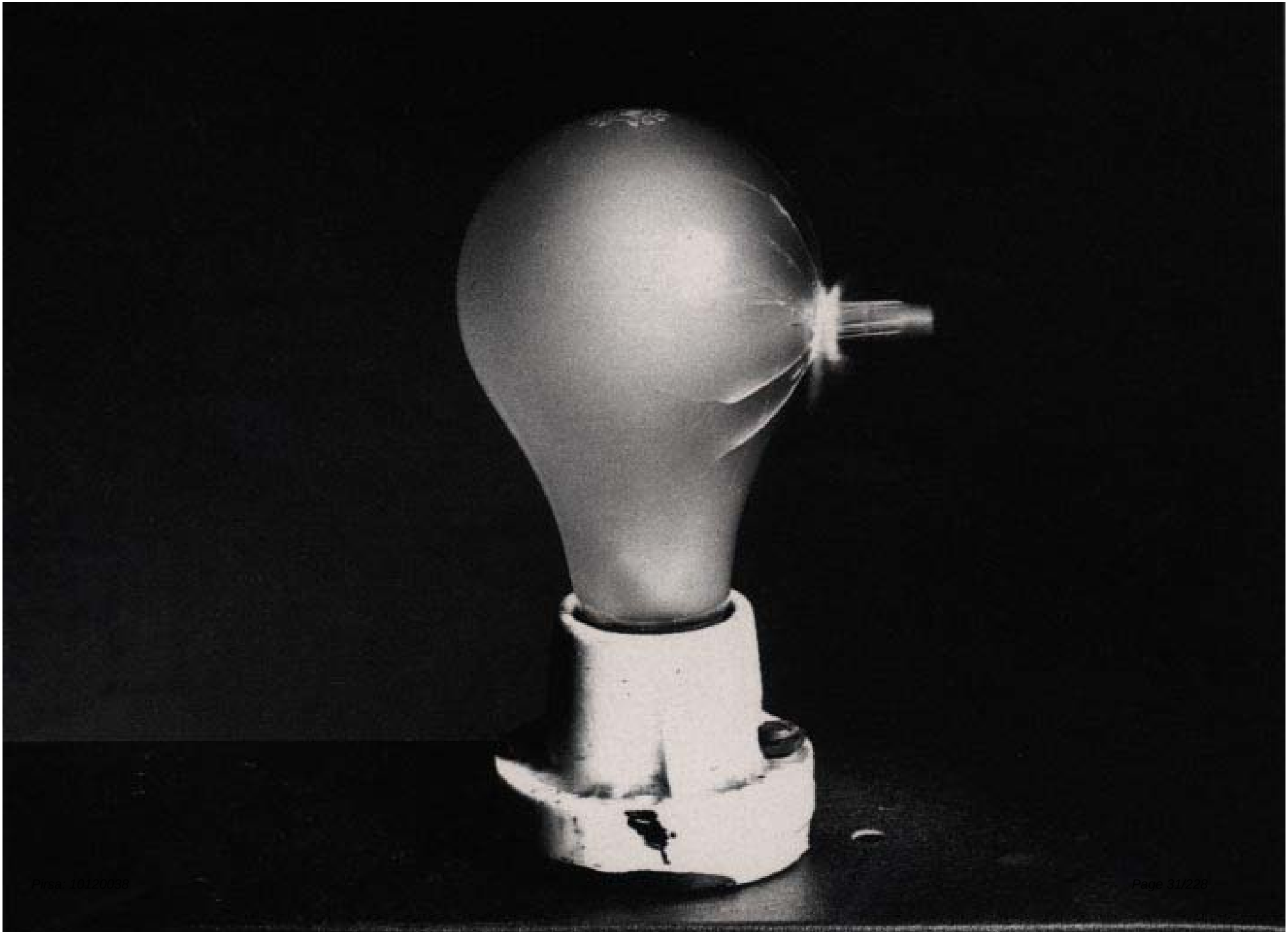
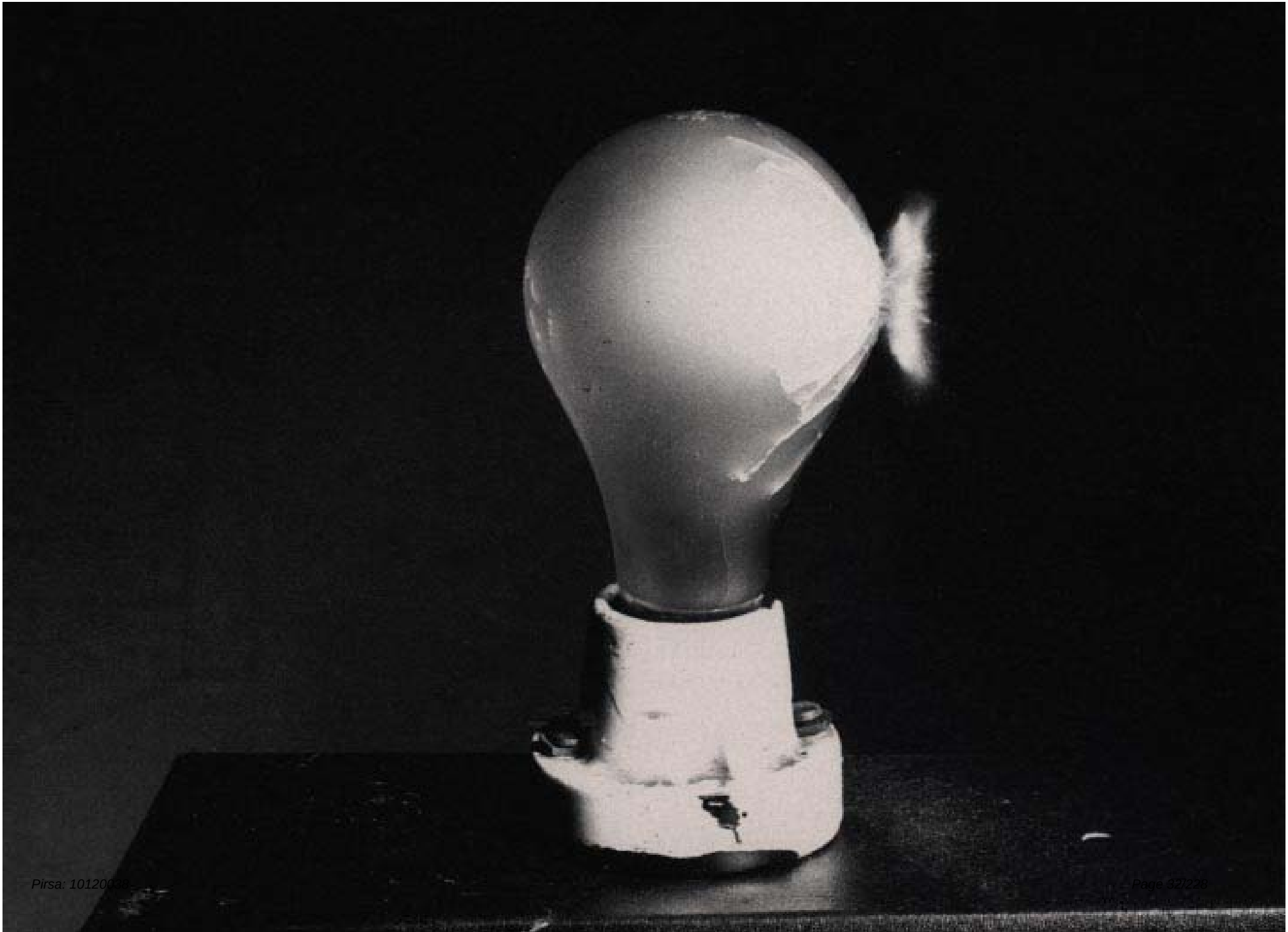
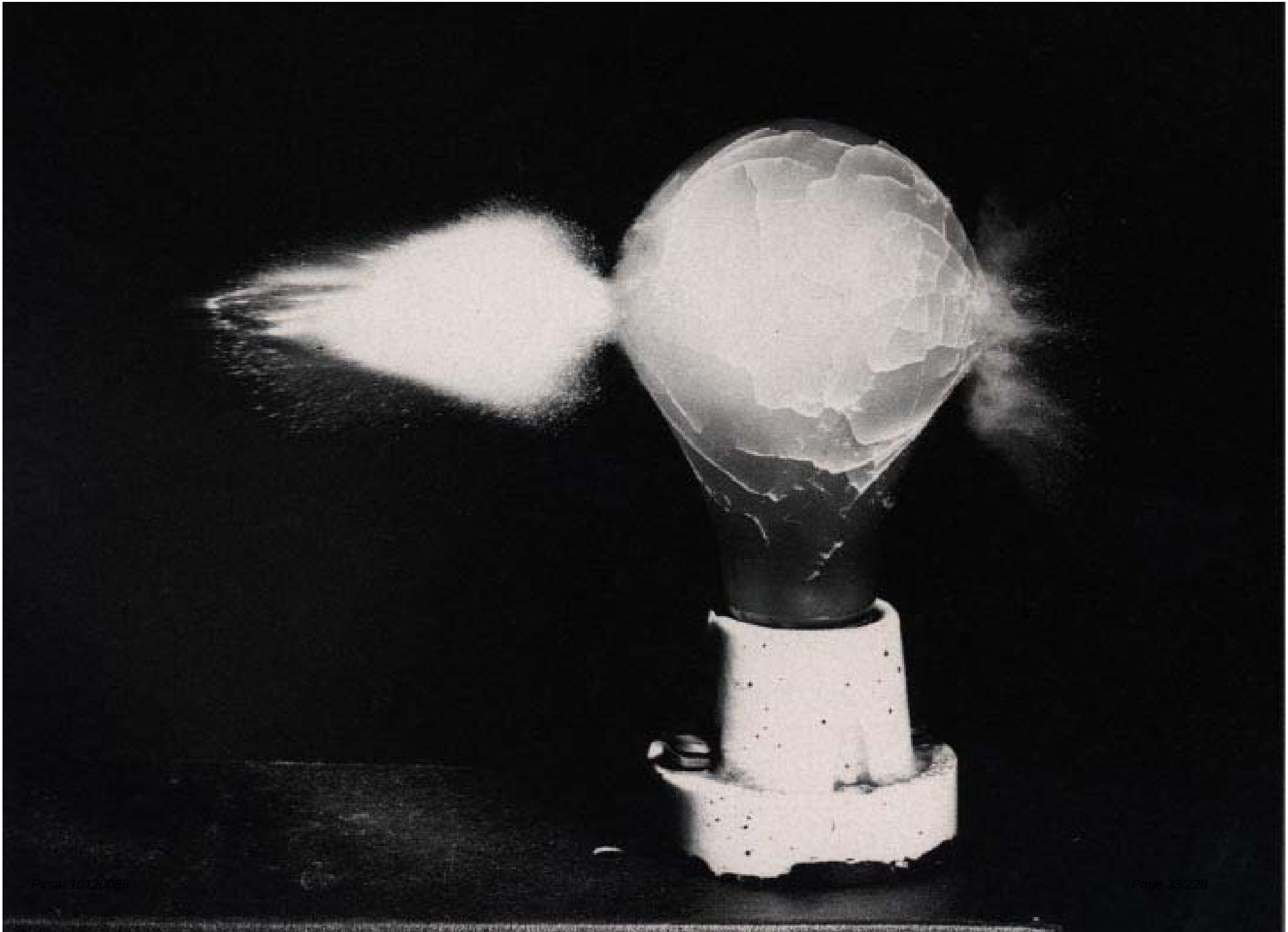
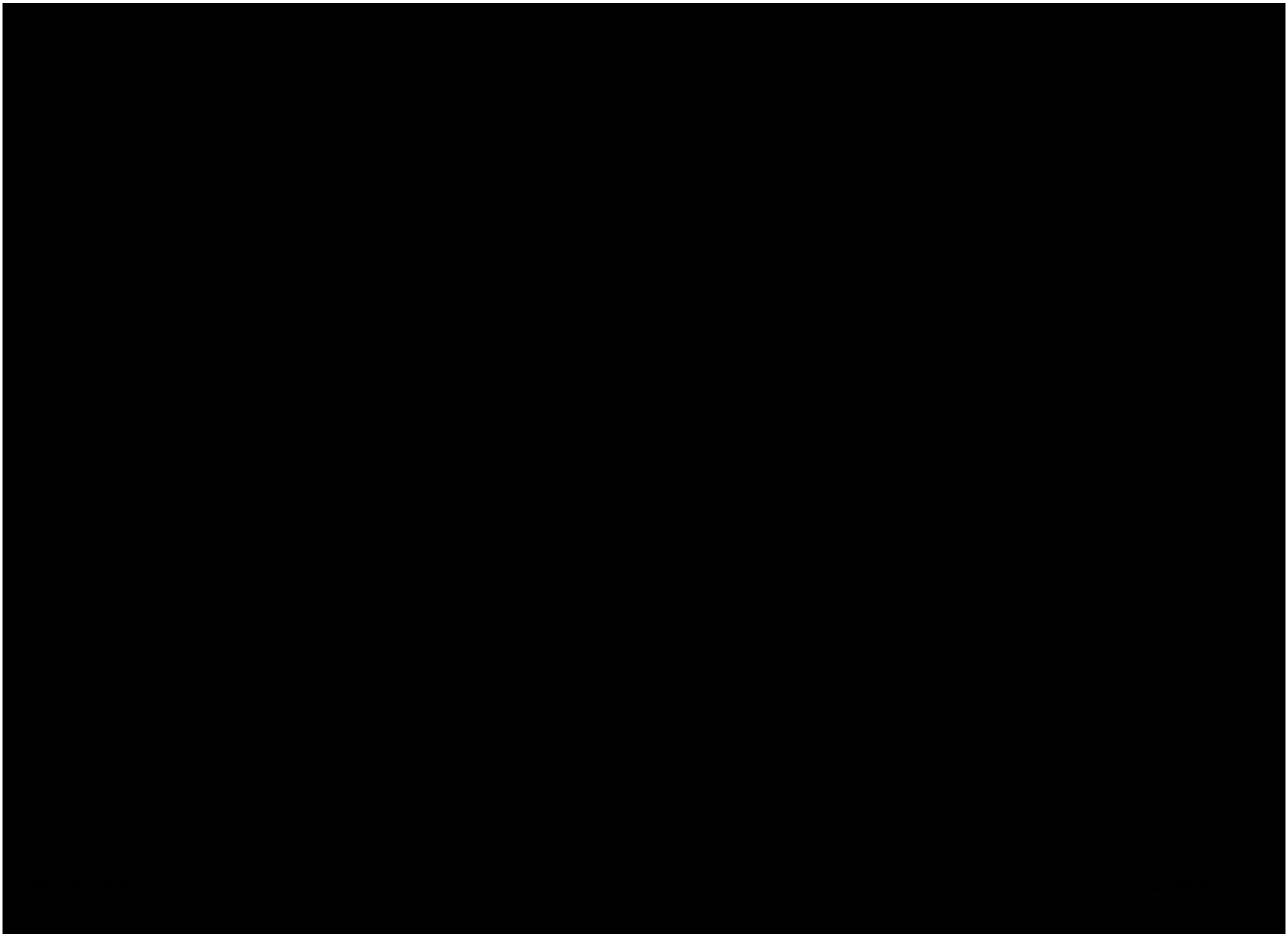












moon

10^0 s

one second

moon

10^0 s

one second

moon

10^0 s

one second

moon

10^0 s

one second

moon

10^0 s

one second

10^1 s

10 seconds

10^1 s

10 seconds

10^1 s

10 seconds

10^1 s

10 seconds

10^1 s

10 seconds

10^2 s

one minute

10^2 s

one minute

10^2 s

one minute

10^2 s

one minute

10^2 s

one minute

RT to sun

10^3 s

17 minutes

RT to sun

10^3 s

17 minutes

RT to sun

10^3 s

17 minutes

RT to sun

10^3 s

17 minutes

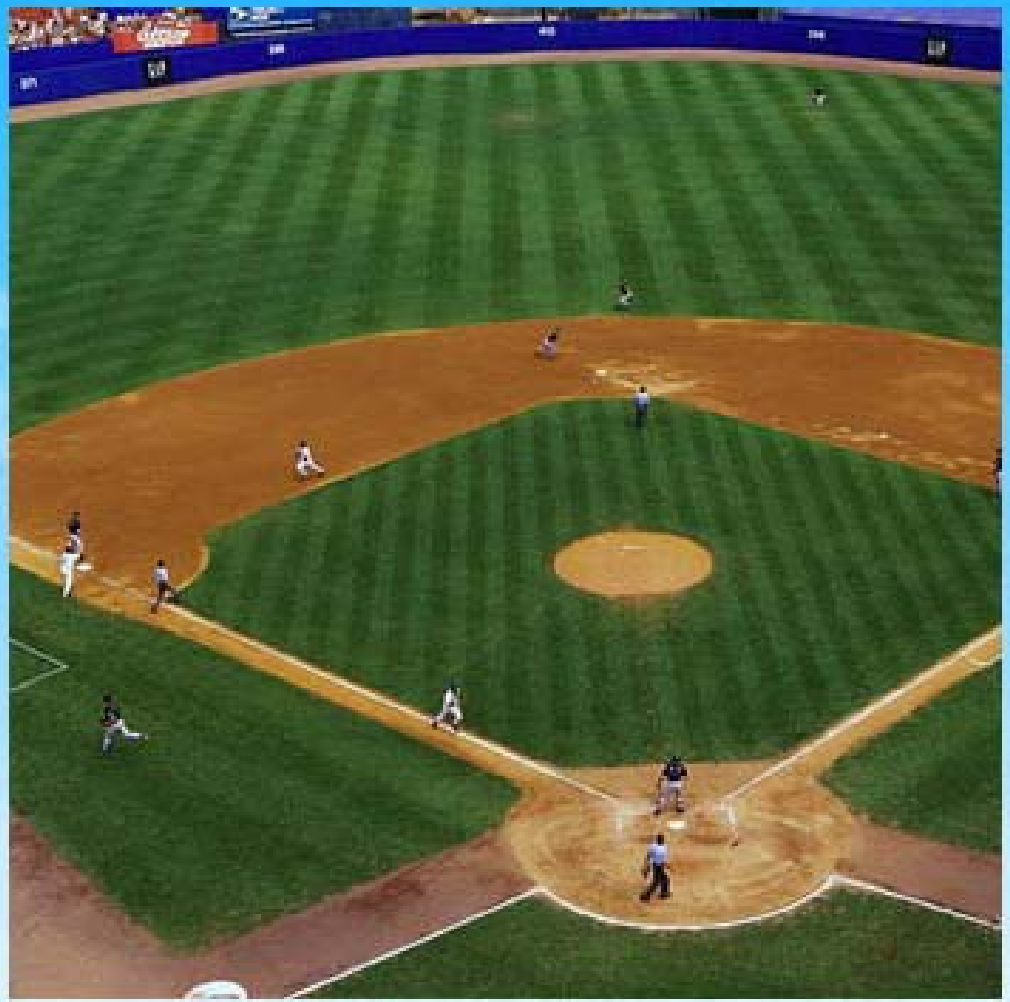
RT to sun

10^3 s

17 minutes

Uranus

10^4 s



average baseball game

Uranus

10^4 s

average baseball game

Uranus

10^4 s

average baseball game

Uranus

10^4 s

average baseball game

Uranus

10^4 s

average baseball game

10^5 s

1 day

10^5 s

1 day

10^5 s

1 day

10^5 s

1 day

10^5 s

1 day

10^6 s

2 weeks

10^6 s

2 weeks

10^6 s

2 weeks

10^6 s

2 weeks

10^6 s

2 weeks

10^7 s

one semester

10^7 s

one semester

10^7 s

one semester

10^7 s

one semester

10^7 s

one semester

Proxima Centauri

10^8 s

3 years

Proxima Centauri

10^8 s

3 years

Proxima Centauri

10^8 s

3 years

Proxima Centauri

10^8 s

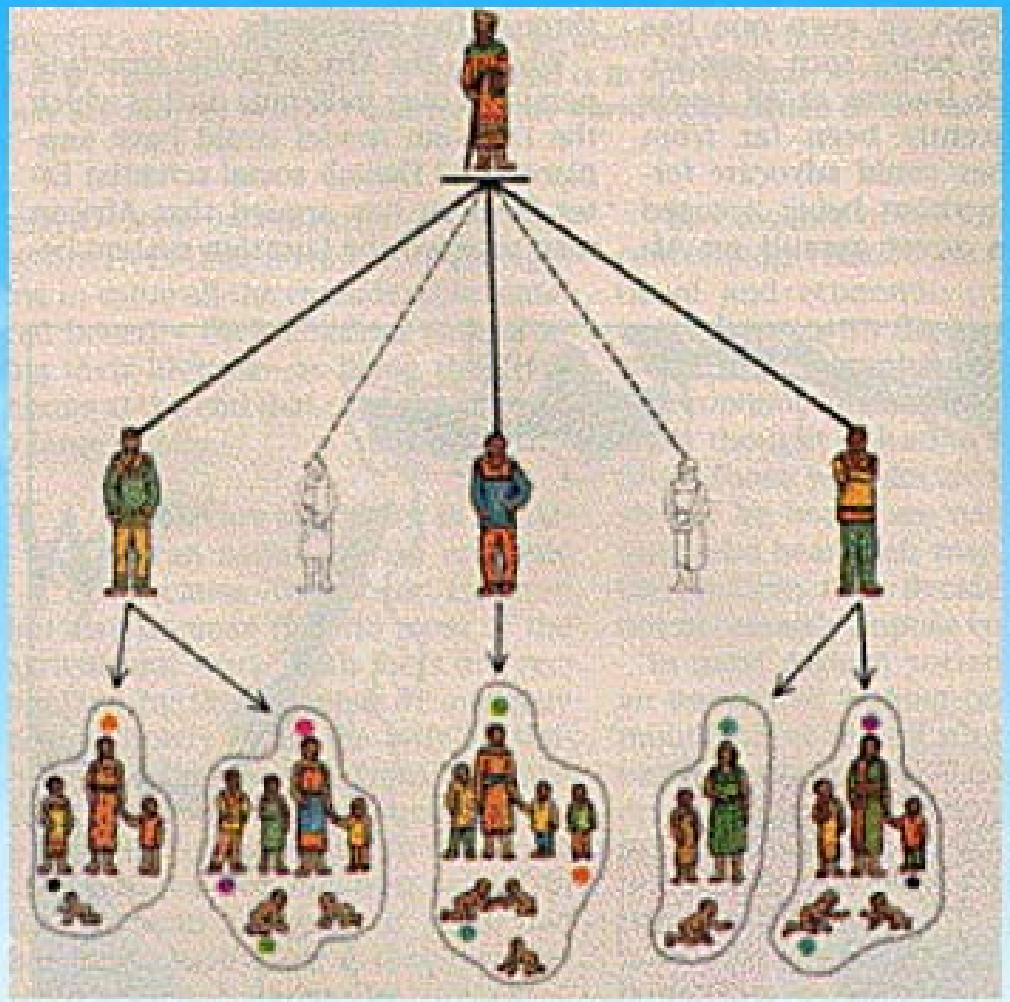
3 years

Proxima Centauri

10^8 s

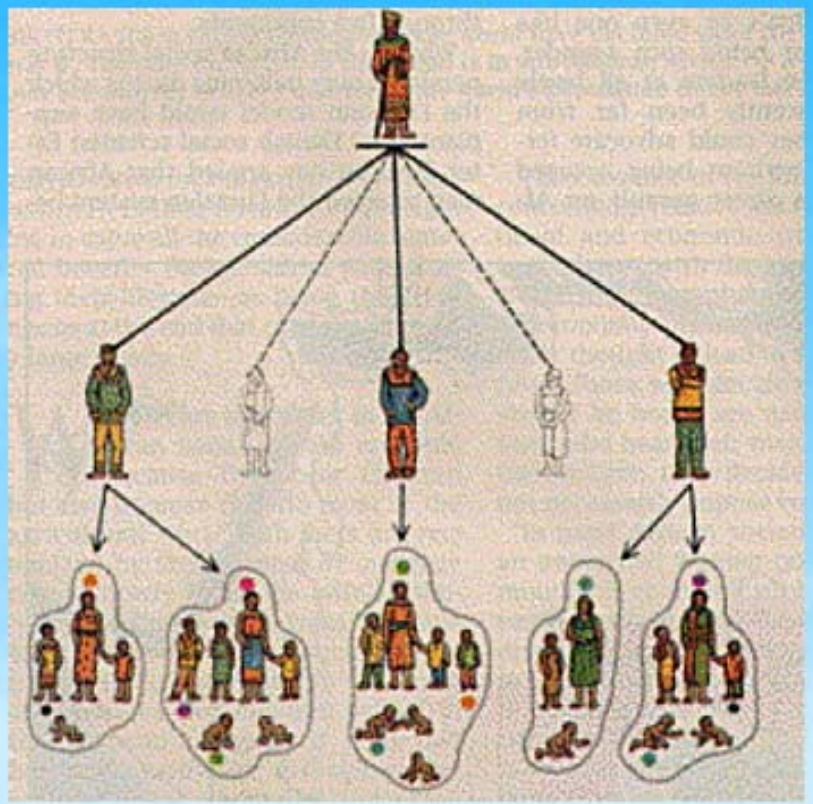
3 years

10^9 s



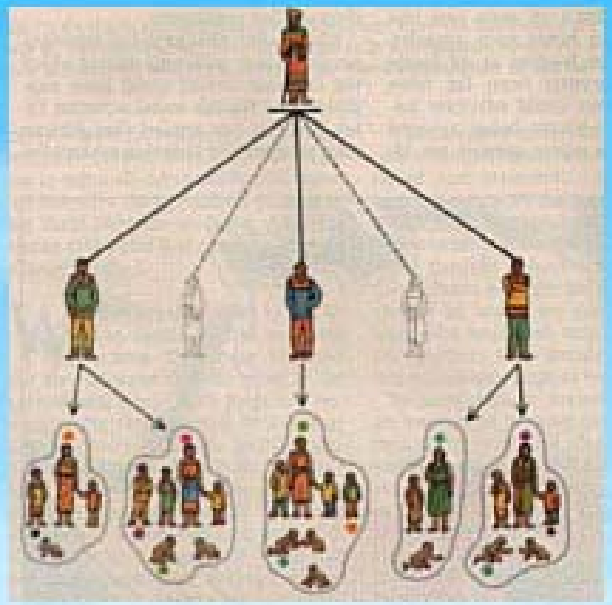
human generation

10^9 s



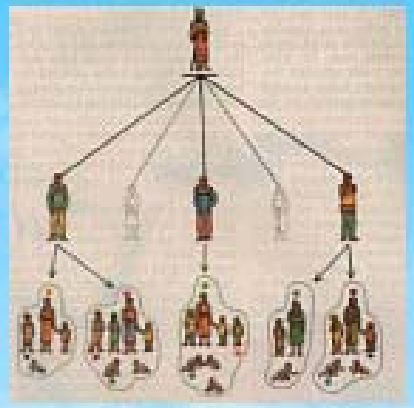
human generation

10^9 s



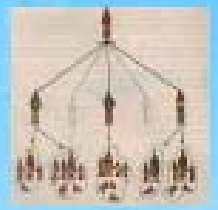
human generation

10^9 s



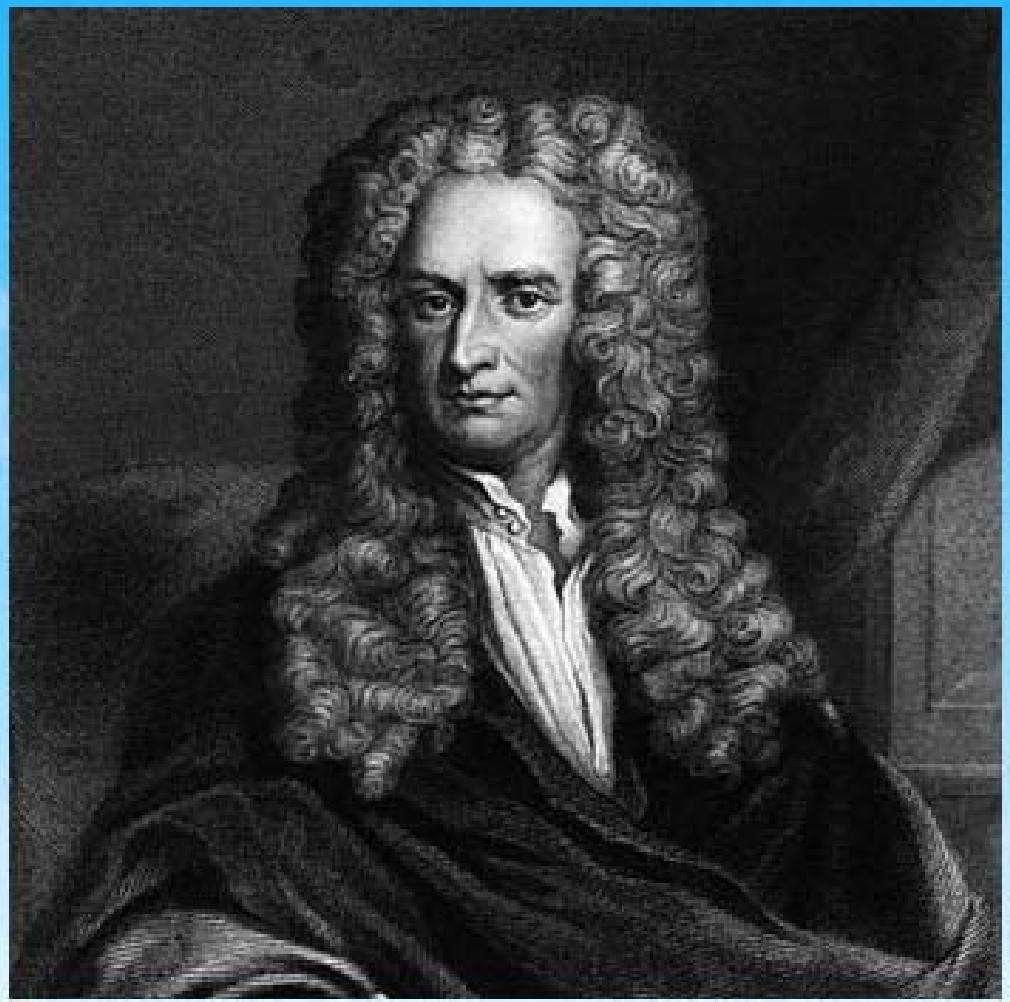
human generation

10^9 s



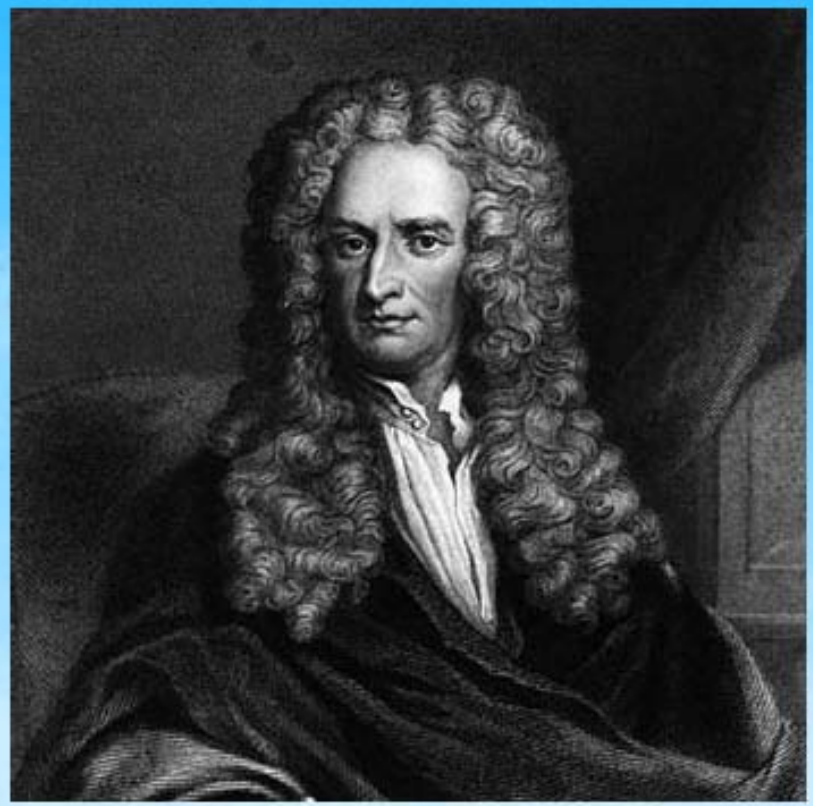
human generation

10^{10} s



time since Newton

10^{10} s

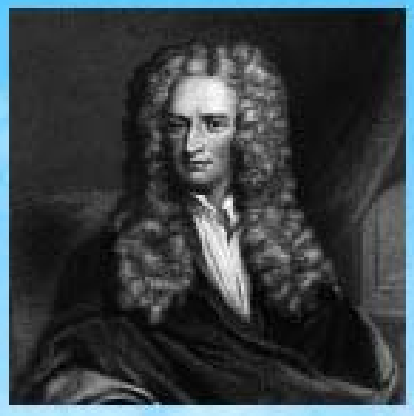


time since Newton

10^{10} s

time since Newton

10^{10} s



time since Newton

10^{10} s

time since Newton

10^{11} s

ancient civilizations

10^{11} s

ancient civilizations

10^{11} s

ancient civilizations

10^{11} s

ancient civilizations

10^{11} s

ancient civilizations

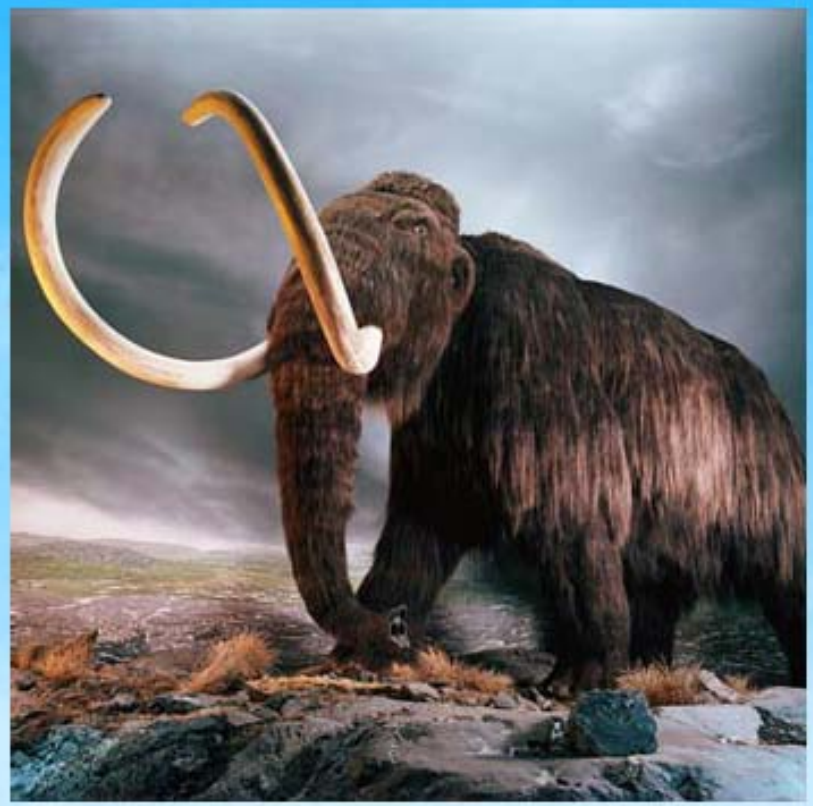
center of galaxy

10^{12} s

most recent ice age

center of galaxy

10^{12} s



most recent ice age

center of galaxy

10^{12} s

most recent ice age

center of galaxy

10^{12} s

most recent ice age

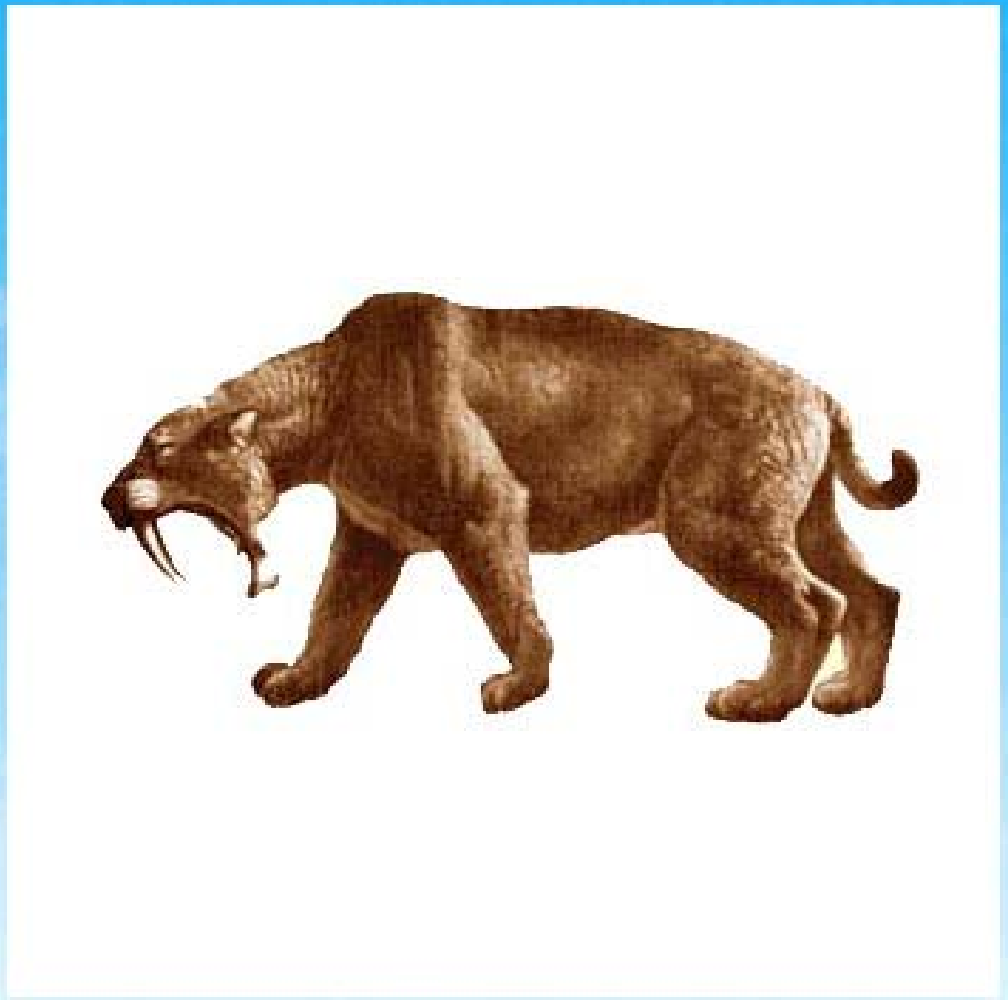
center of galaxy

10^{12} s

most recent ice age

Andromeda galaxy

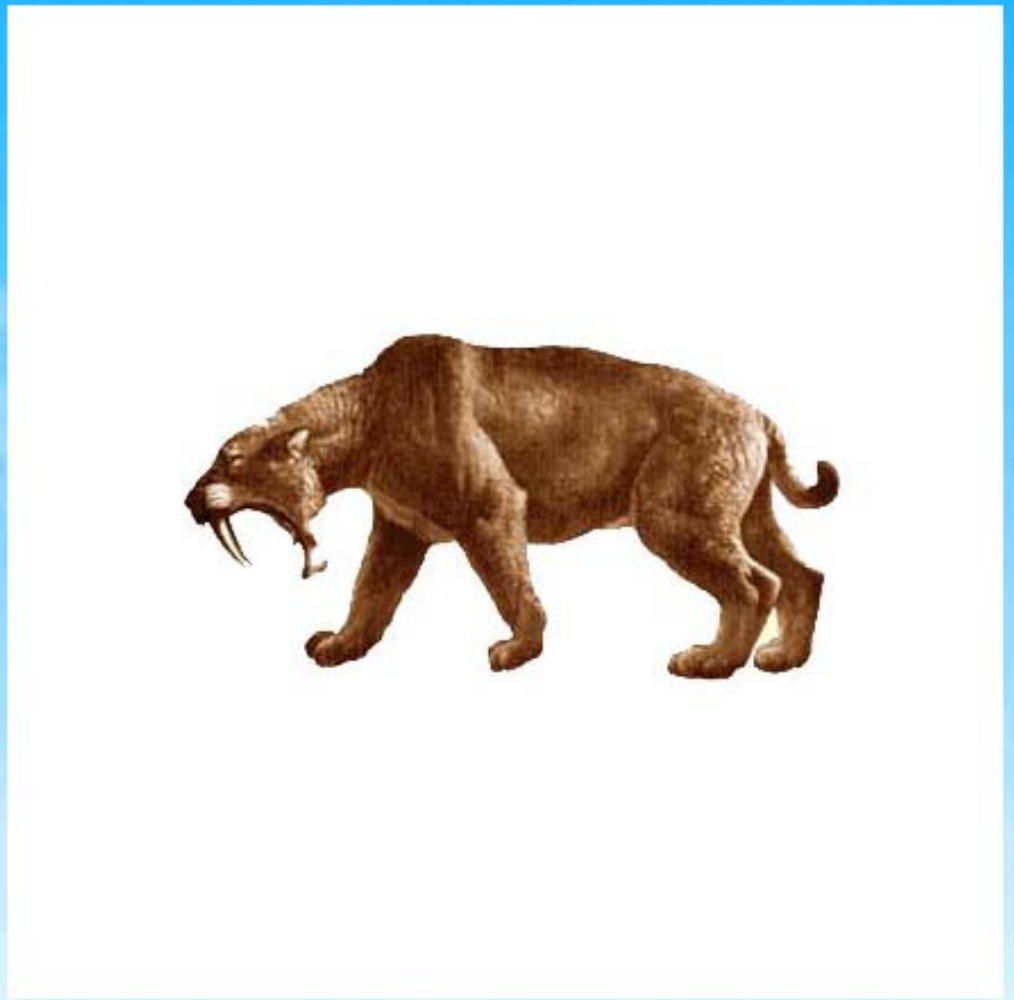
10^{13} s



300,000 years

Andromeda galaxy

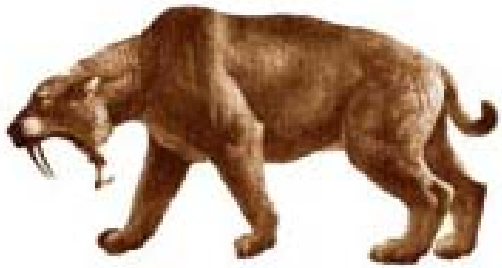
10^{13} s



300,000 years

Andromeda galaxy

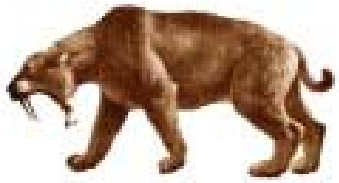
10^{13} s



300,000 years

Andromeda galaxy

10^{13} s



300,000 years

Andromeda galaxy

10^{13} s

300,000 years

10^{14} s

earliest human

10^{14} s

earliest human

10^{14} s

earliest human

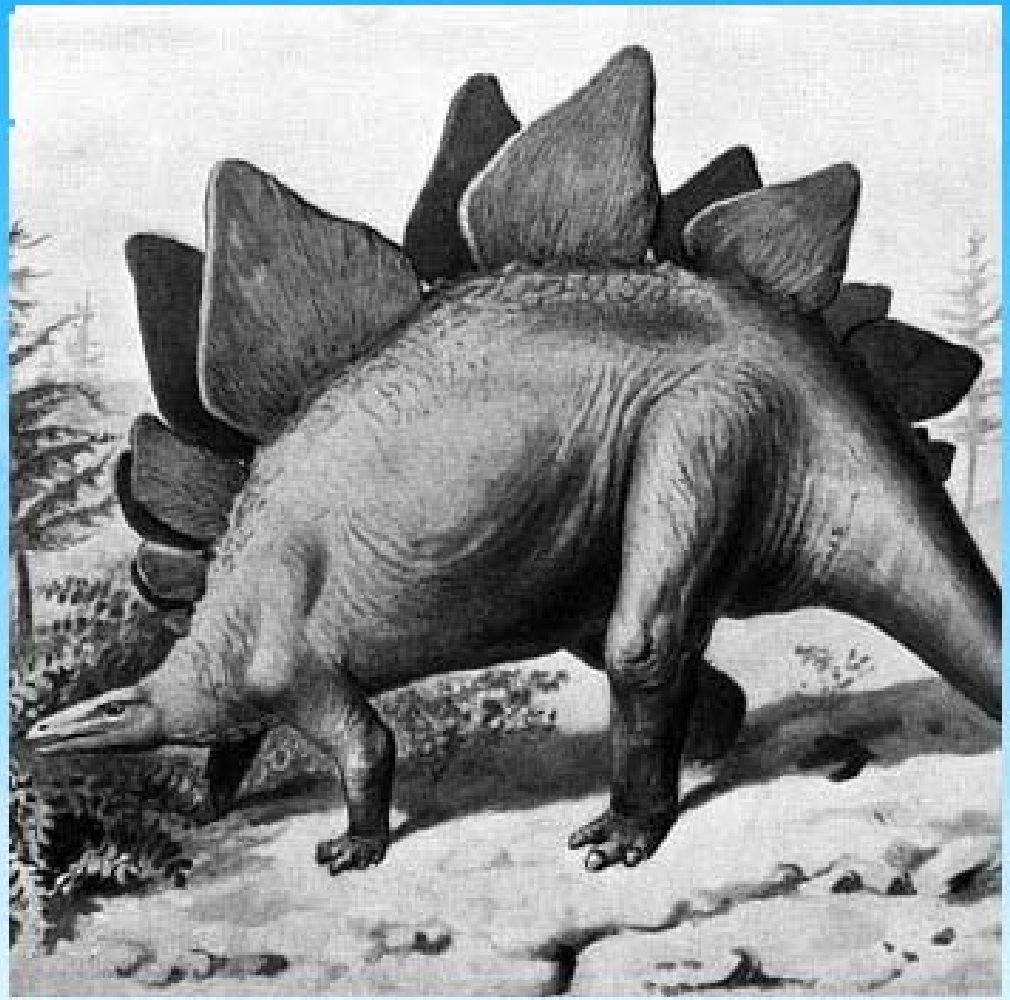
10^{14} s

earliest human

10^{14} s

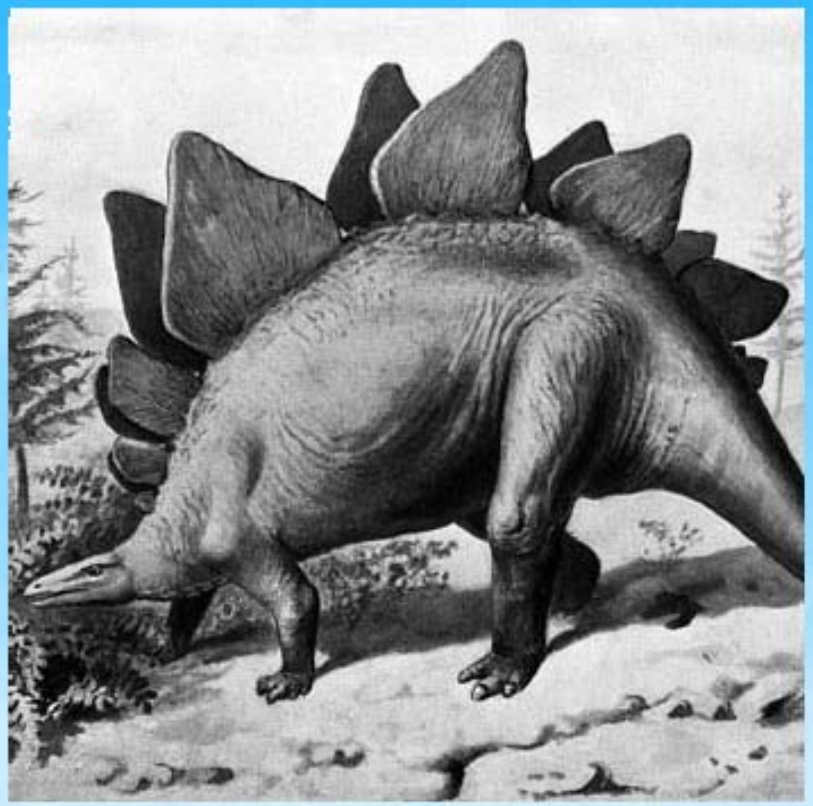
earliest human

10^{15} s



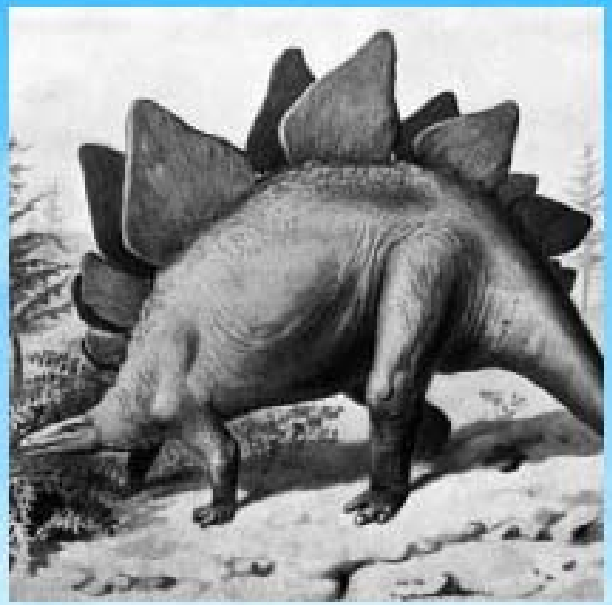
dinosaurs

10^{15} s



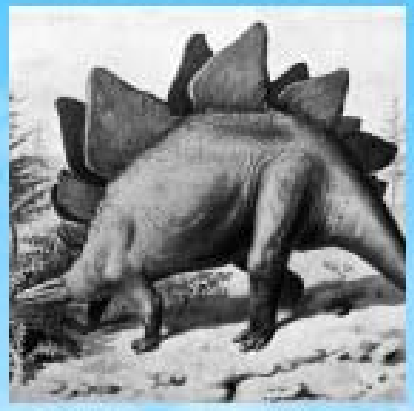
dinosaurs

10^{15} s



dinosaurs

10^{15} s

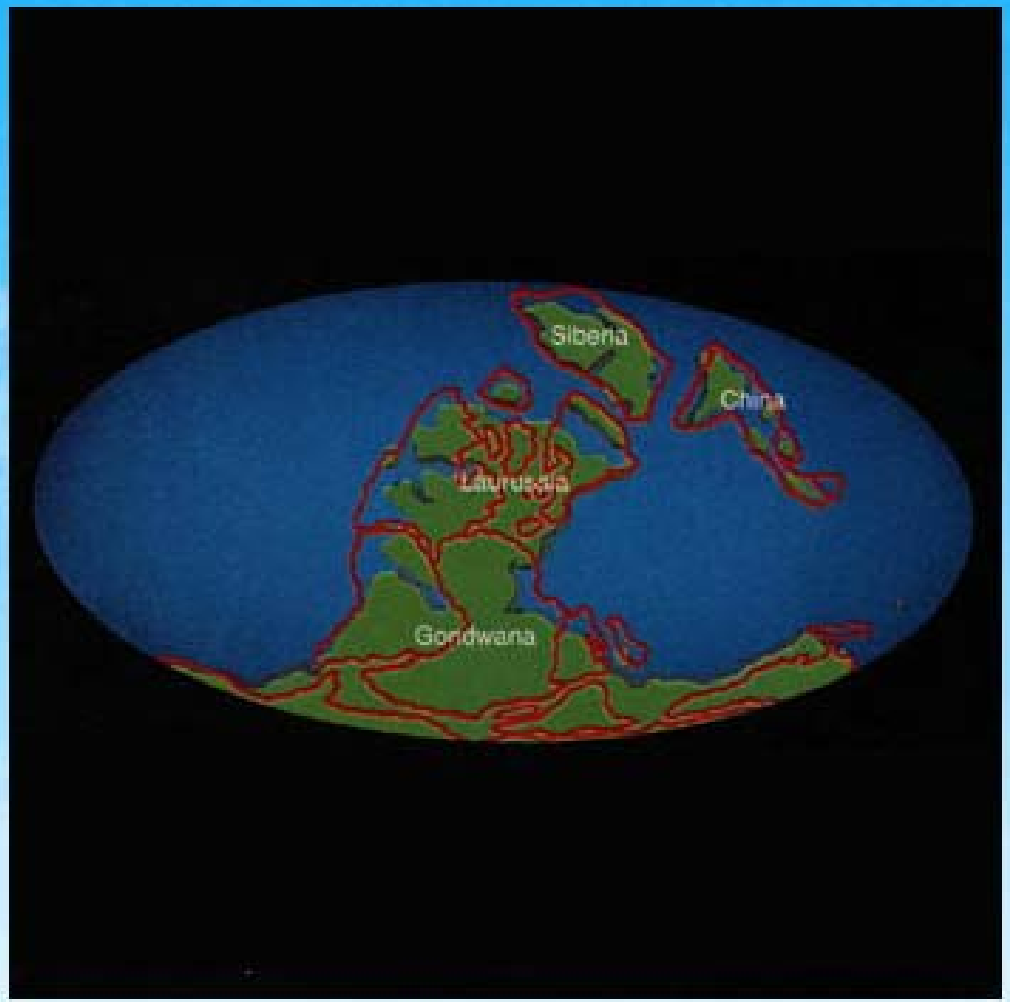


dinosaurs

10^{15} s

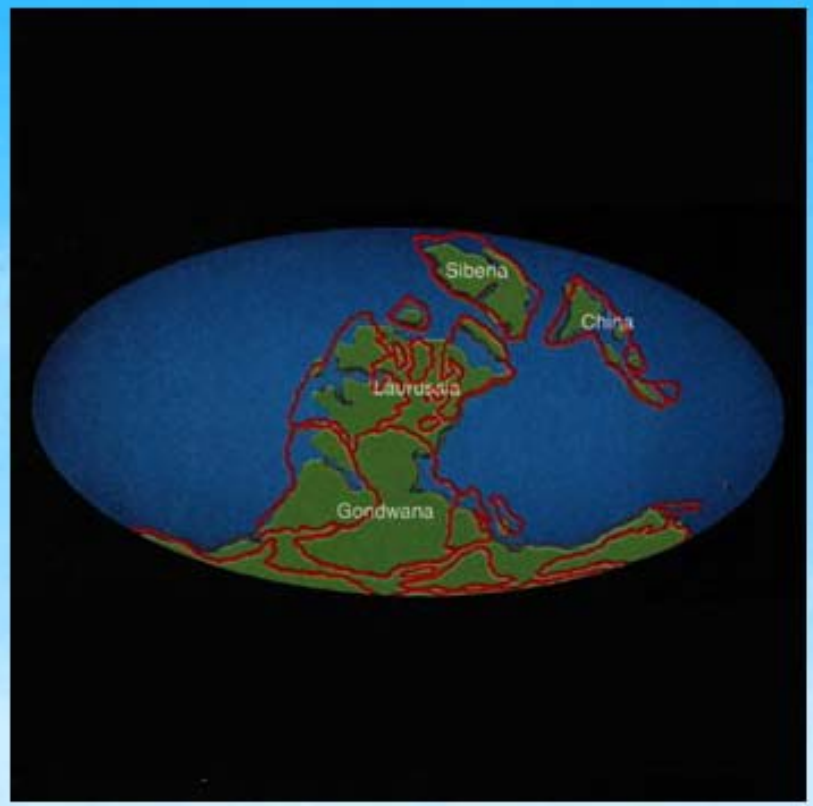
dinosaurs

10^{16} s



continental drift

10^{16} s



continental drift

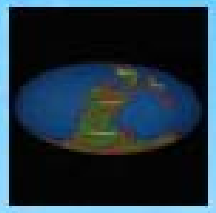
10^{16} s

continental drift

10^{16} s

continental drift

10^{16} s



continental drift

10^{17} s

age of the solar system

10^{17} s

age of the solar system

10^{17} s

age of the solar system

10^{17} s

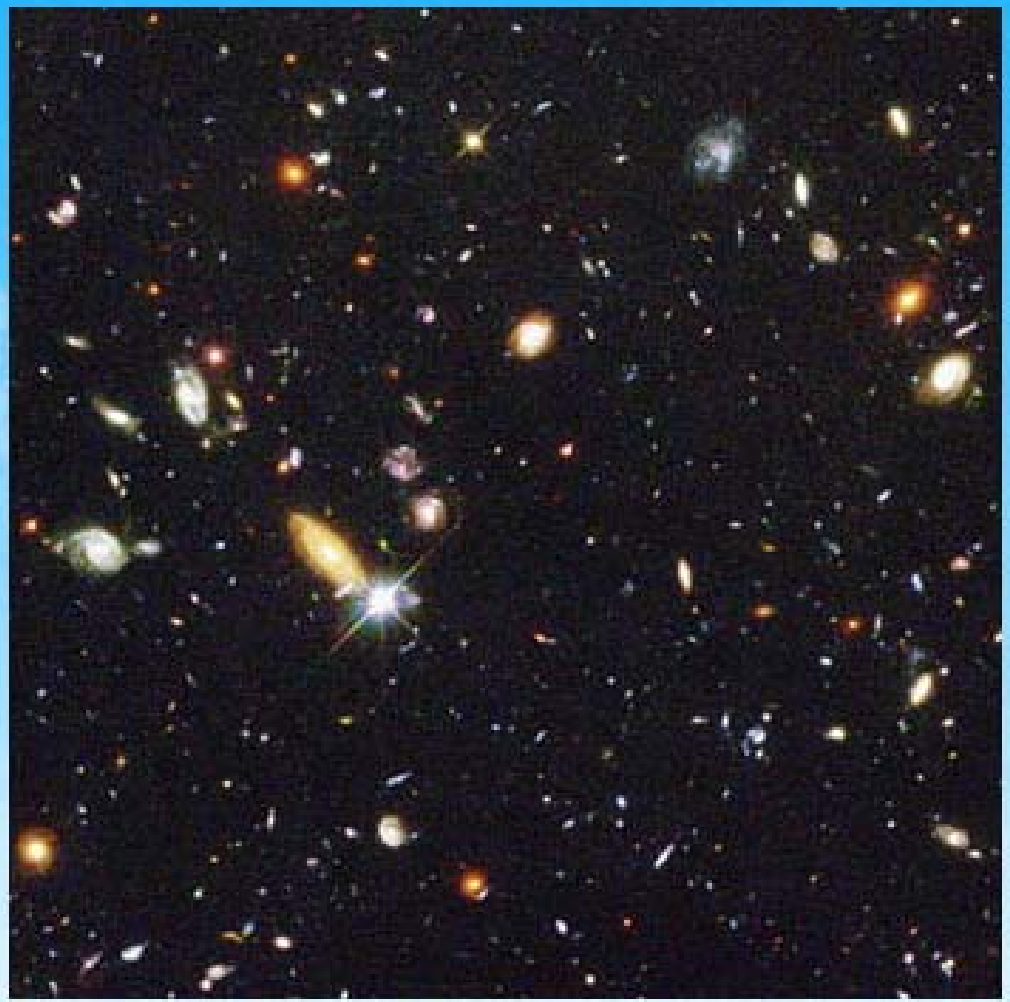
age of the solar system

10^{17} s

age of the solar system

edge of the universe

10^{18} s



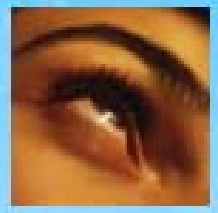
age of known universe

moon

10^0 s

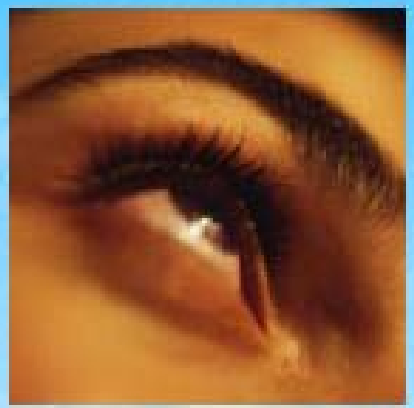
one second

10^{-1} s



blink of an eye

10^{-1} s



blink of an eye

10^{-1} s

blink of an eye

10^{-1} s

blink of an eye

10^{-1} s

blink of an eye

10^{-2} s

golf swing

10^{-2} s

golf swing

10^{-2} s

golf swing

10^{-2} s

golf swing

10^{-2} s

golf swing

San Francisco

10^{-3} s

wingbeat of fly

San Francisco

10^{-3} s

wingbeat of fly

San Francisco

10^{-3} s

wingbeat of fly

San Francisco

10^{-3} s

wingbeat of fly

San Francisco

10^{-3} s

wingbeat of fly

10^{-4} s

lightning

10^{-4} s

lightning

10^{-4} s

lightning

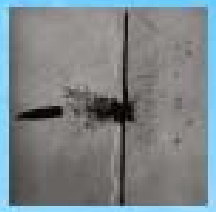
10^{-4} s

lightning

10^{-4} s

lightning

10^{-5} s



bullet through glass

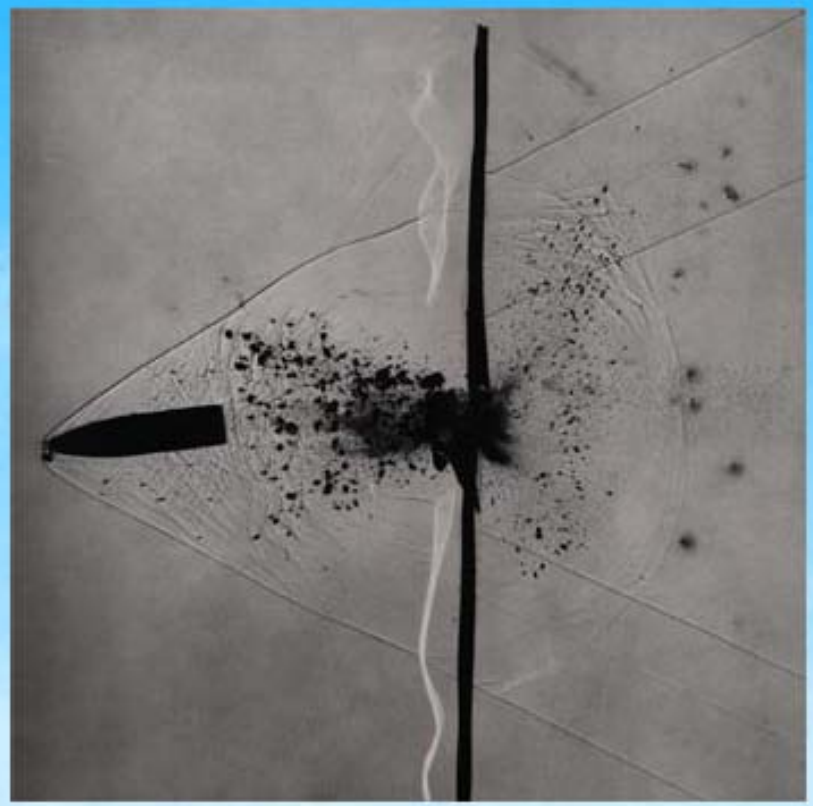
10^{-5} s

bullet through glass

10^{-5} s

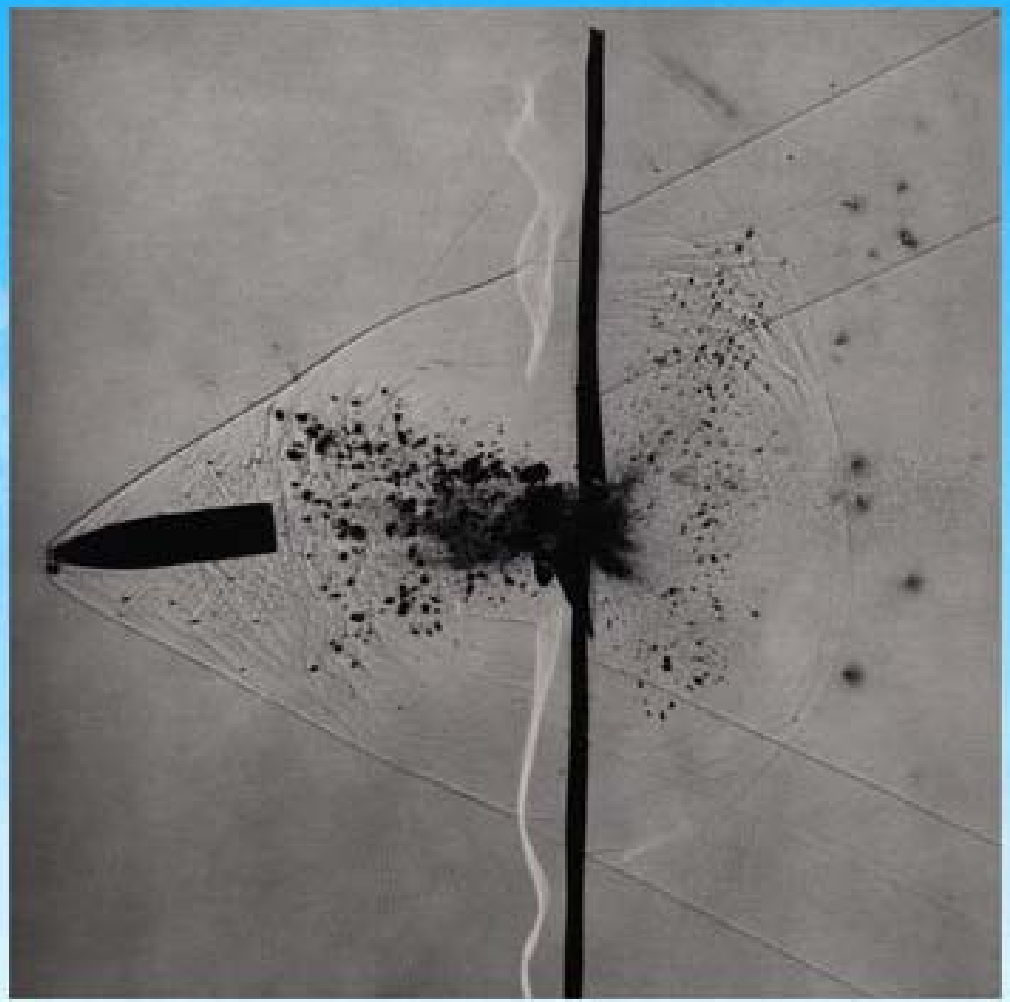
bullet through glass

10^{-5} s



bullet through glass

10^{-5} s

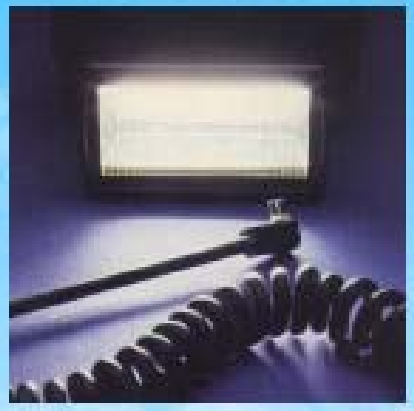


bullet through glass

10^{-6} s

strobe flash

10^{-6} s



strobe flash

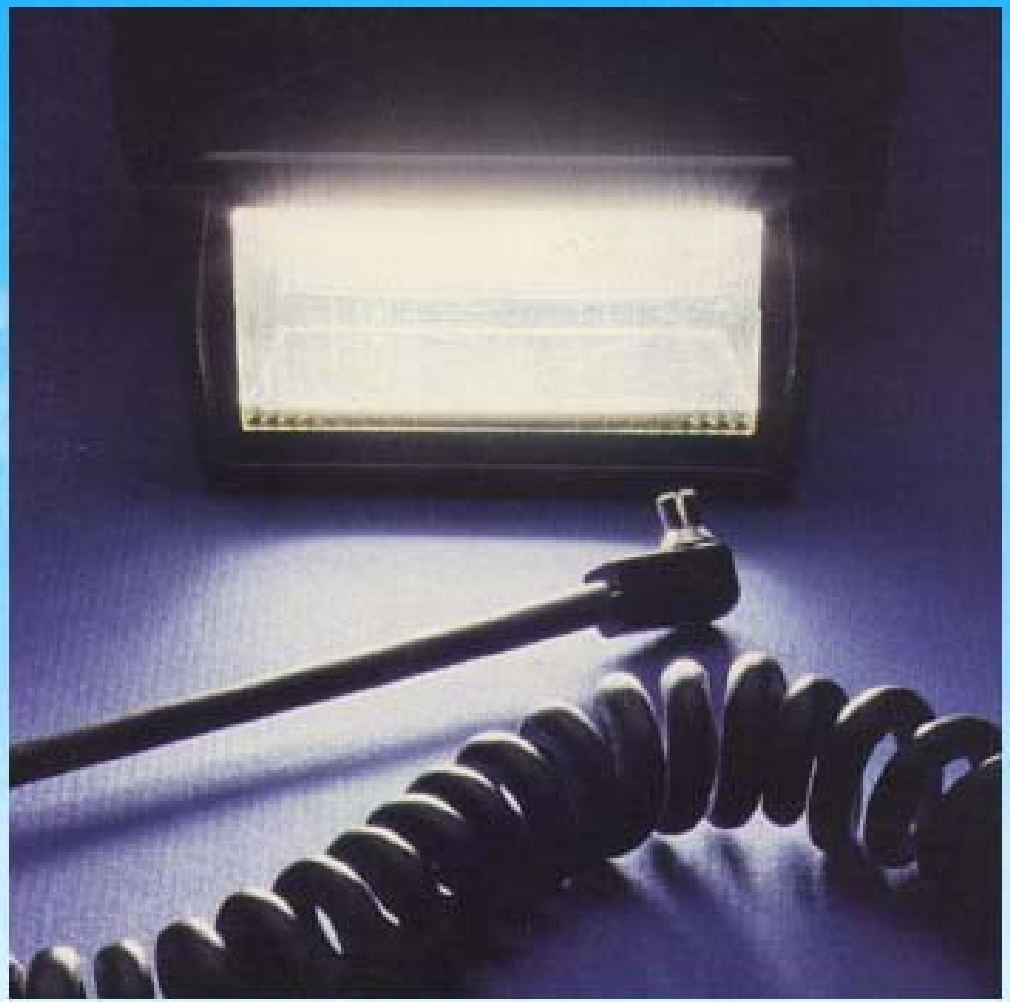
10^{-6} s

strobe flash

10^{-6} s

strobe flash

10^{-6} s



strobe flash

lecture hall

10^{-7} s

hard disk write time

lecture hall

10^{-7} s

hard disk write time

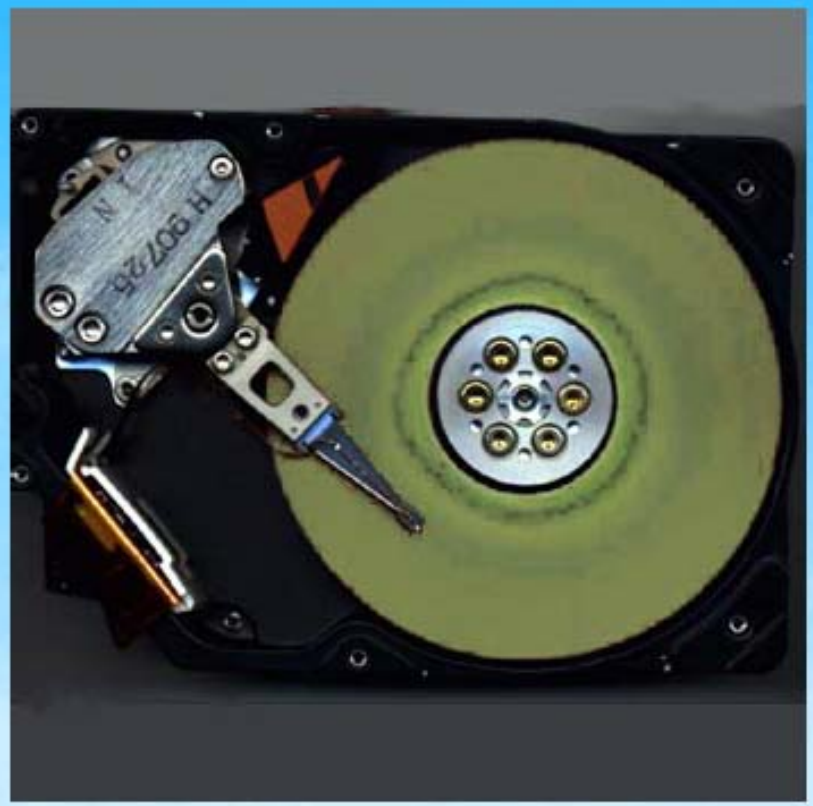
lecture hall

10^{-7} s

hard disk write time

lecture hall

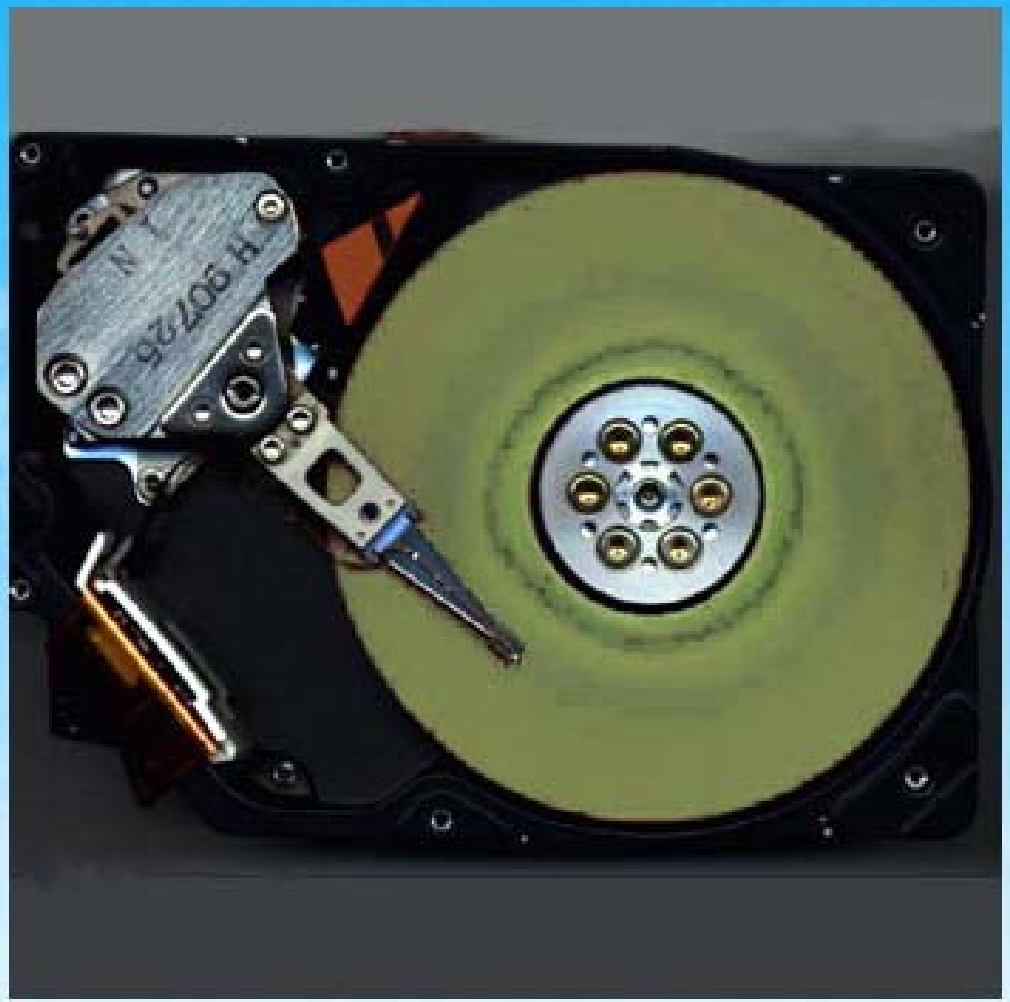
10^{-7} s



hard disk write time

lecture hall

10^{-7} s



hard disk write time

10^{-8} s

Deep Blue calculation

10^{-8} s

Deep Blue calculation

10^{-8} s

Deep Blue calculation

10^{-8} s

Deep Blue calculation

10^{-8} s

Deep Blue calculation

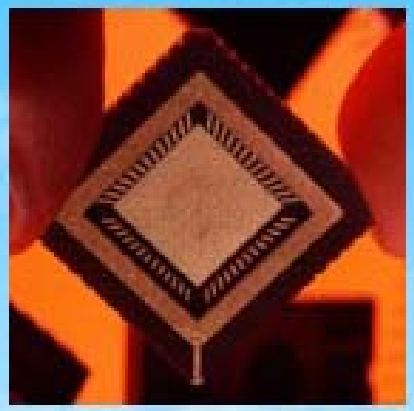
one foot

10^{-9} s

clock speed of chip

one foot

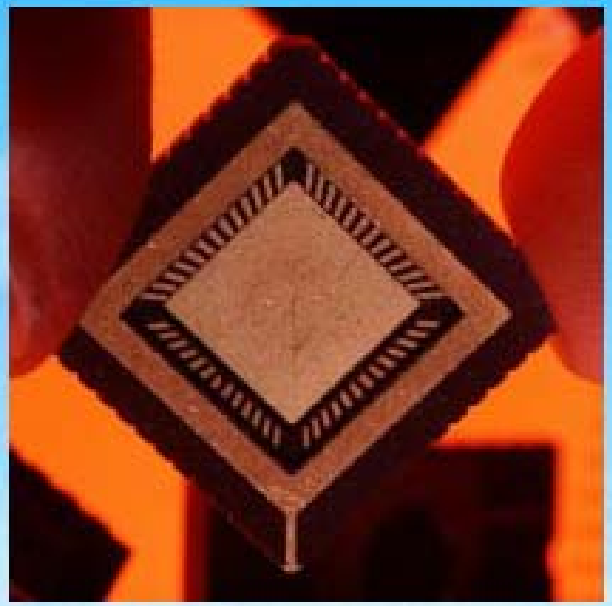
10^{-9} s



clock speed of chip

one foot

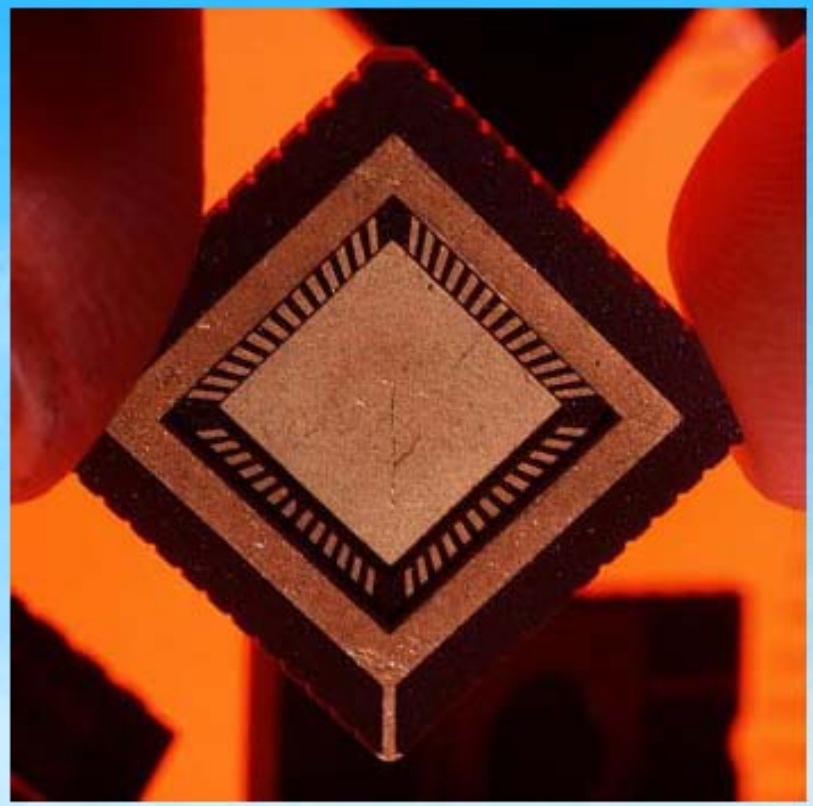
10^{-9} s



clock speed of chip

one foot

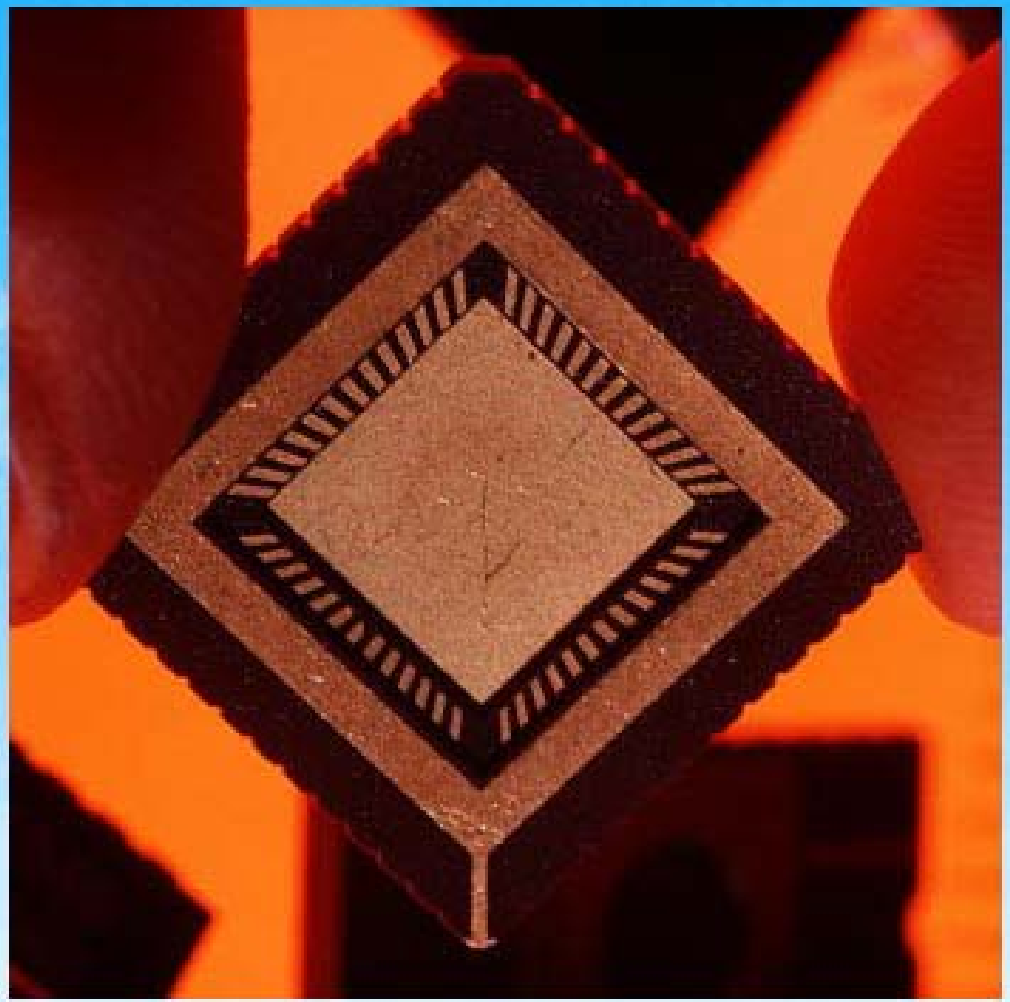
10^{-9} s



clock speed of chip

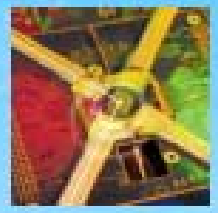
one foot

10^{-9} s



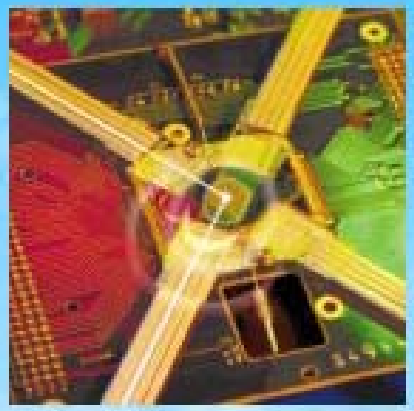
clock speed of chip

10^{-10} s



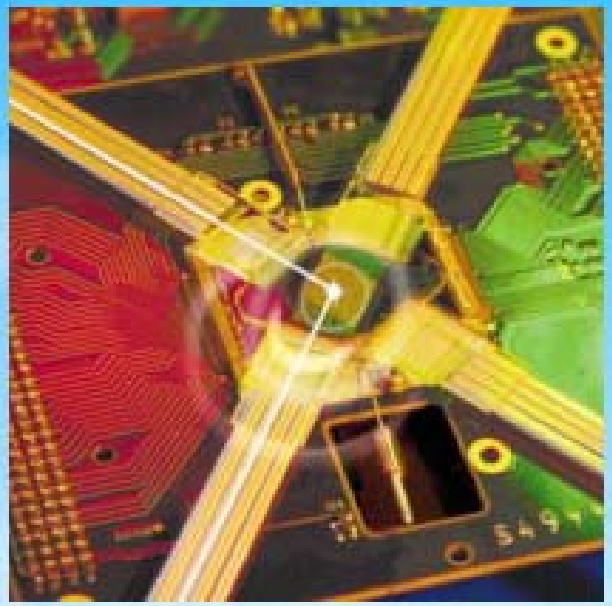
fastest electronic switch

10^{-10} s



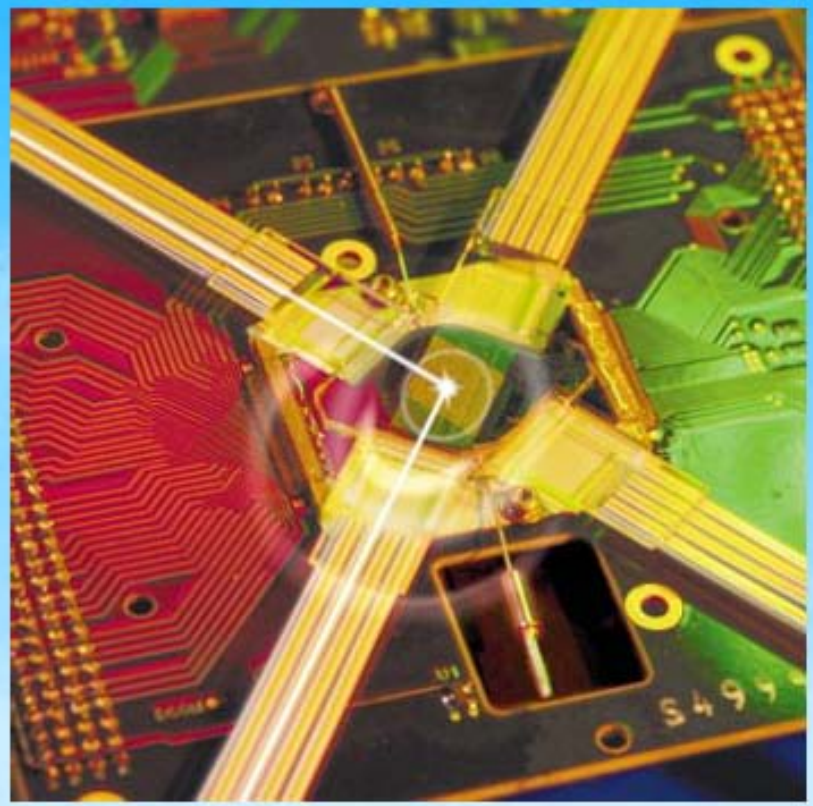
fastest electronic switch

10^{-10} s



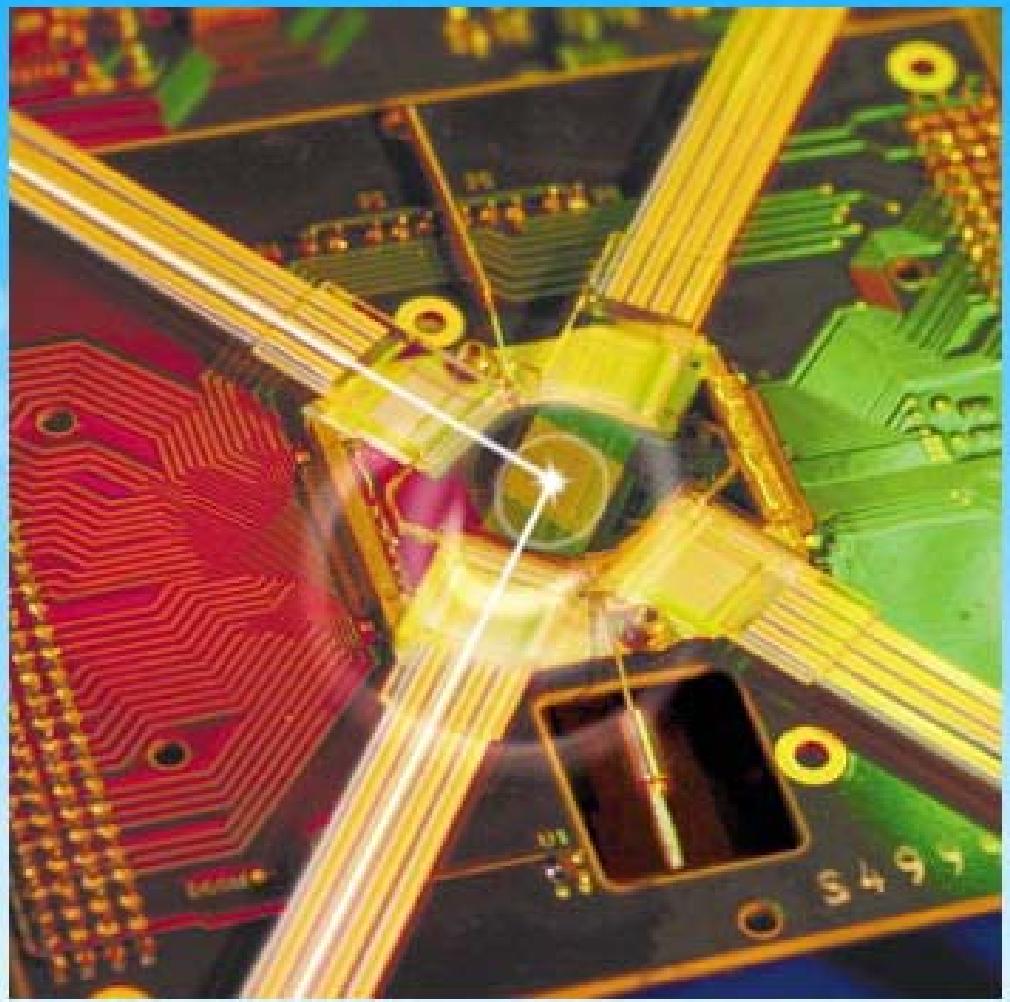
fastest electronic switch

10^{-10} s



fastest electronic switch

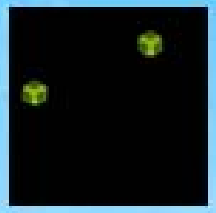
10^{-10} s



fastest electronic switch

window pane

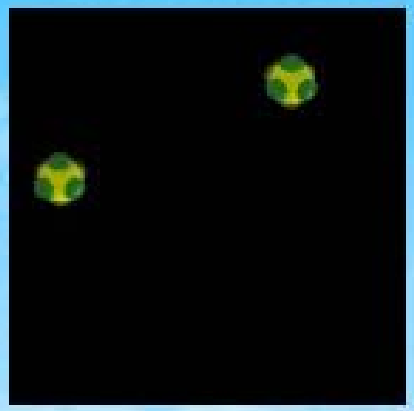
10^{-11} s



molecular collision

window pane

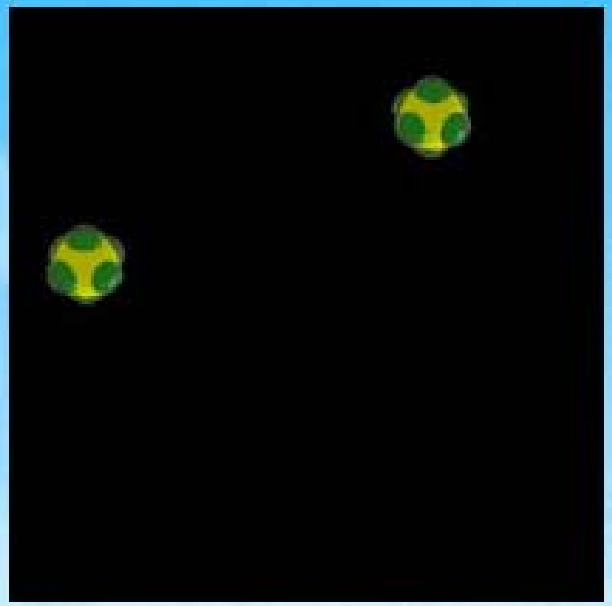
10^{-11} s



molecular collision

window pane

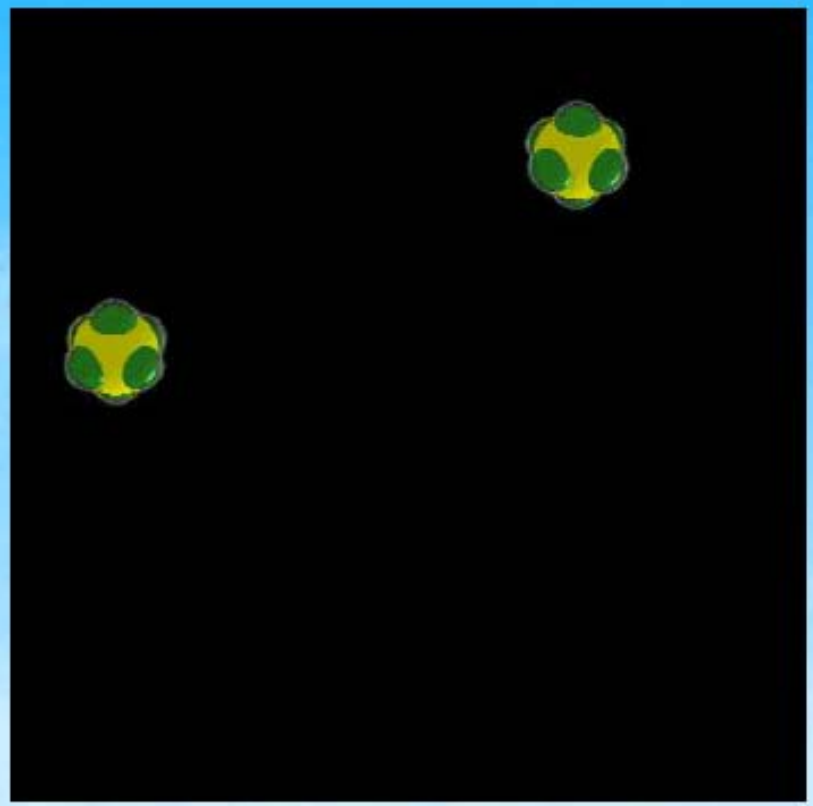
10^{-11} s



molecular collision

window pane

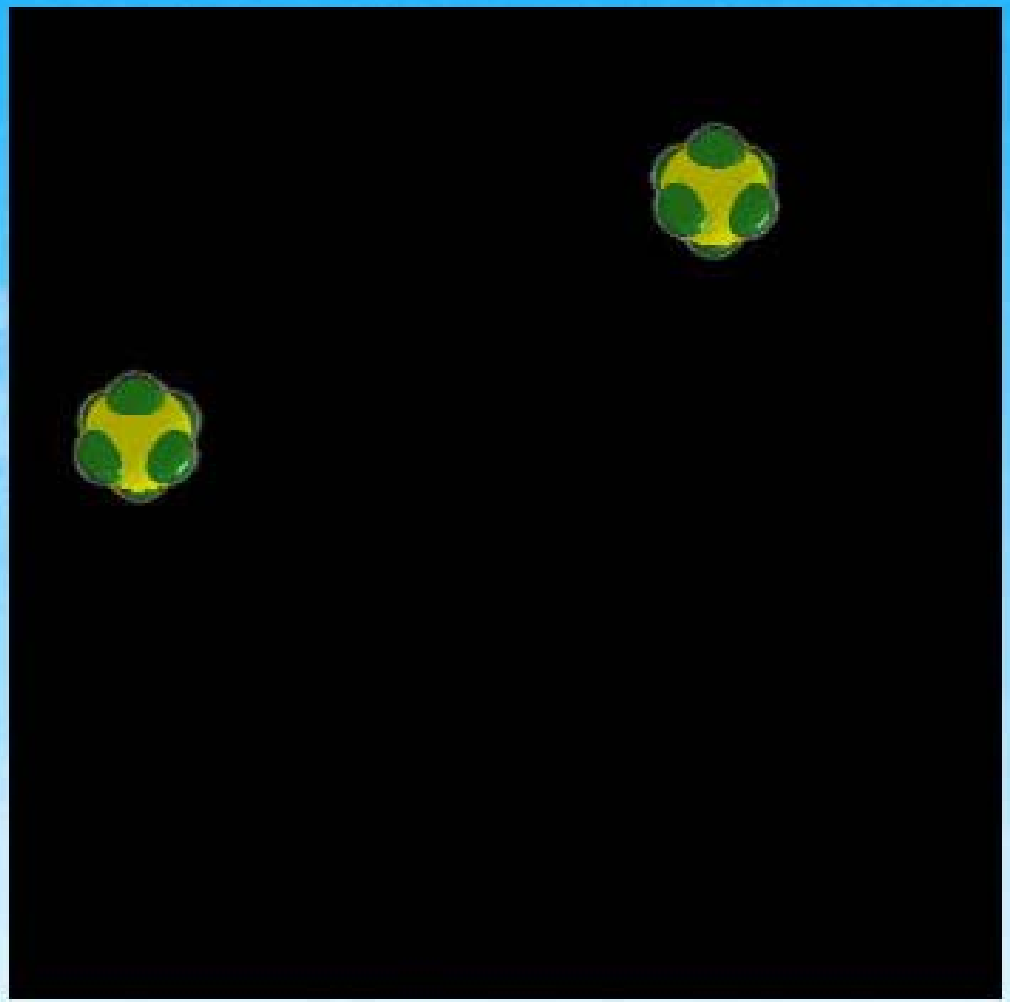
10^{-11} s



molecular collision

window pane

10^{-11} s



molecular collision

10^{-12} s

molecular rotation

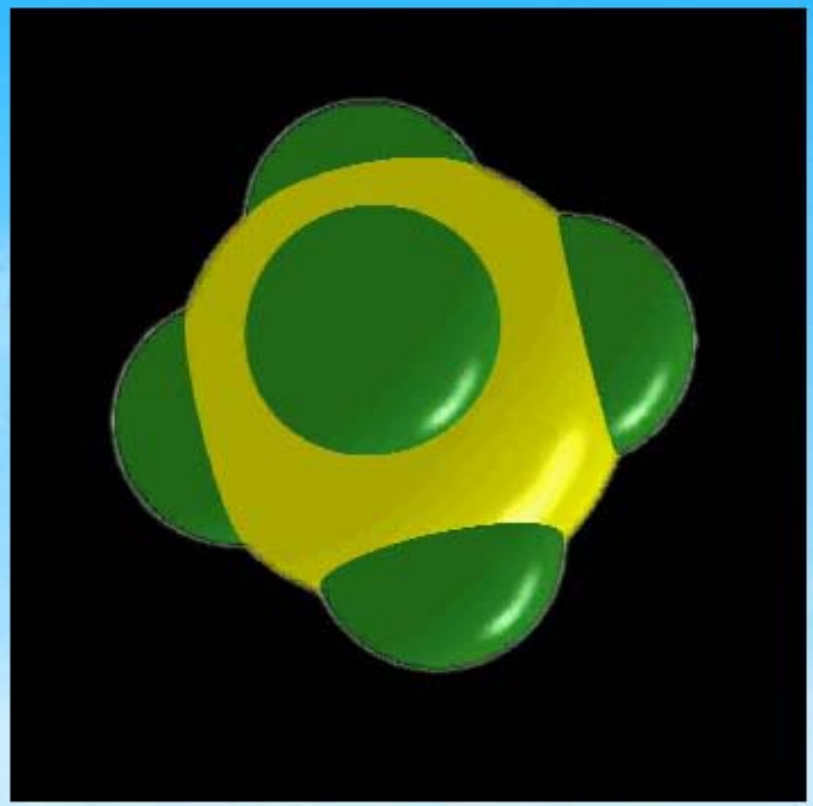
10^{-12} s

molecular rotation

10^{-12} s

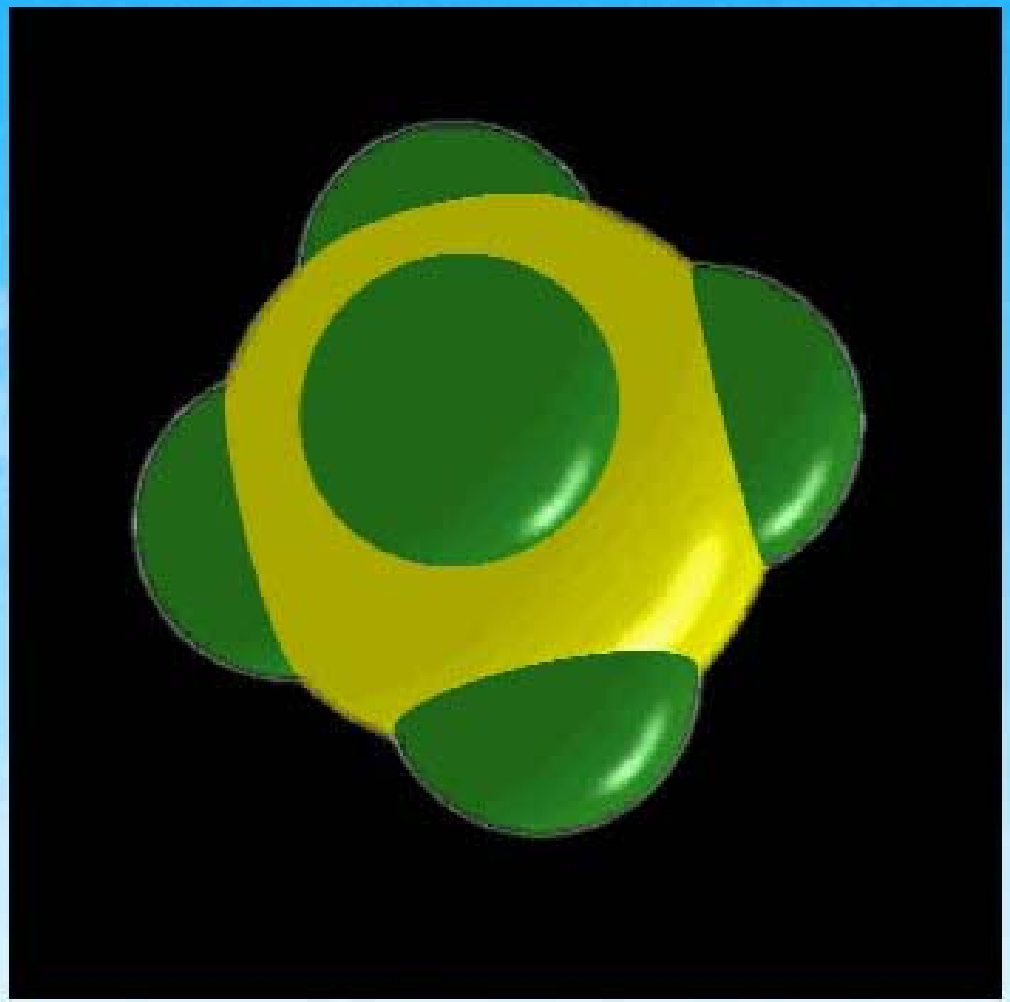
molecular rotation

10^{-12} s



molecular rotation

10^{-12} s



molecular rotation

width of human hair

10^{-13} s

molecular vibration

width of human hair

10^{-13} s

molecular vibration

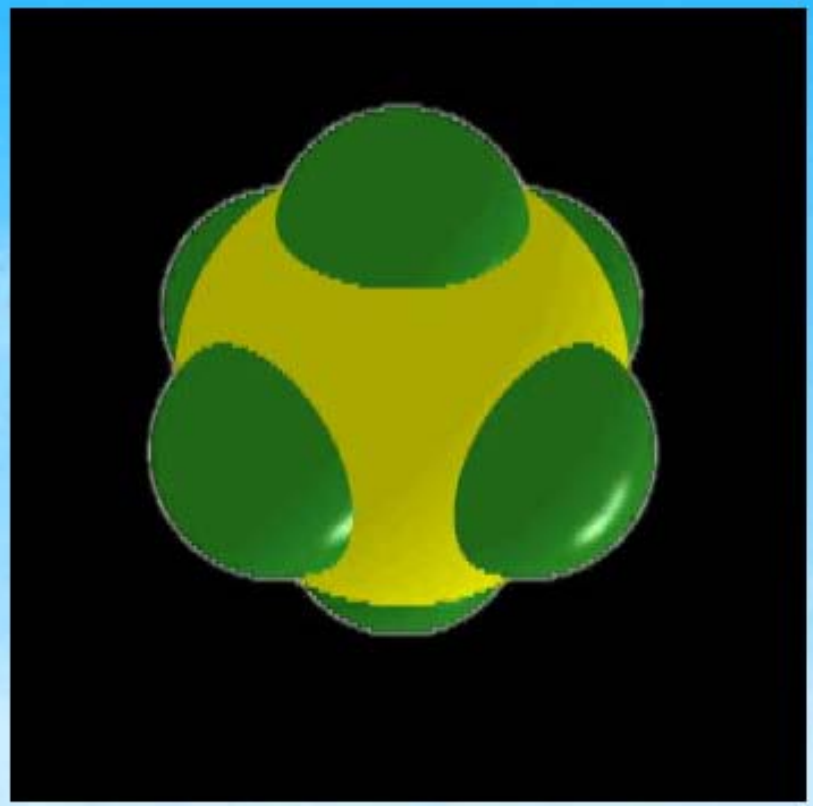
width of human hair

10^{-13} s

molecular vibration

width of human hair

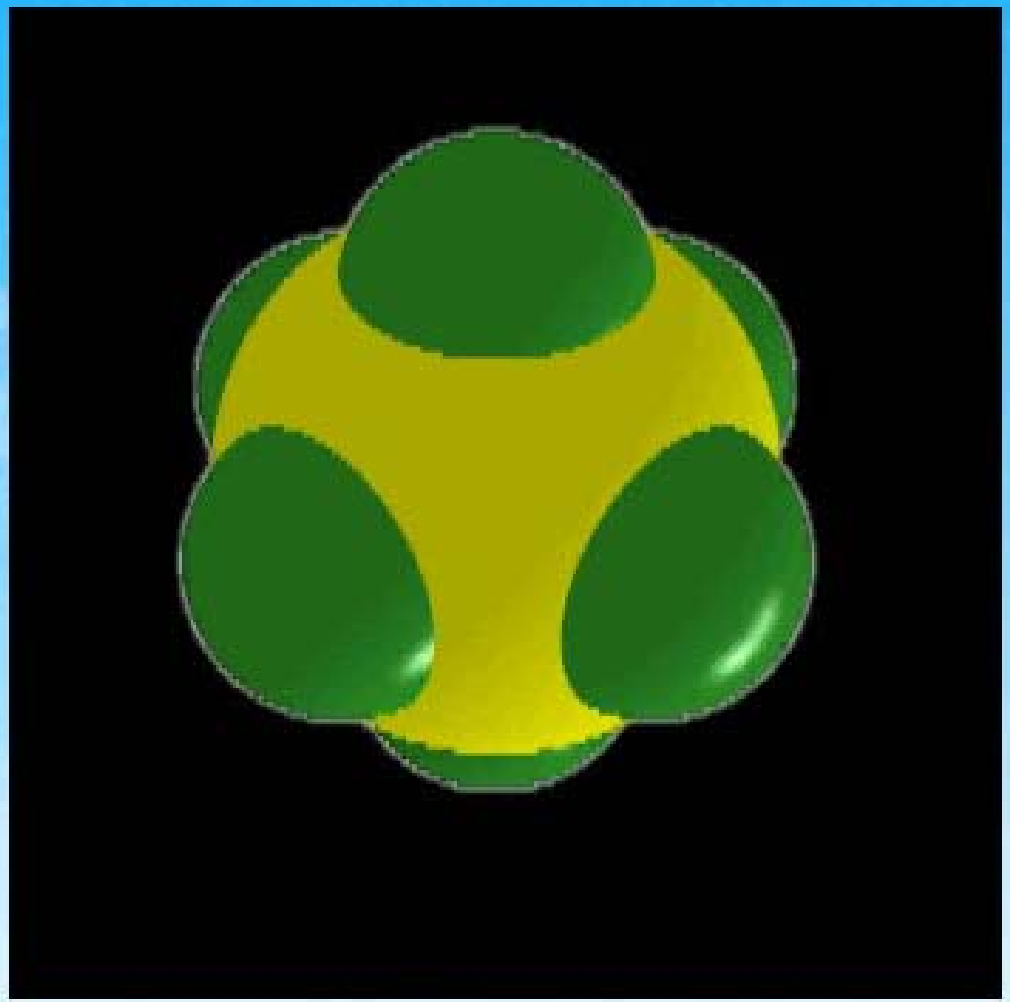
10^{-13} s



molecular vibration

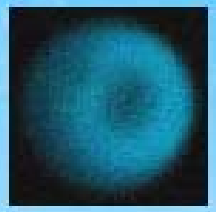
width of human hair

10^{-13} s



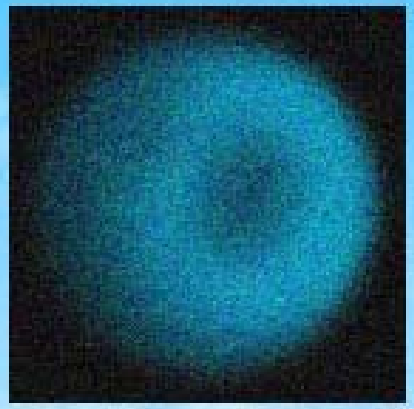
molecular vibration

10^{-14} s



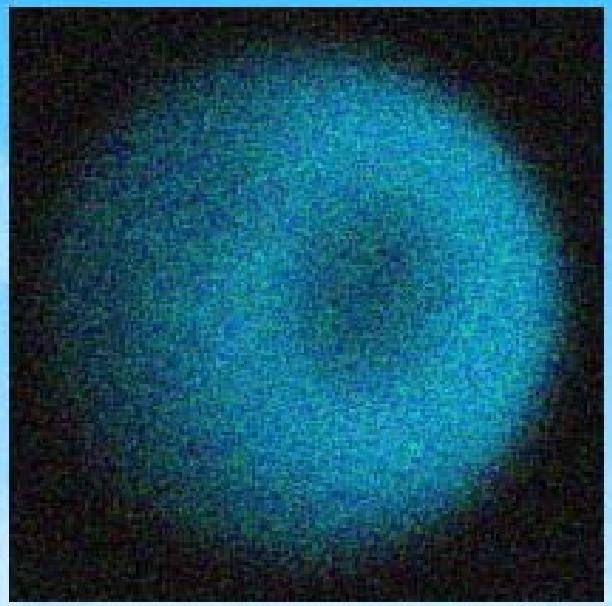
electronic collision

10^{-14} s



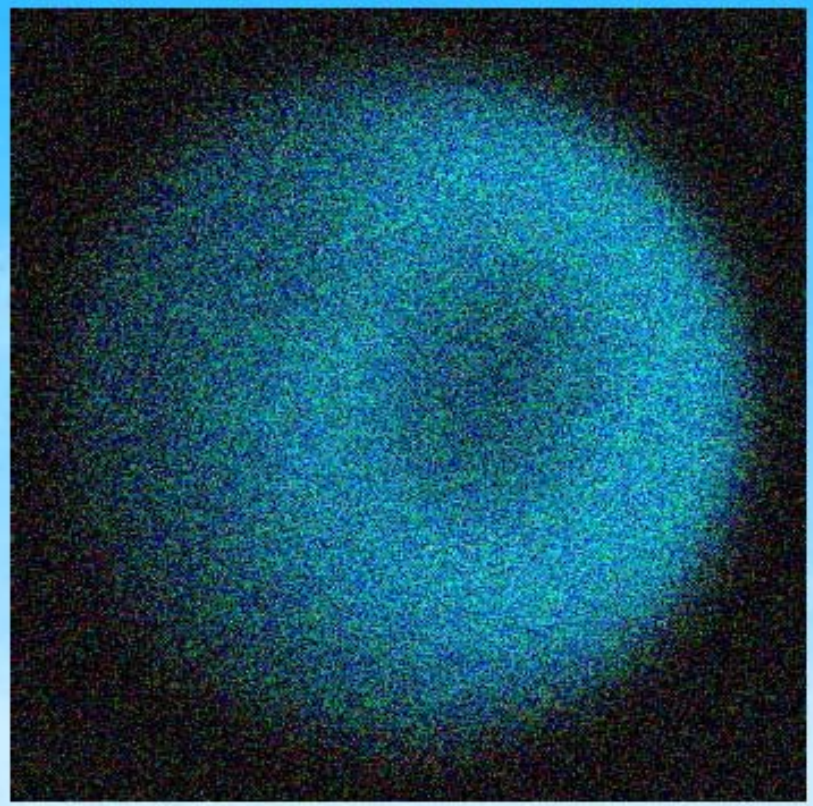
electronic collision

10^{-14} s



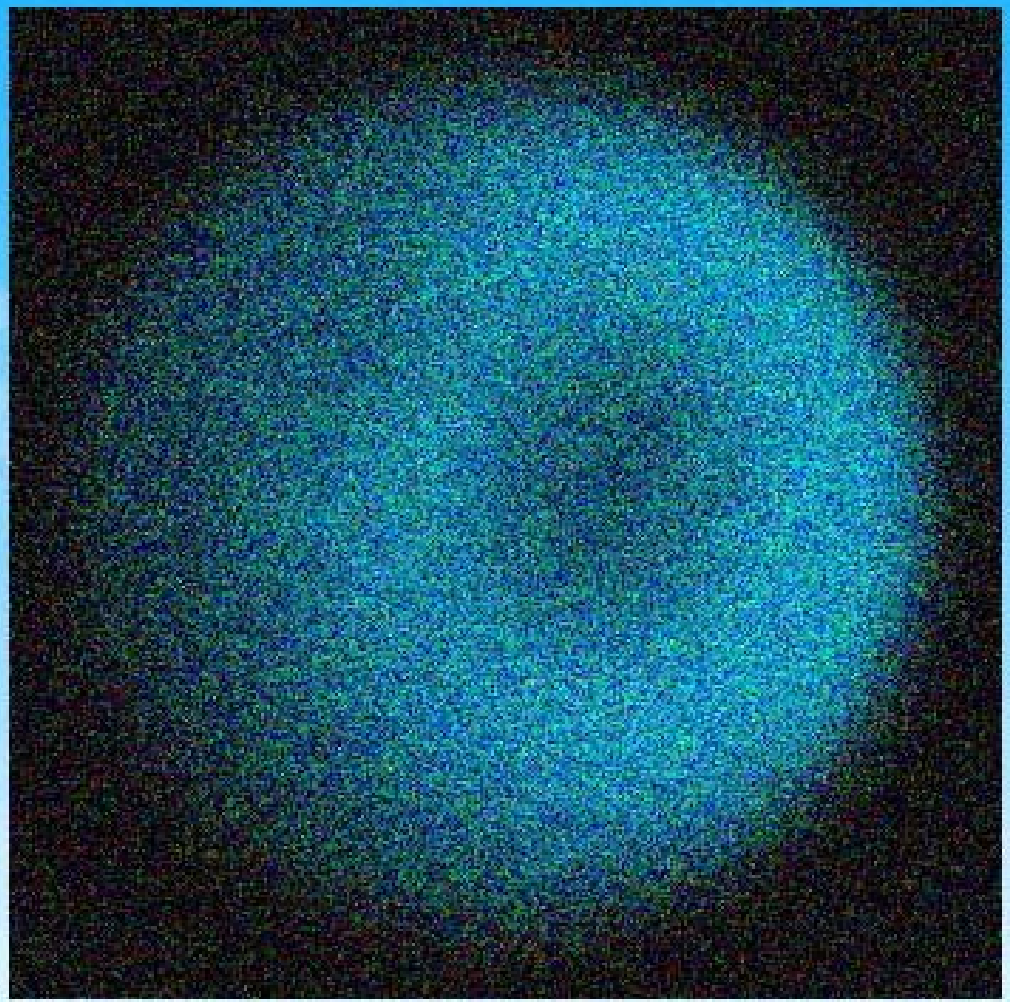
electronic collision

10^{-14} s



electronic collision

10^{-14} s

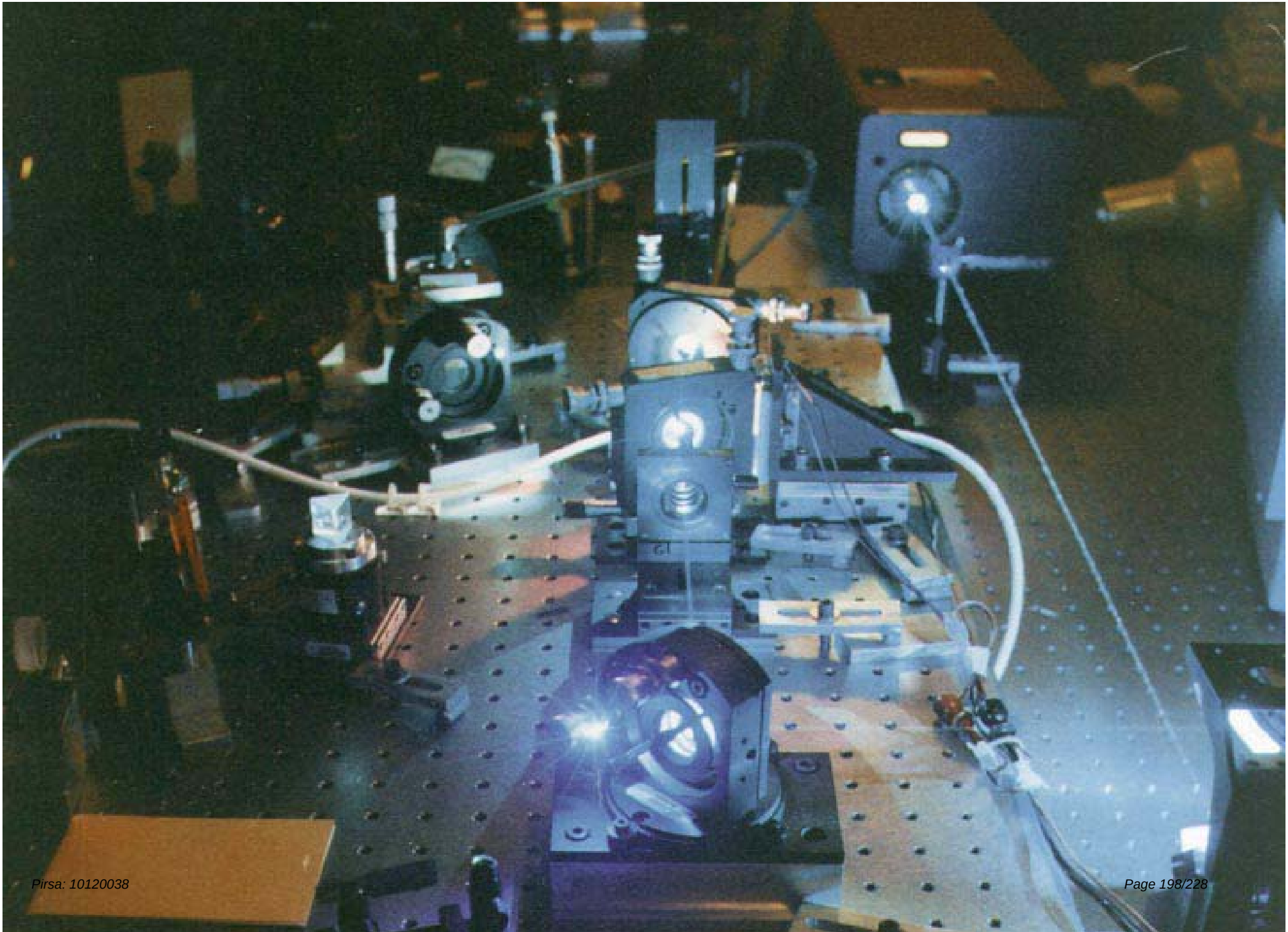


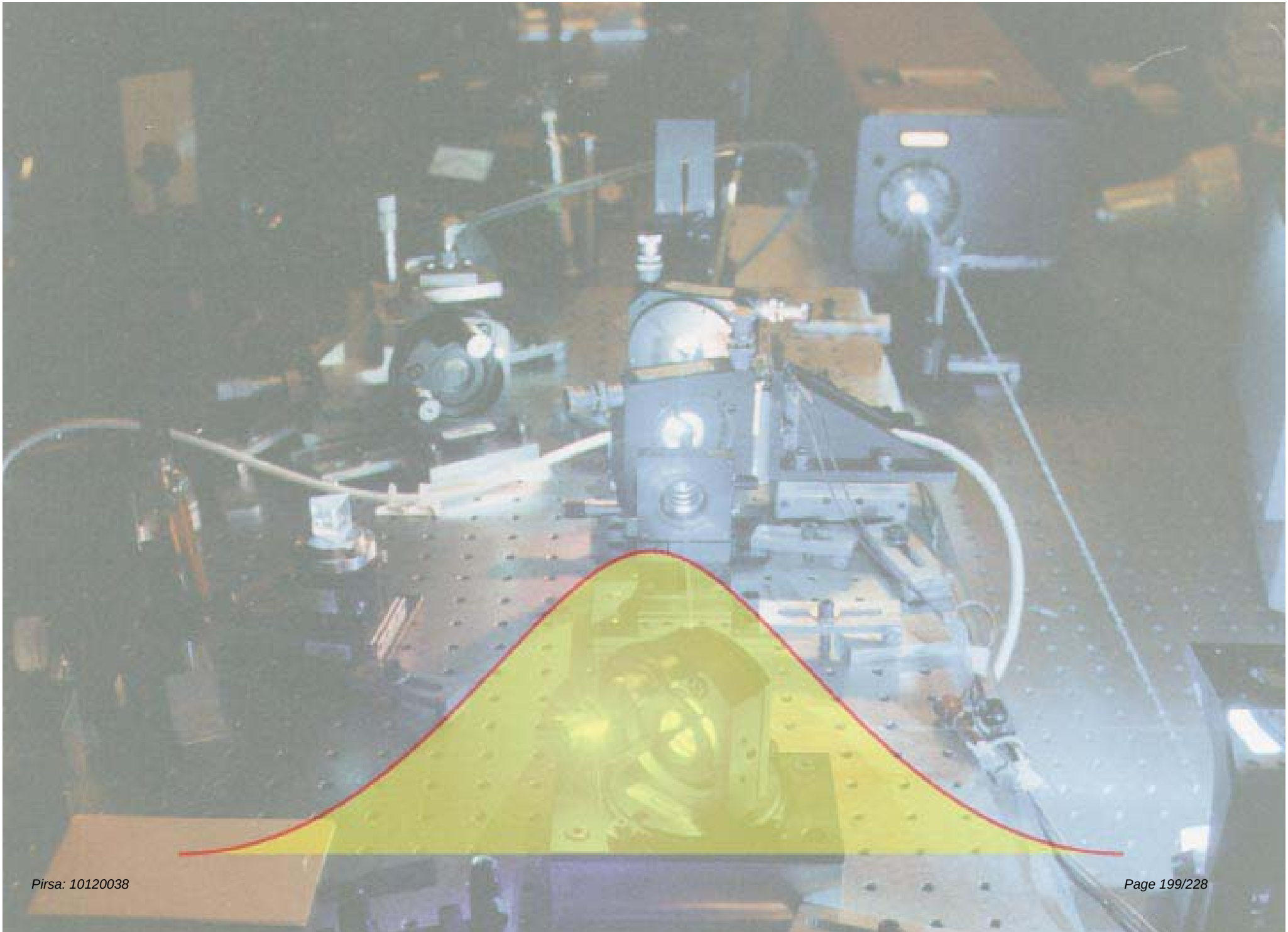
electronic collision

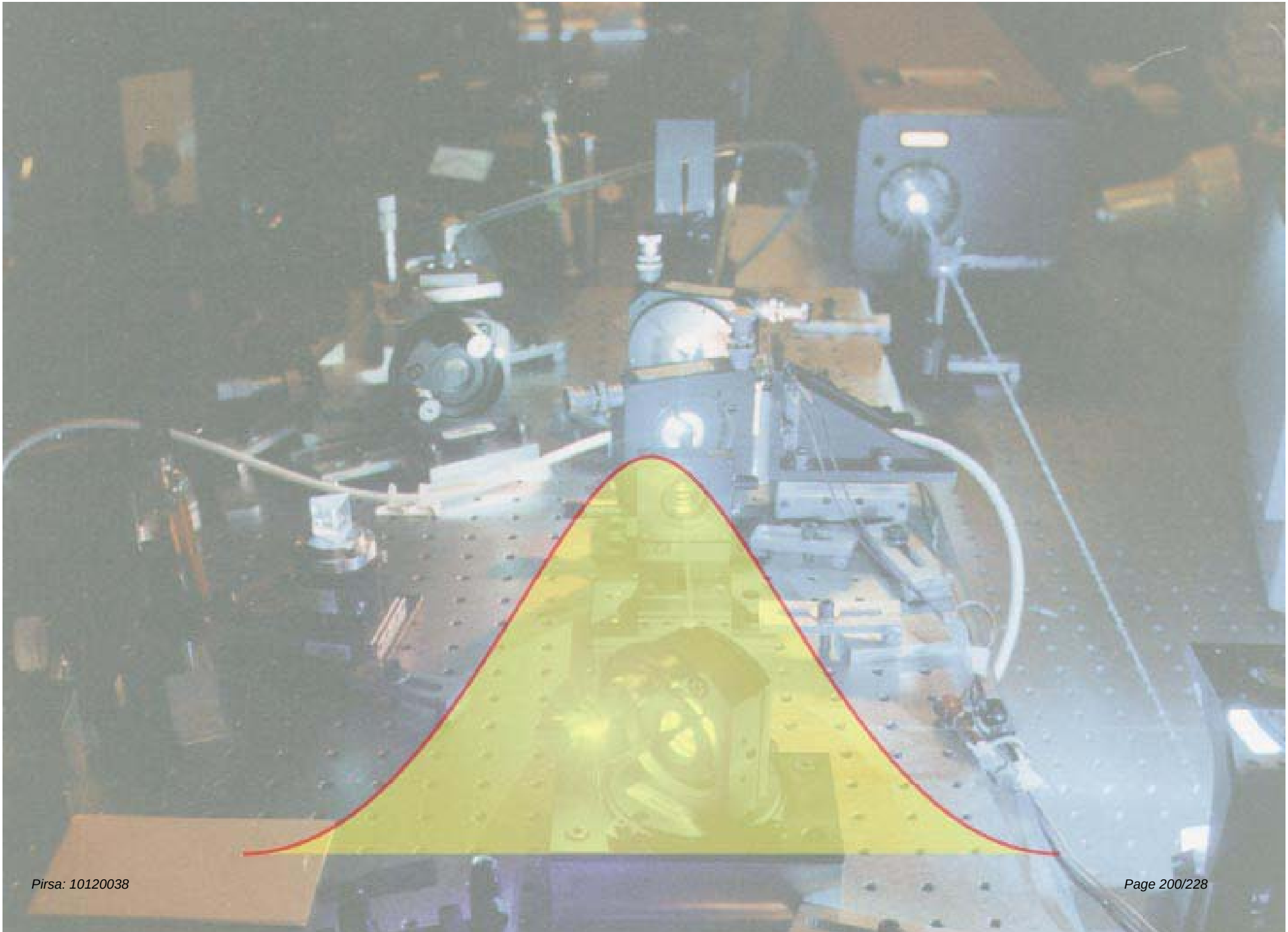
100 atomic layers

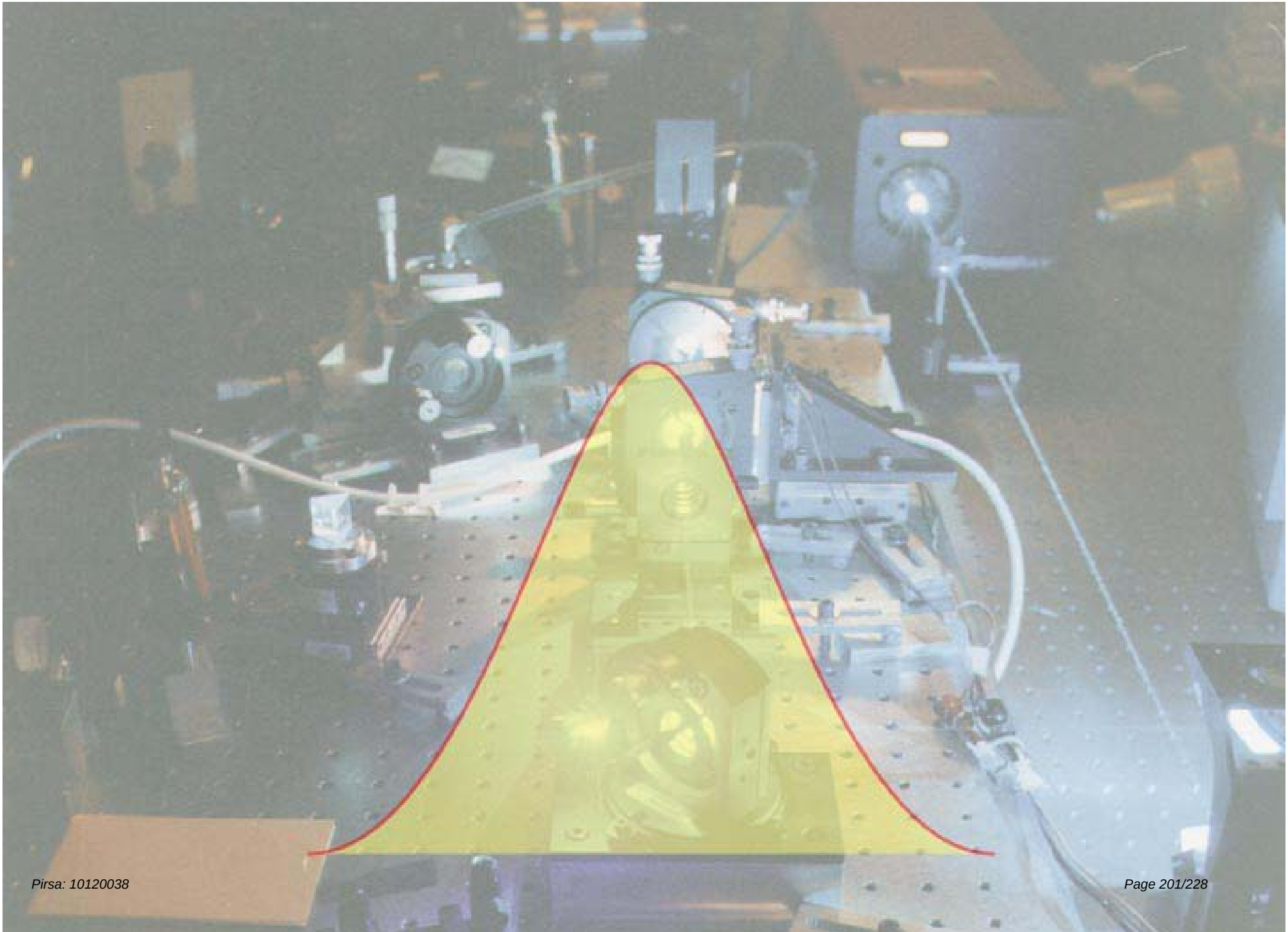
10^{-15} s

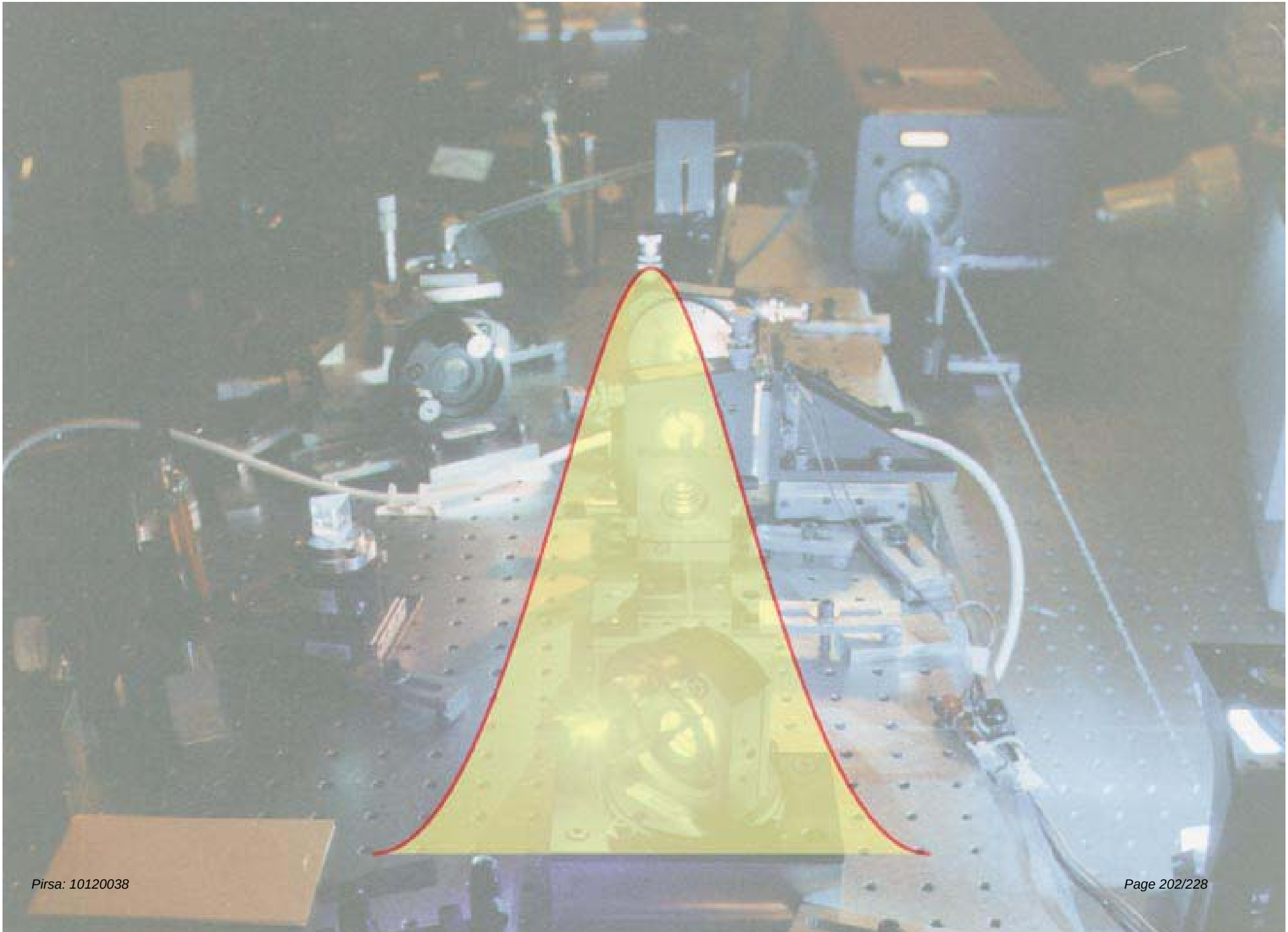
one "femtosecond"

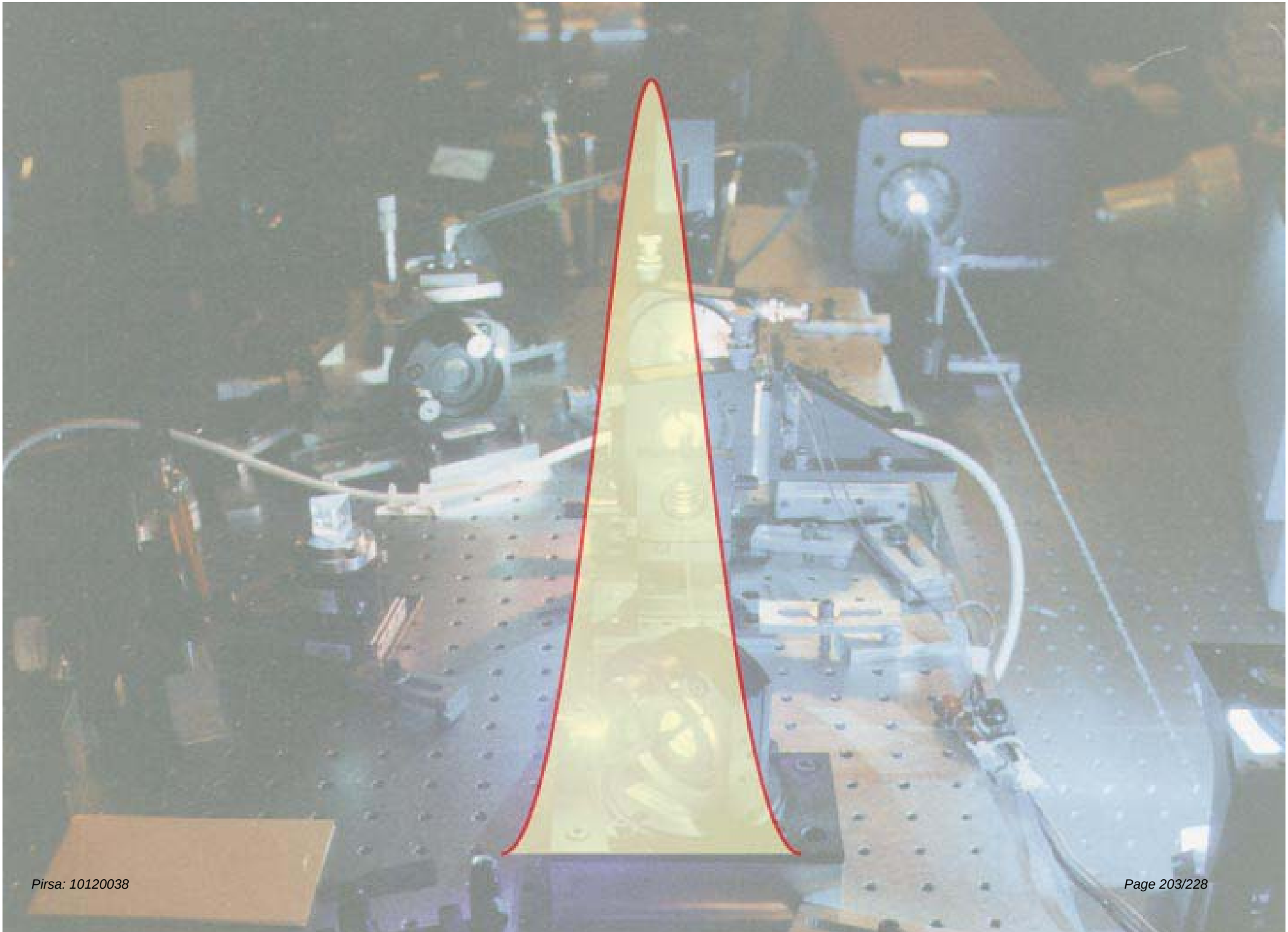


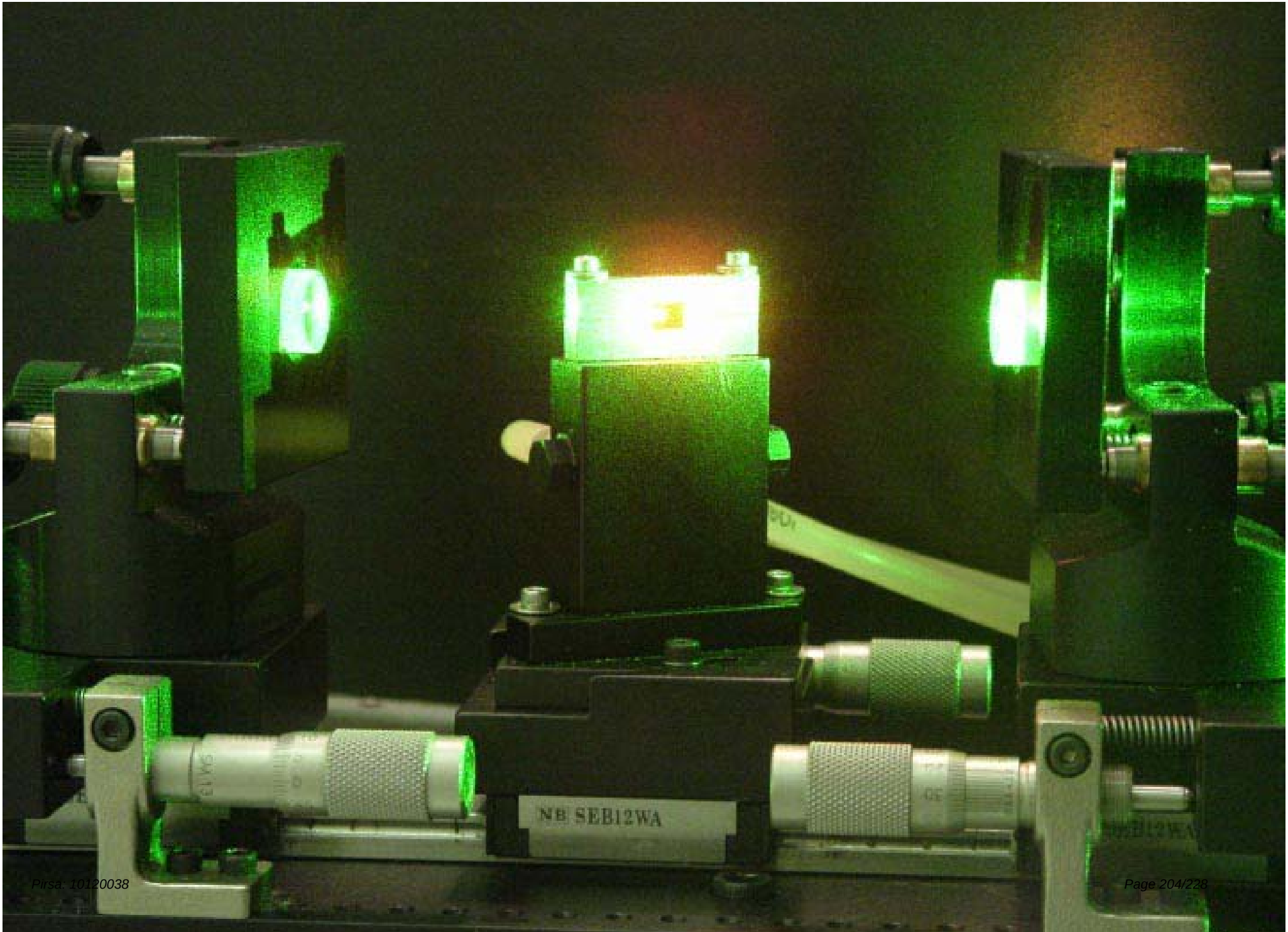


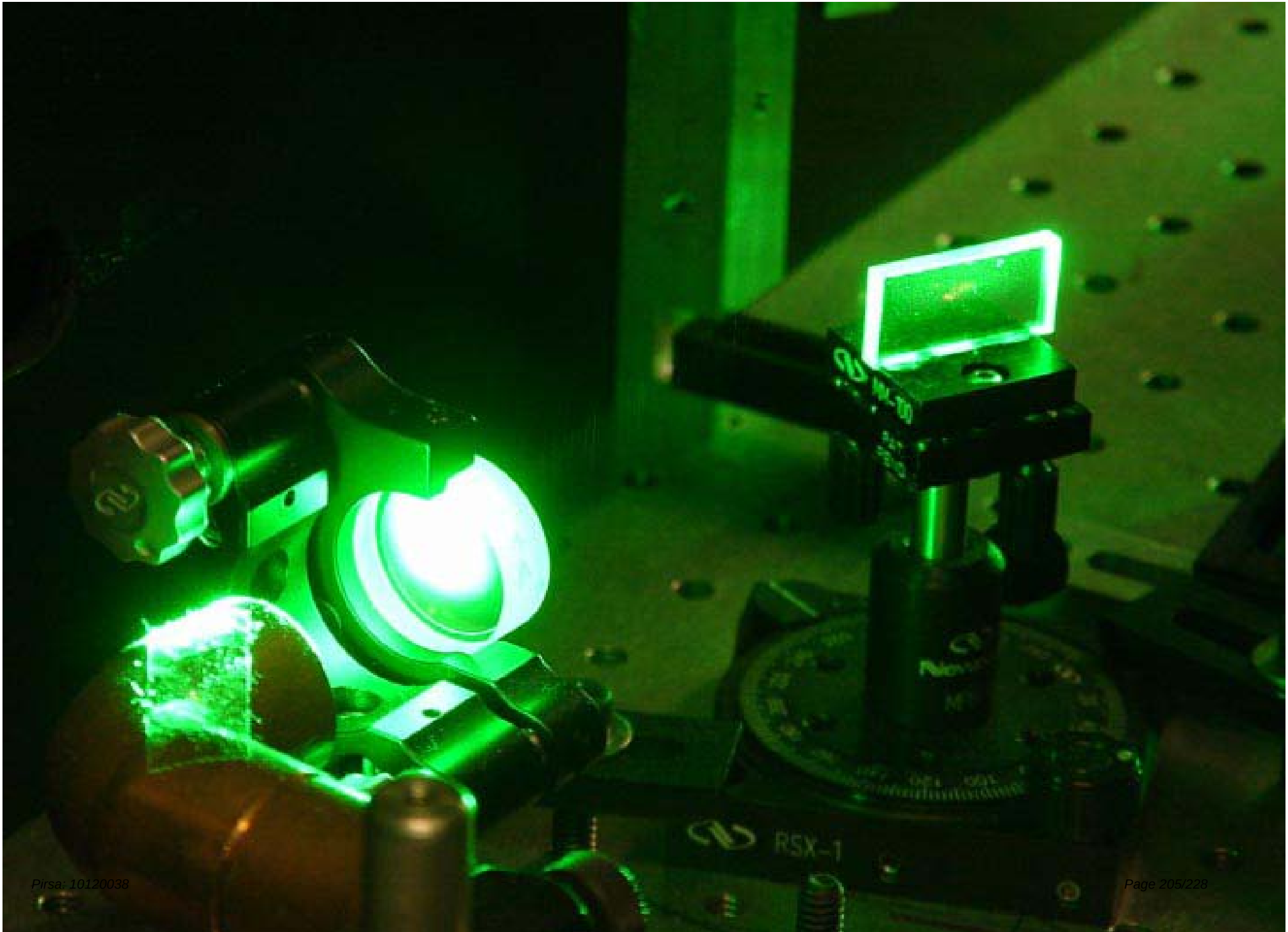


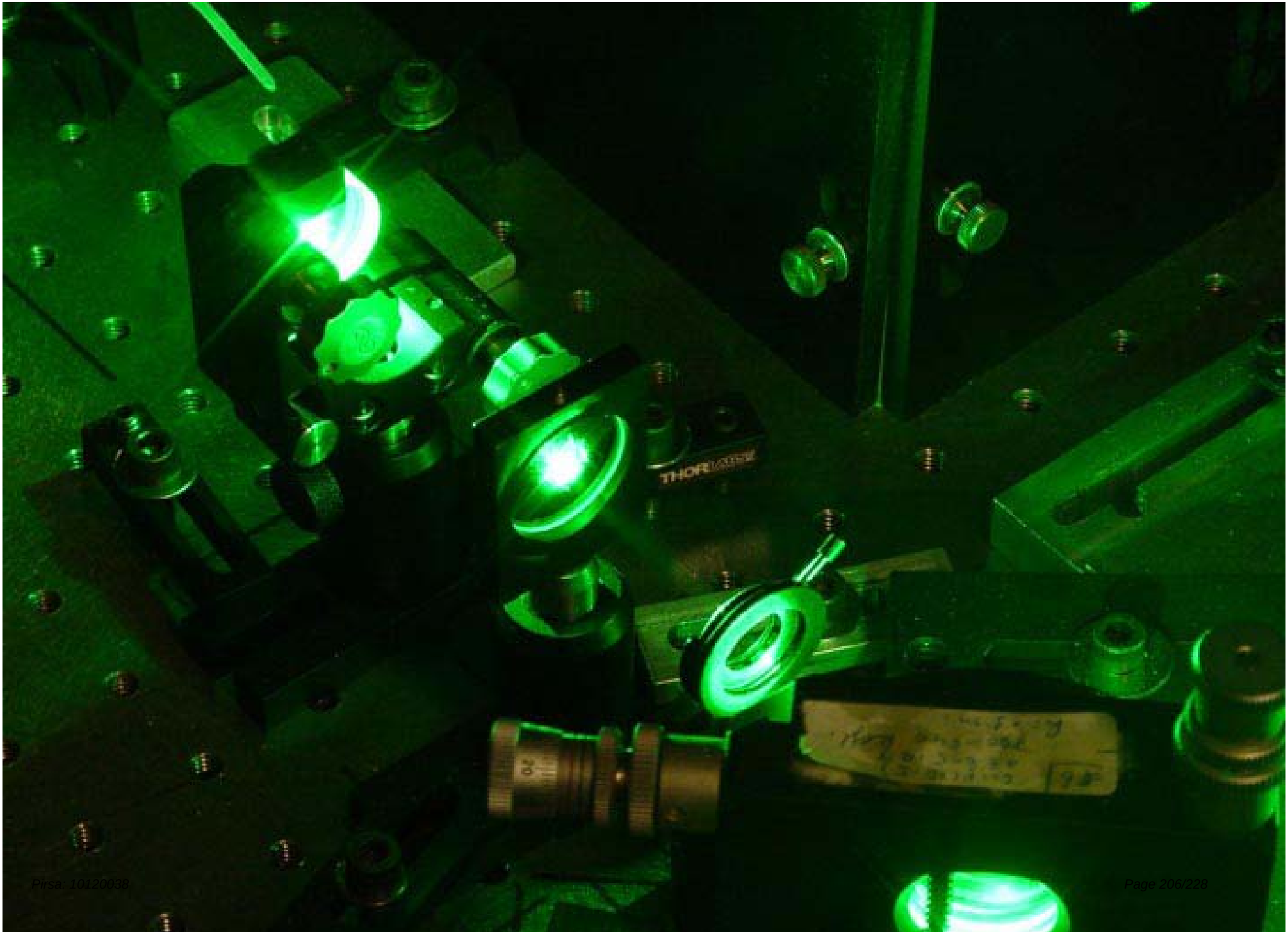


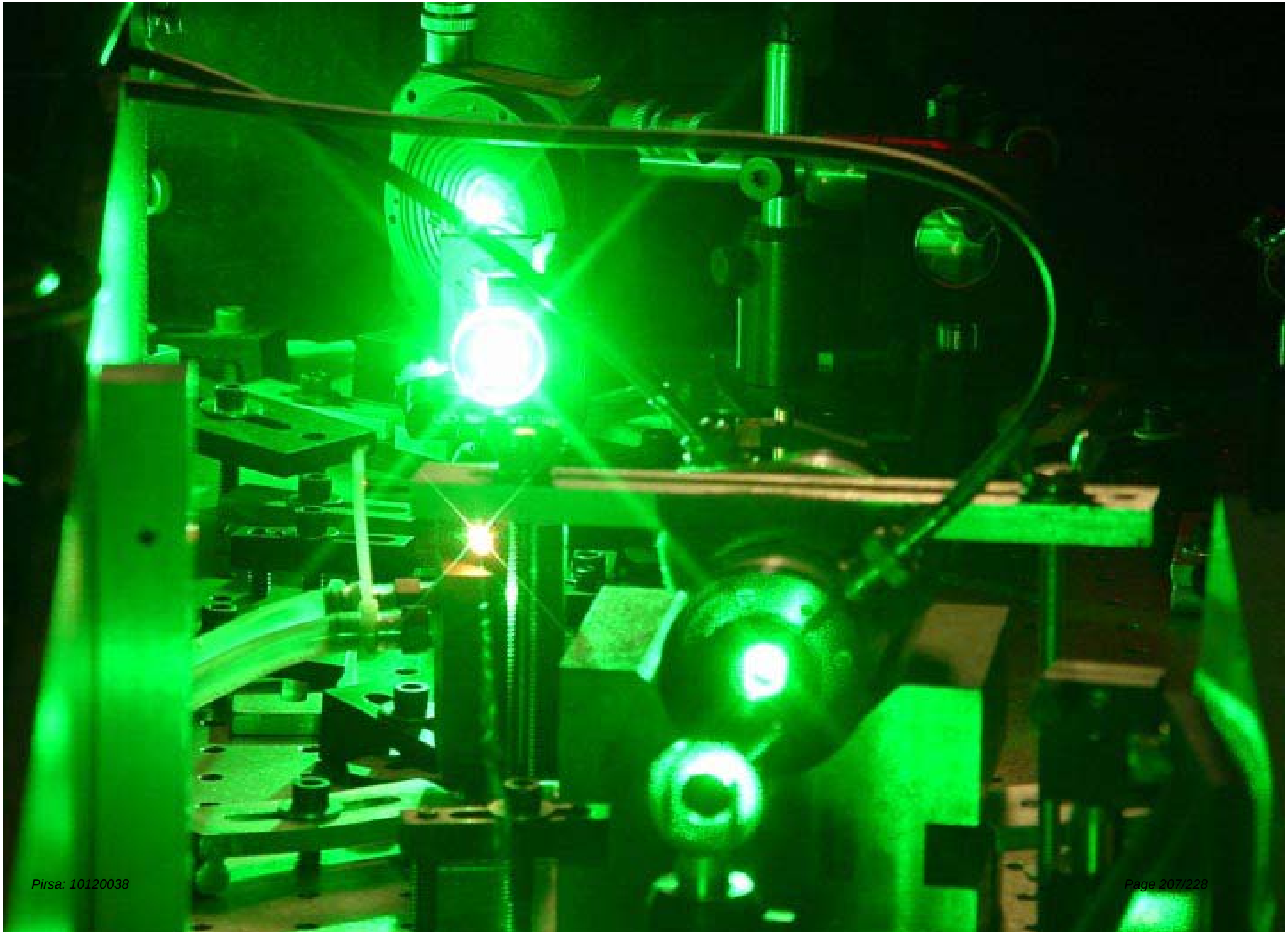


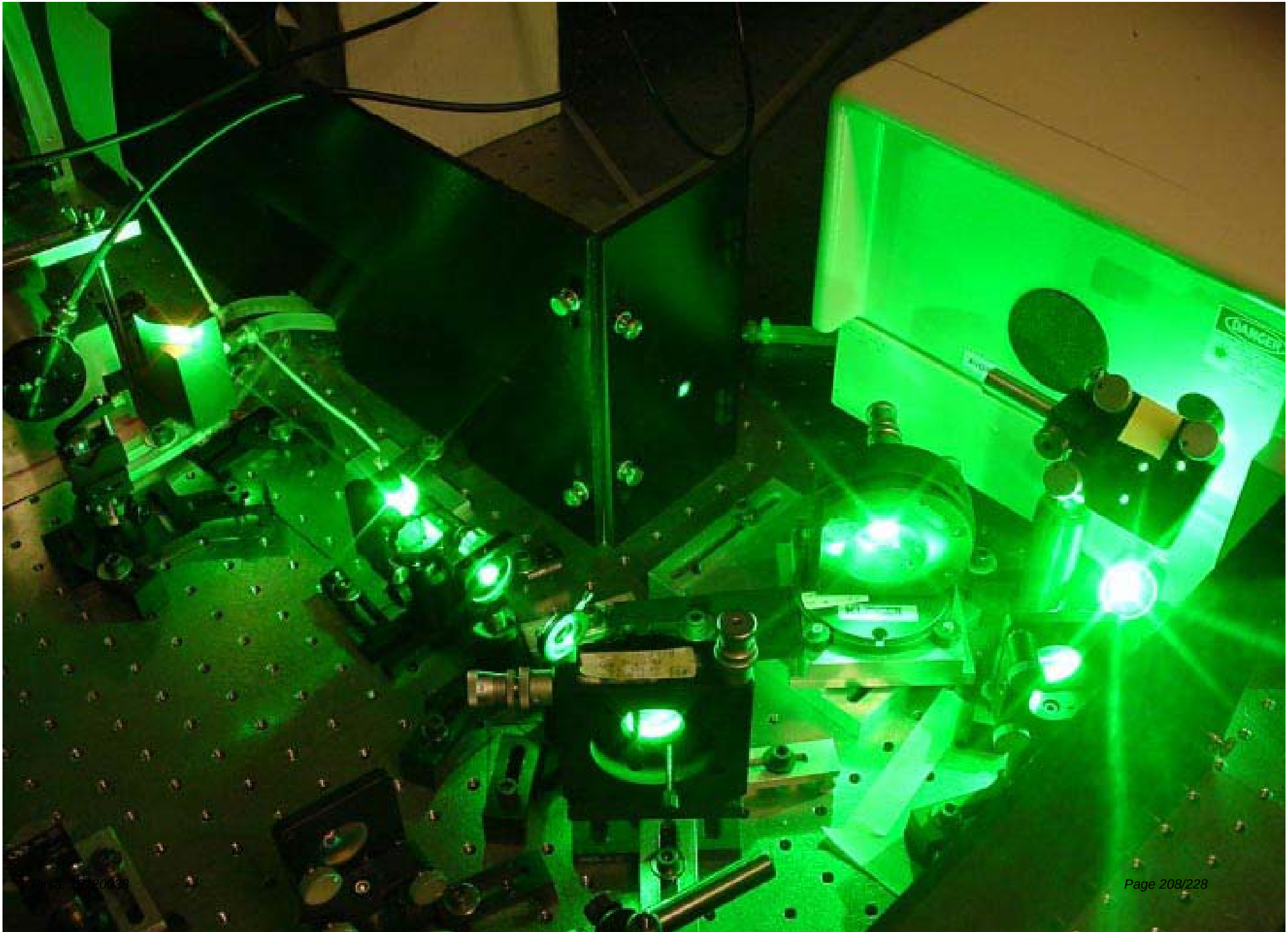


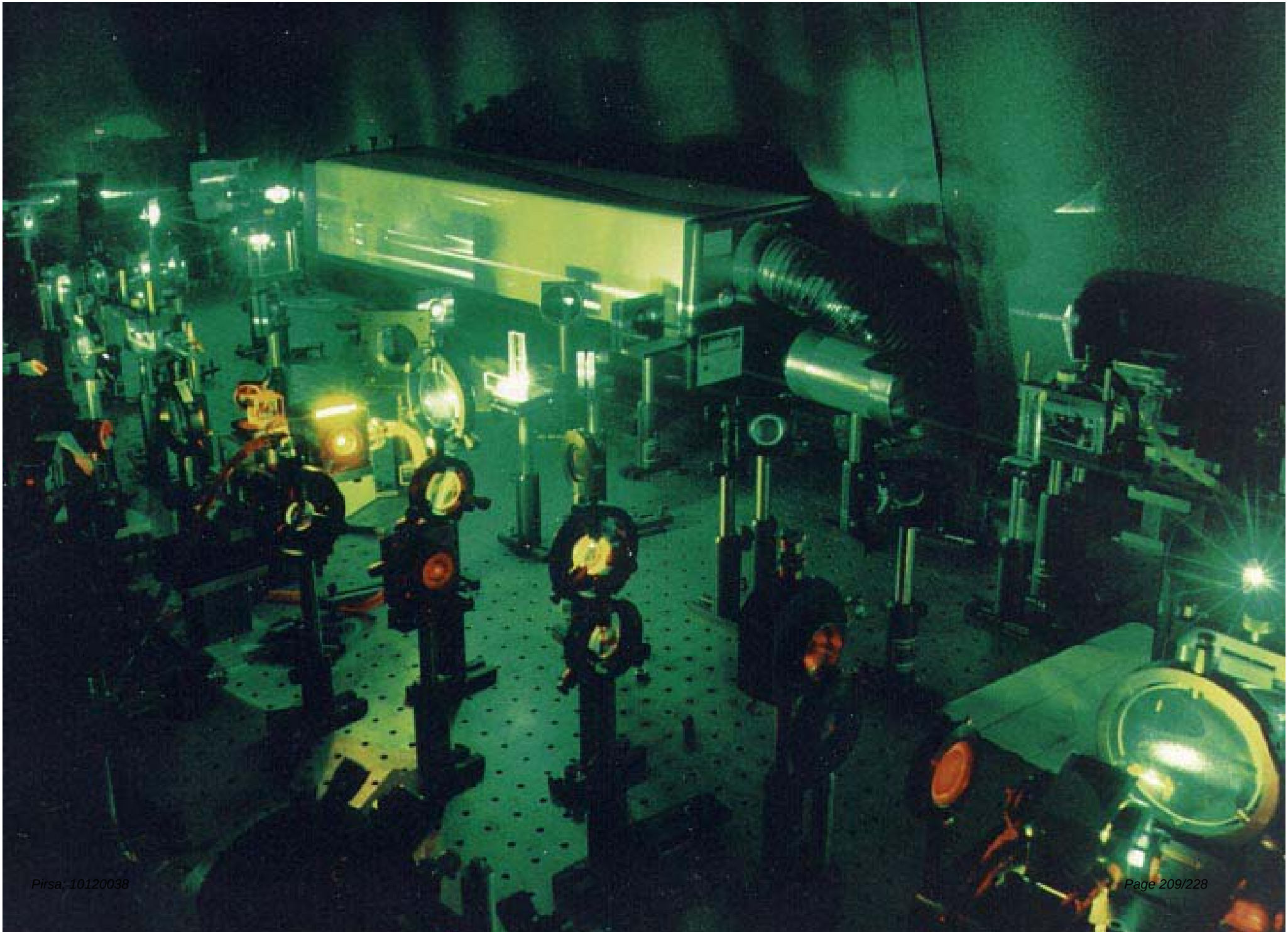

NB SEB12WA

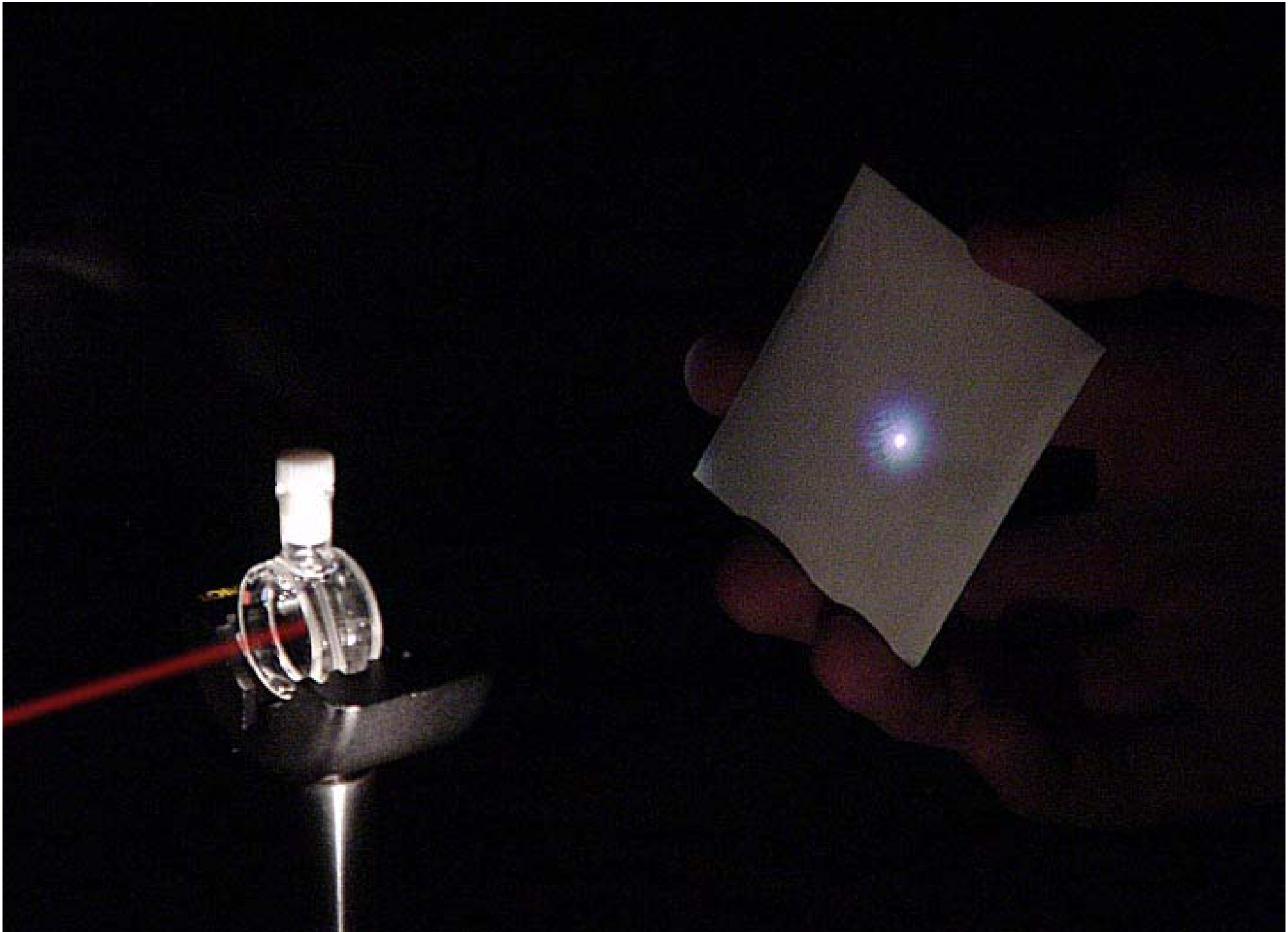

RSX-1

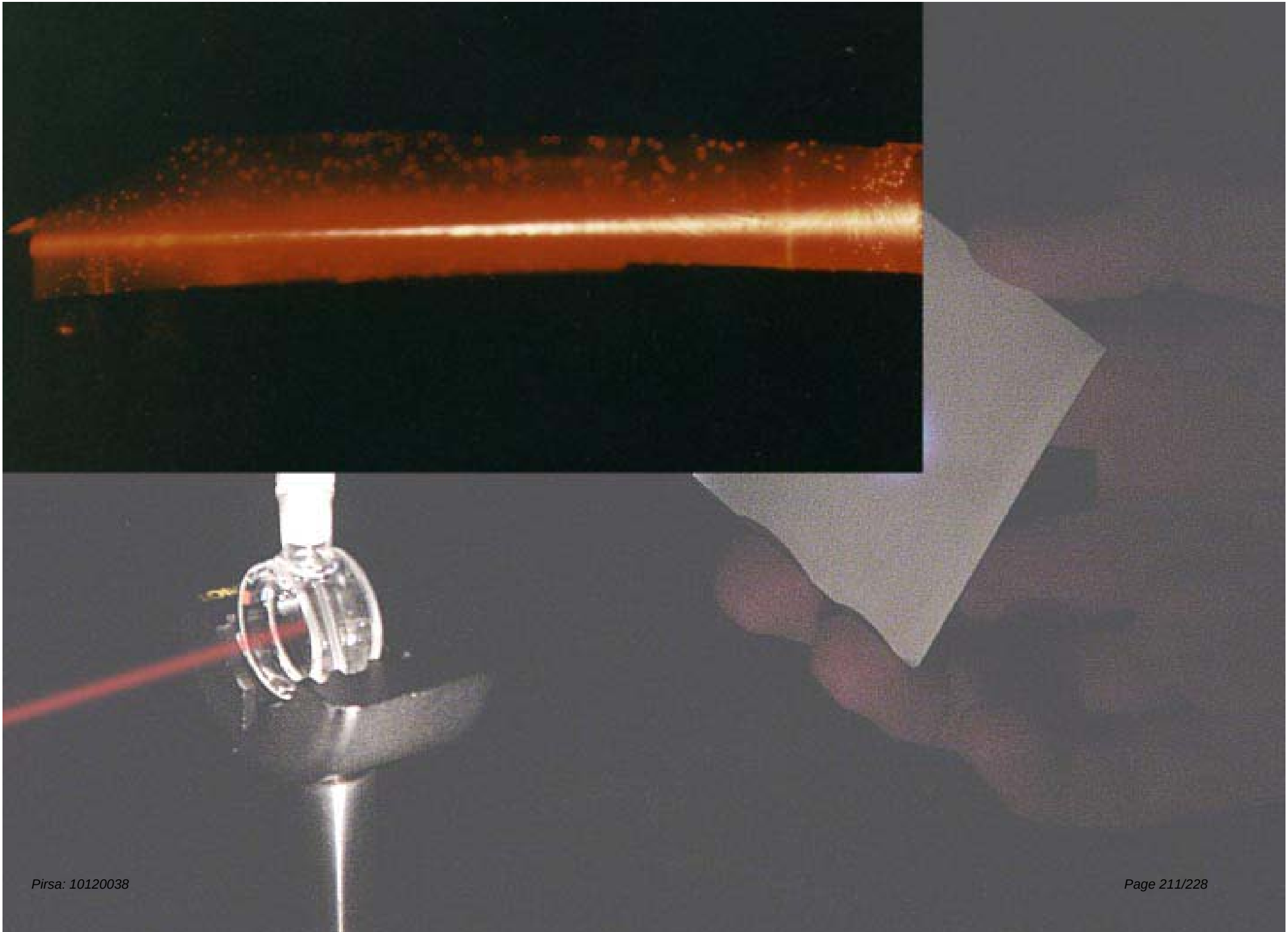


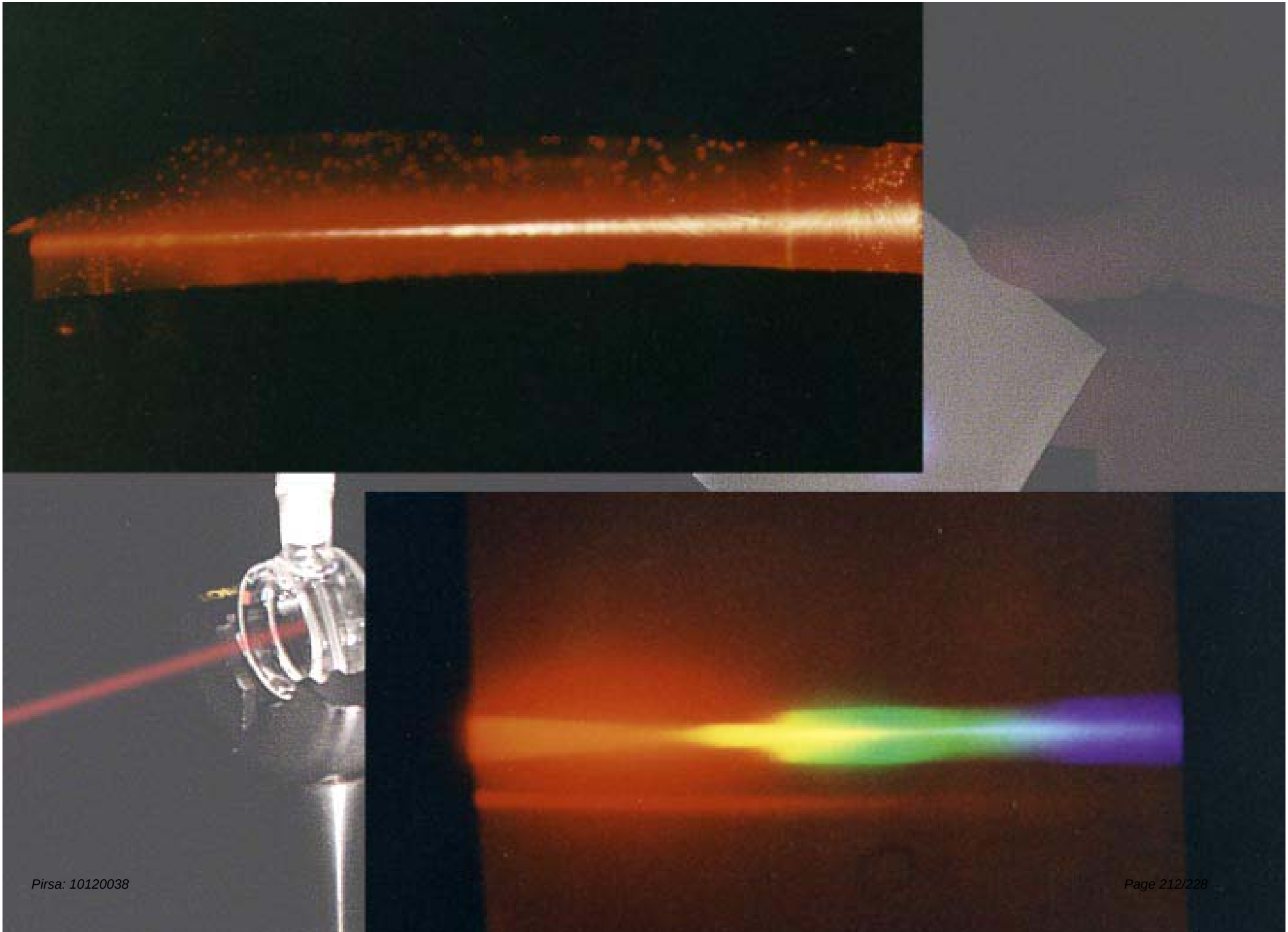


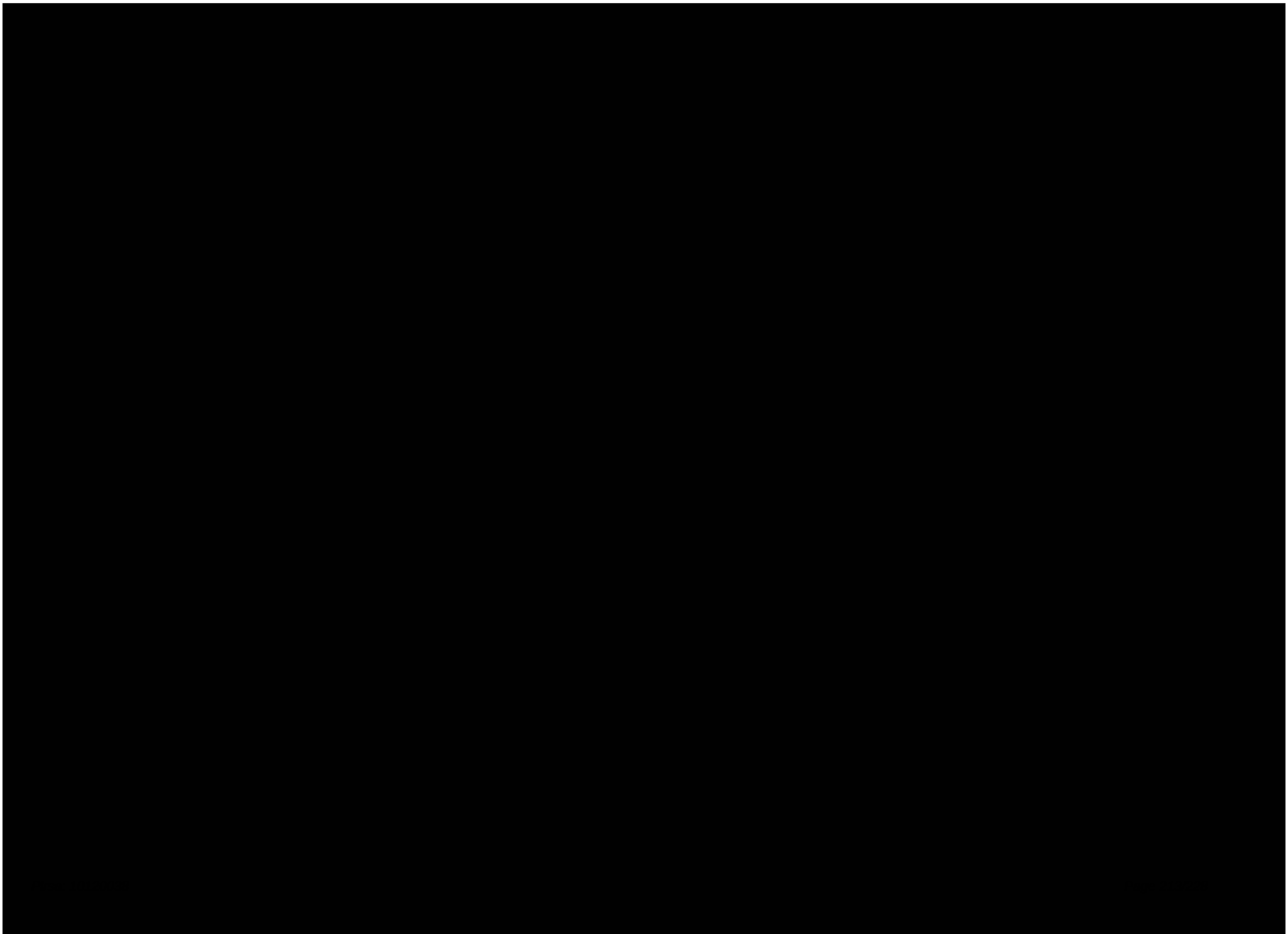


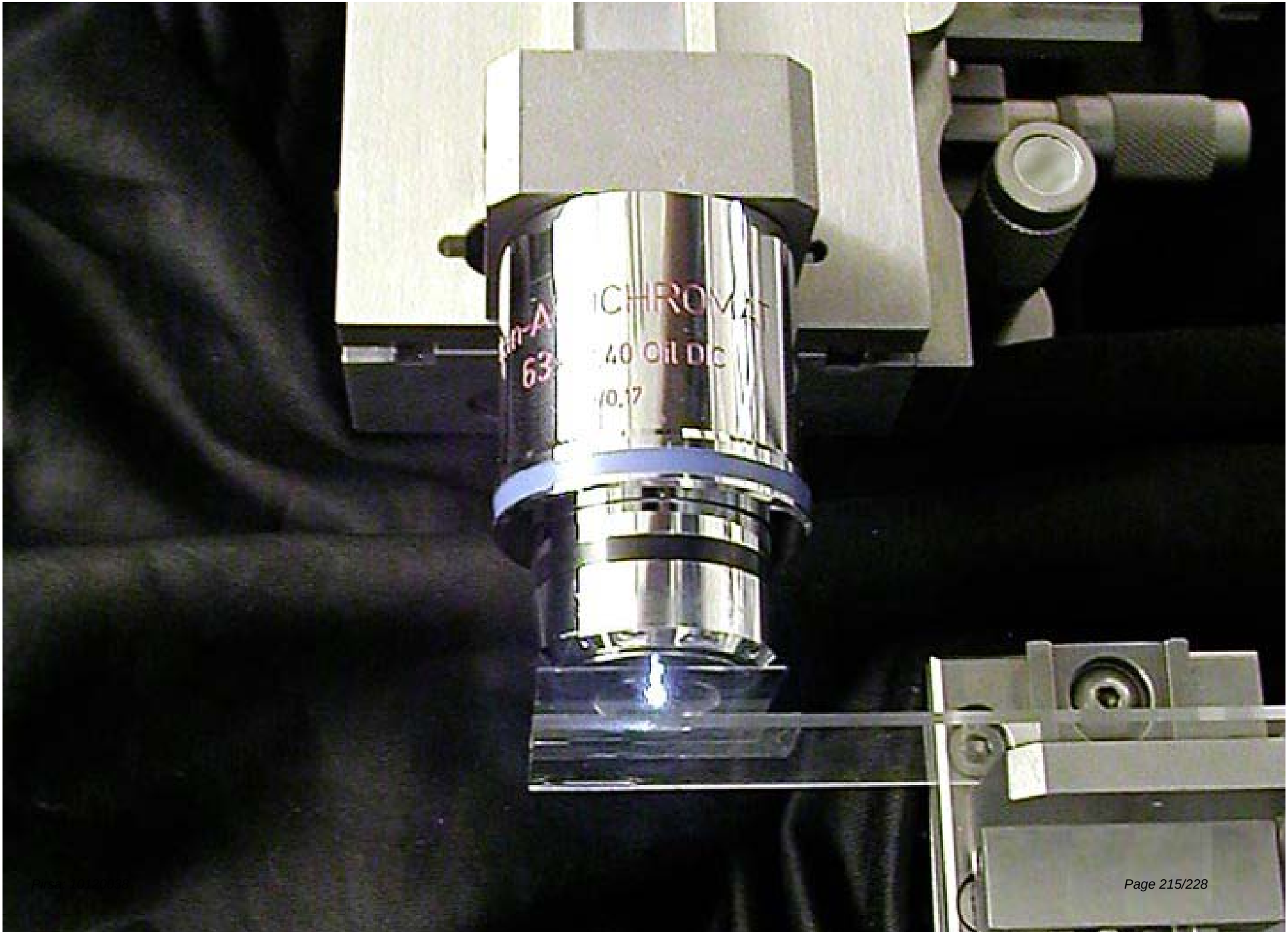


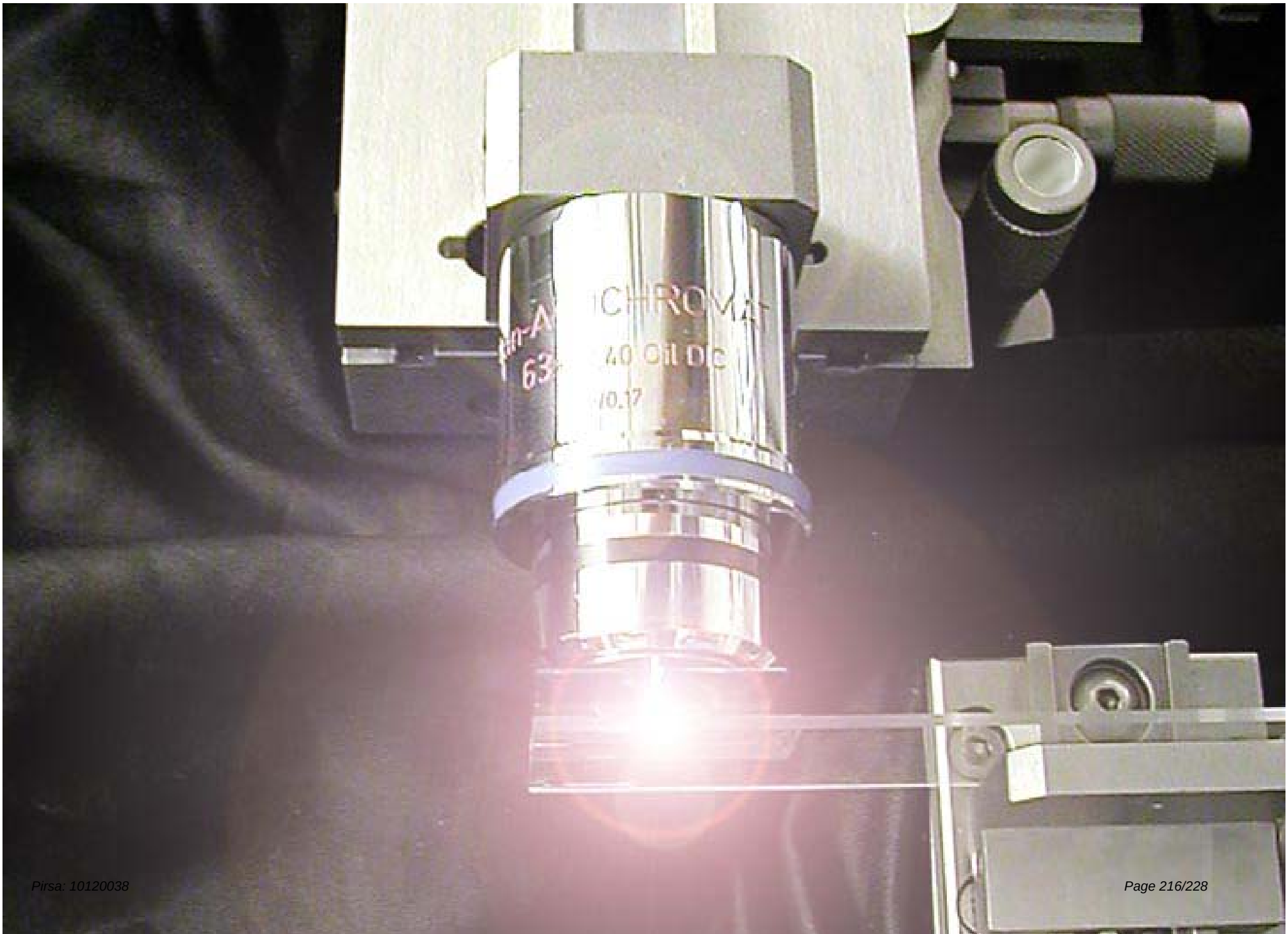


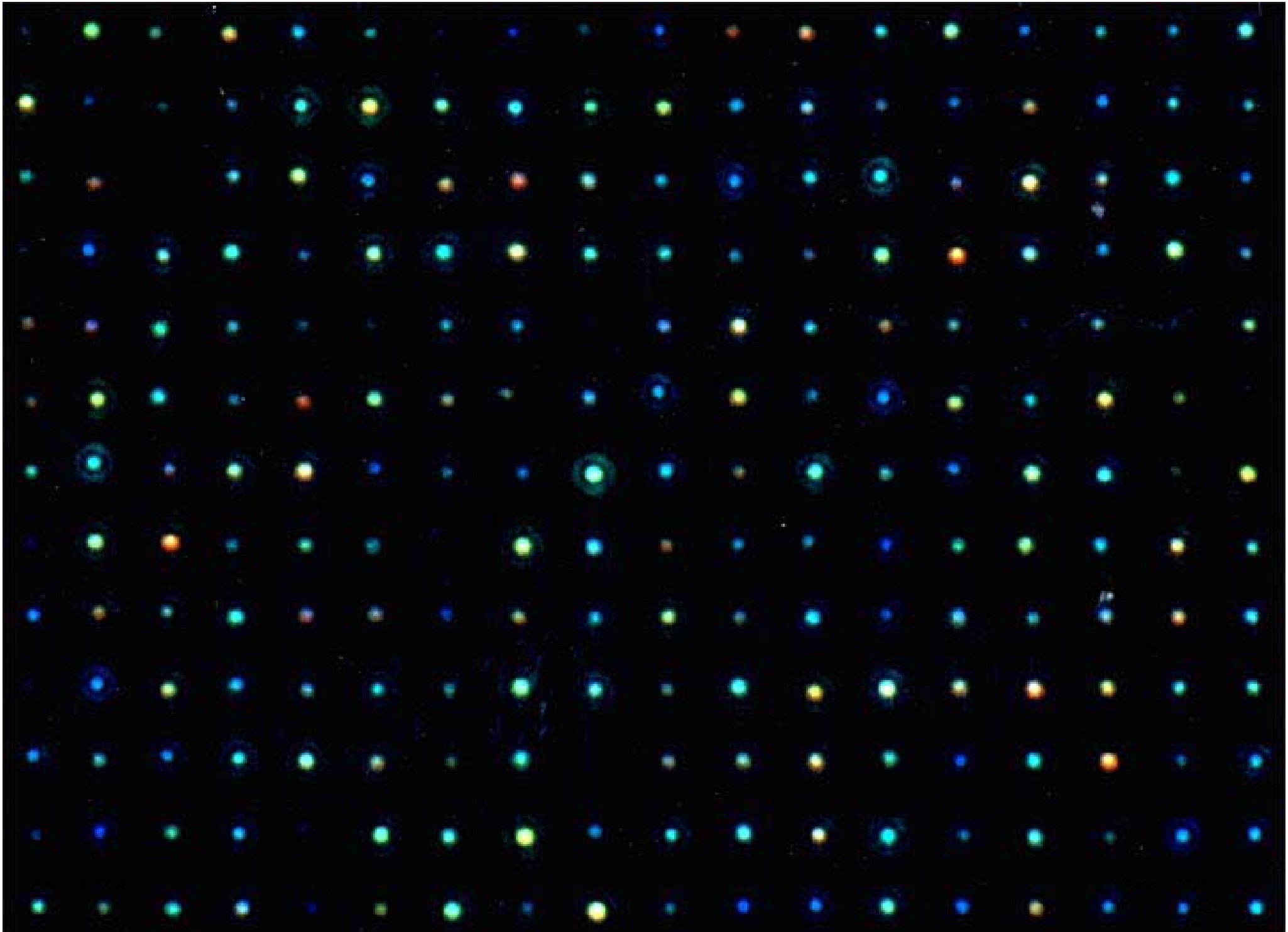


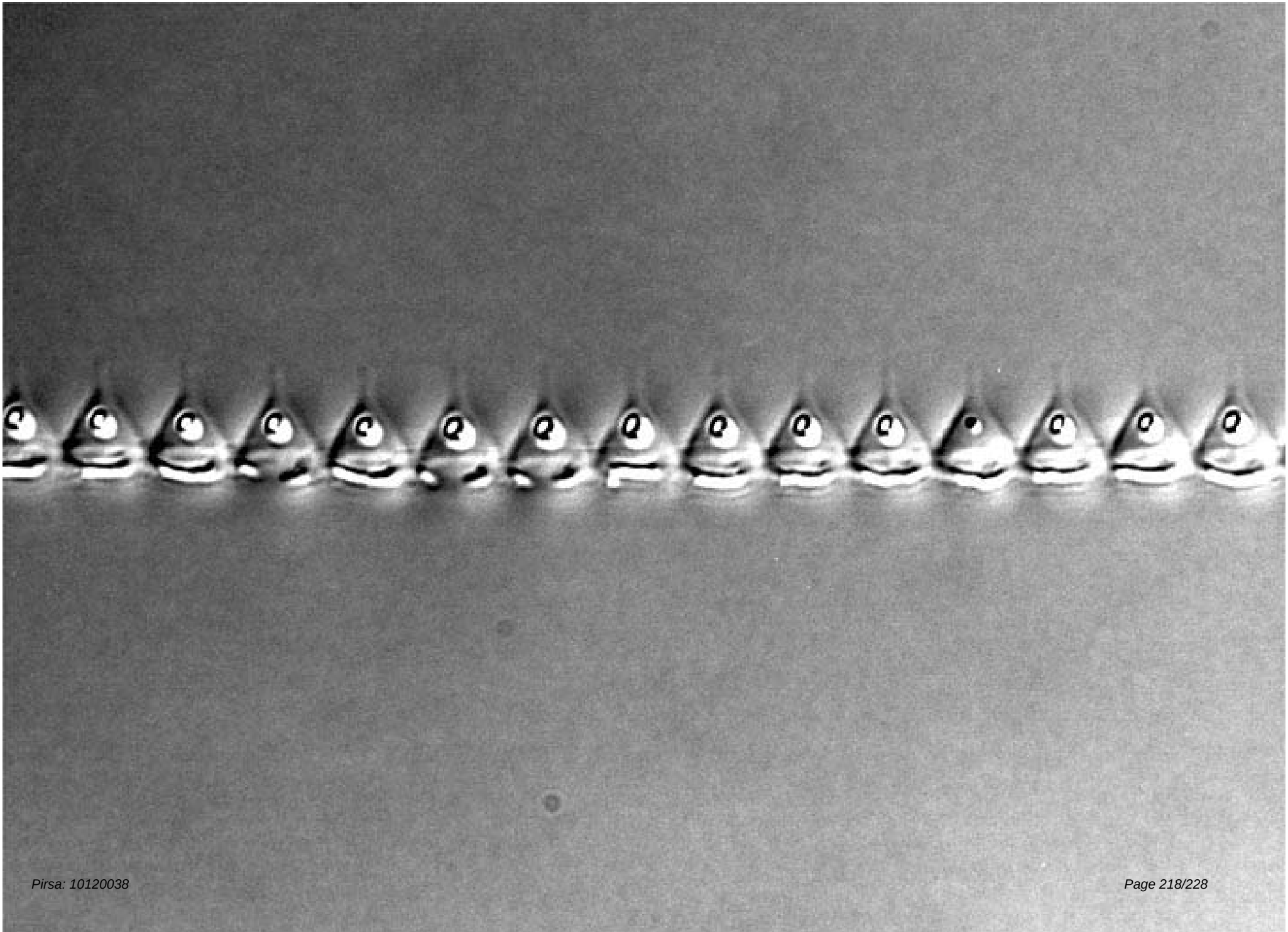


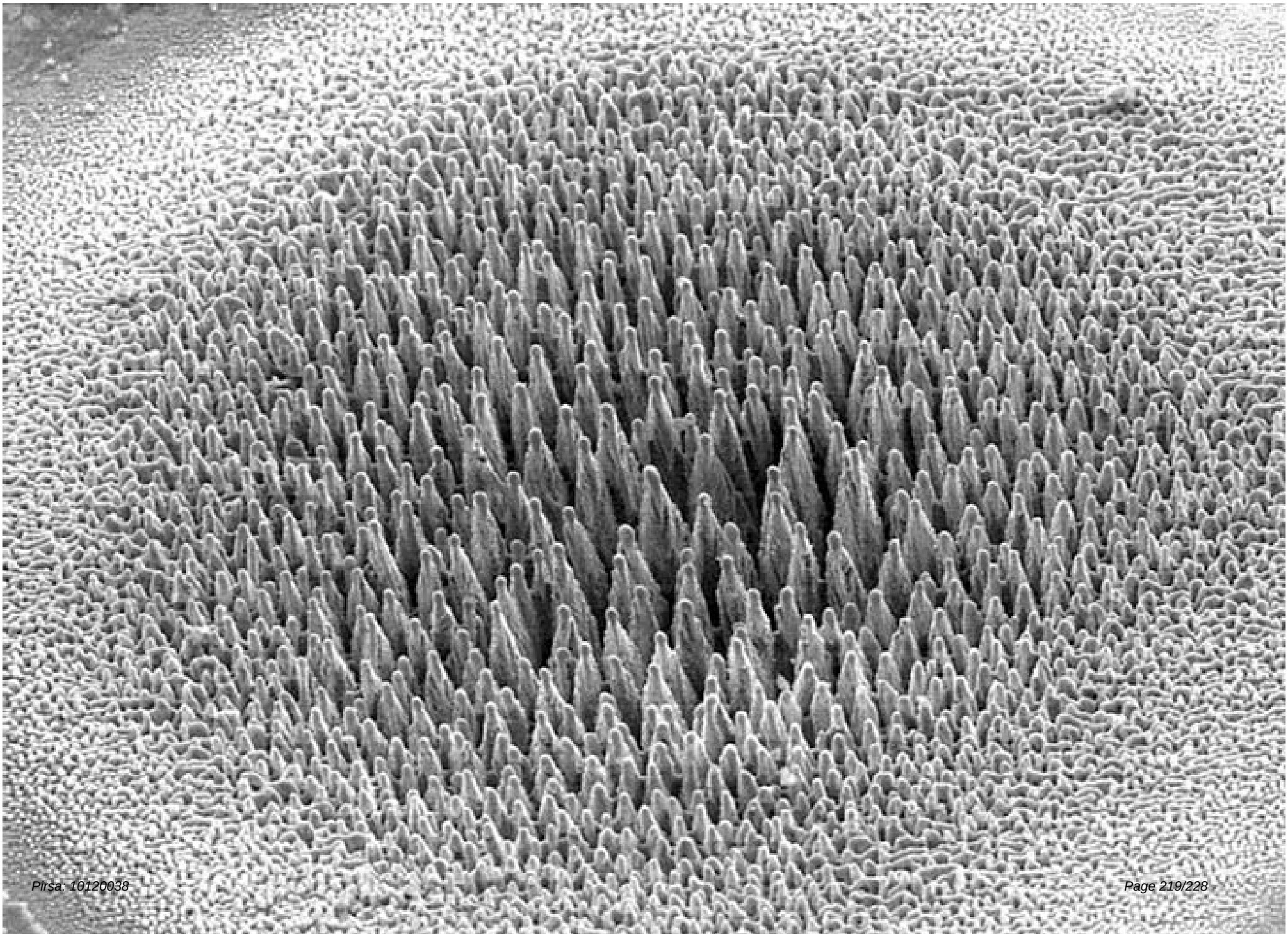


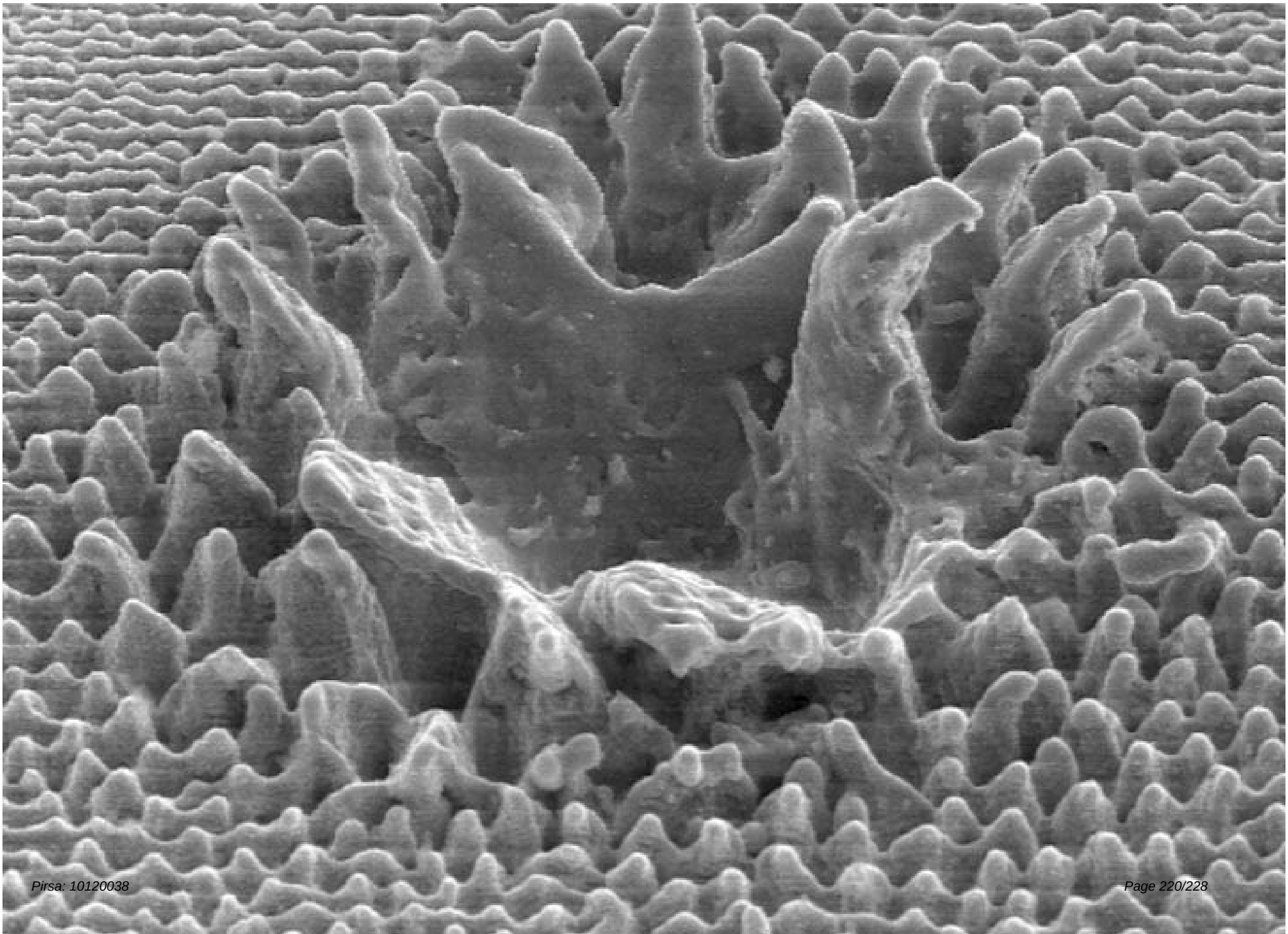

CHROMAT
40 Oil DIC
10.17


CHROMAT
40 Oil DC
10.17

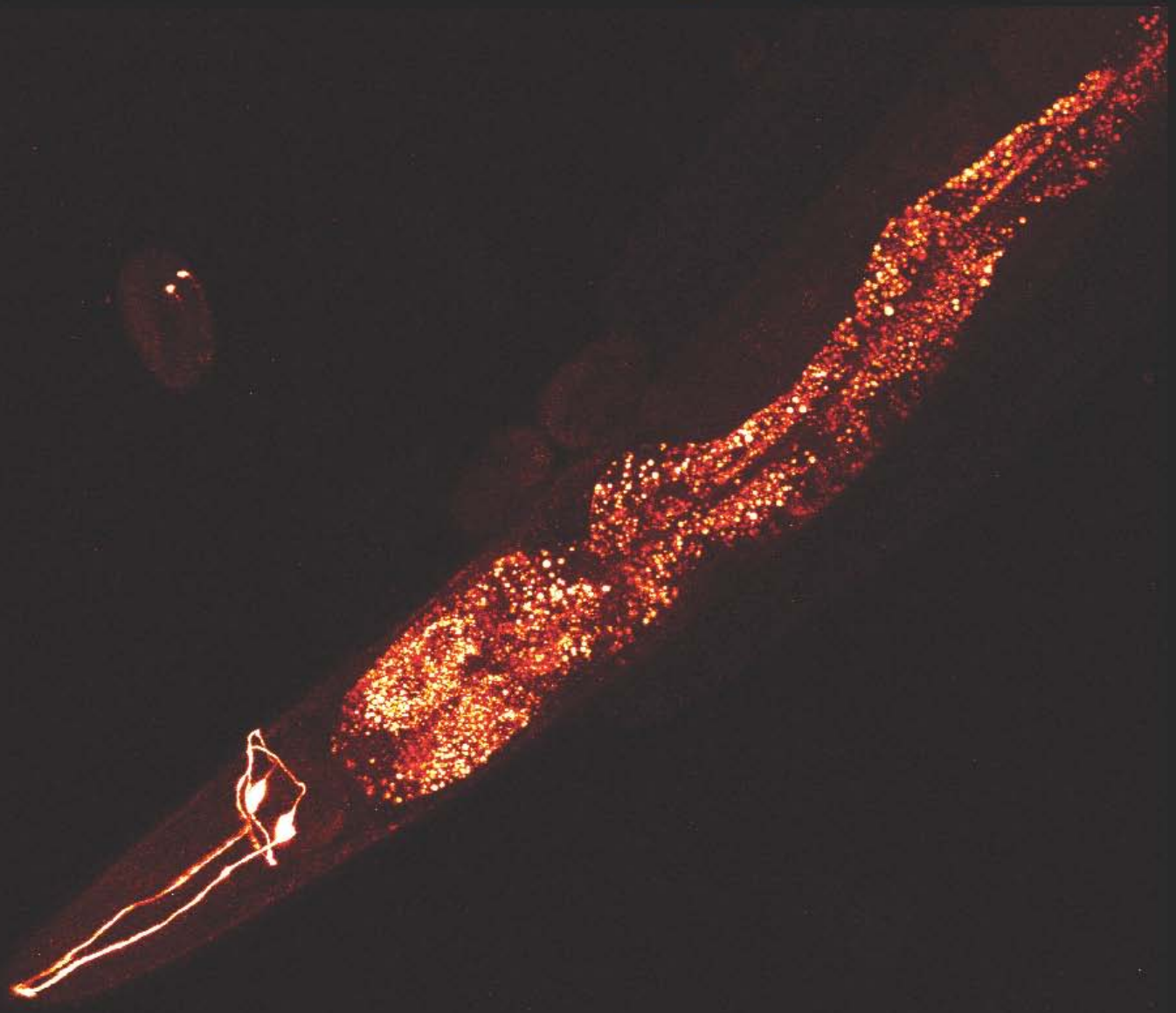




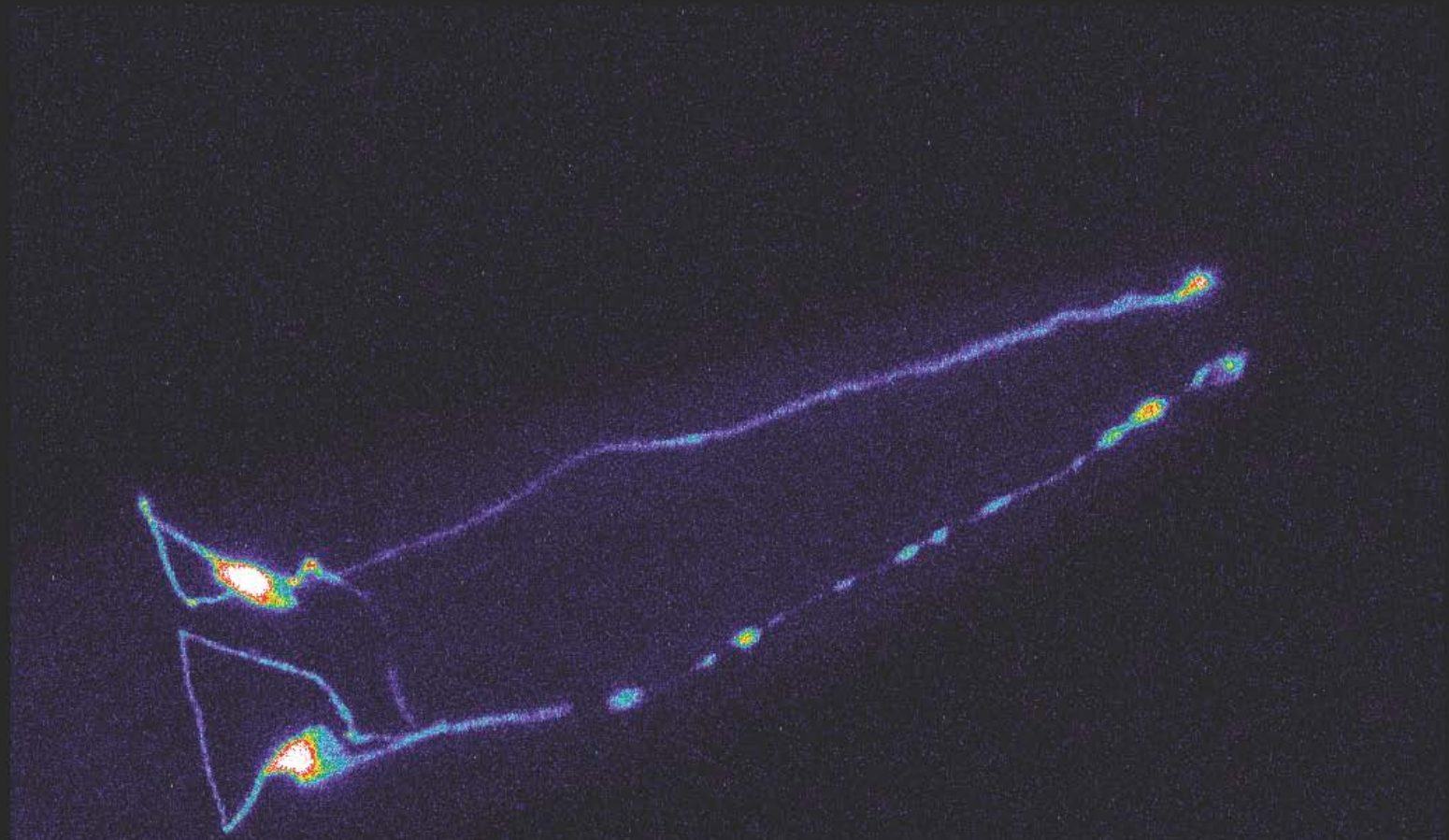


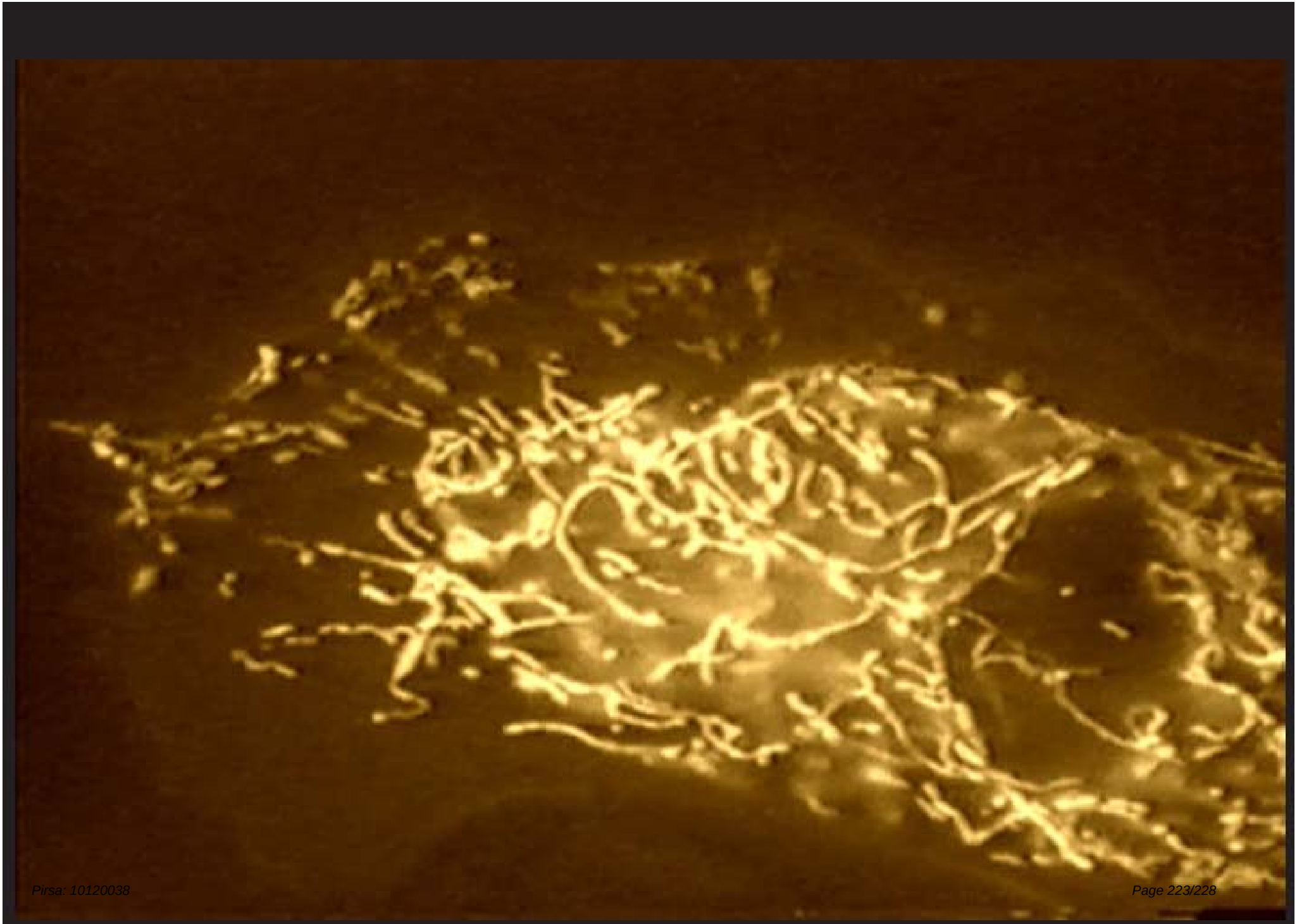


Nanoneurosurgery



Nanoneurosurgery





Oh, Time, suspend your flight!
and you, auspicious hours,
suspend your course!
Let us savor the fleeting joy
of our most beautiful days!

Alphonse de Lamartine (1817)

Plenty of unhappy ones down here
beg you; fly by for them!
Along with their days
take the worries that consume them;
Forget the happy ones!

Alphonse de Lamartine (1817)

In vain I ask for a few more moments,
But time escapes and flees;
I say to this night: "Slow down,"
but dawn will dissipate the night.

Alphonse de Lamartine (1817)

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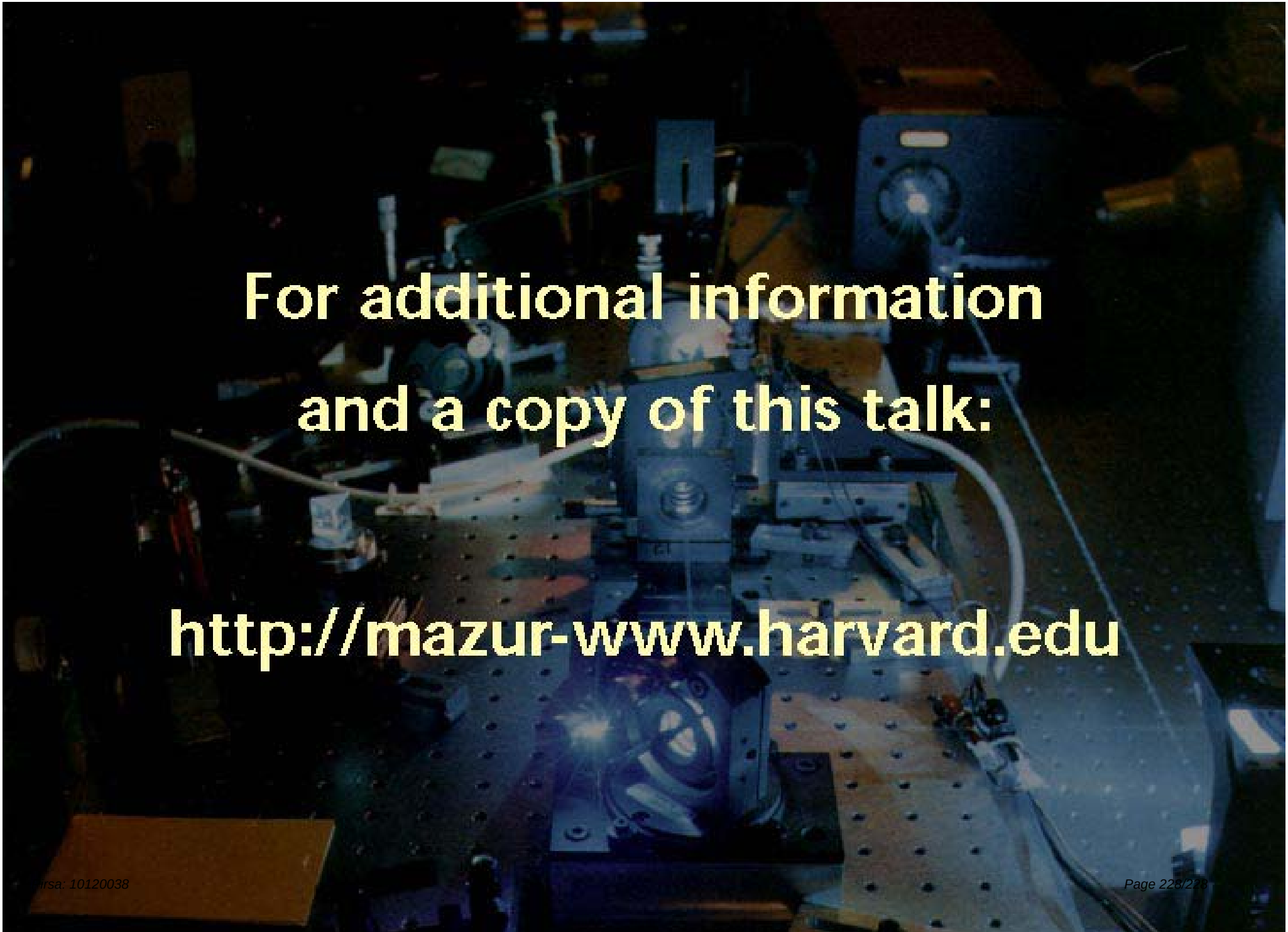
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