svet ako výpočet

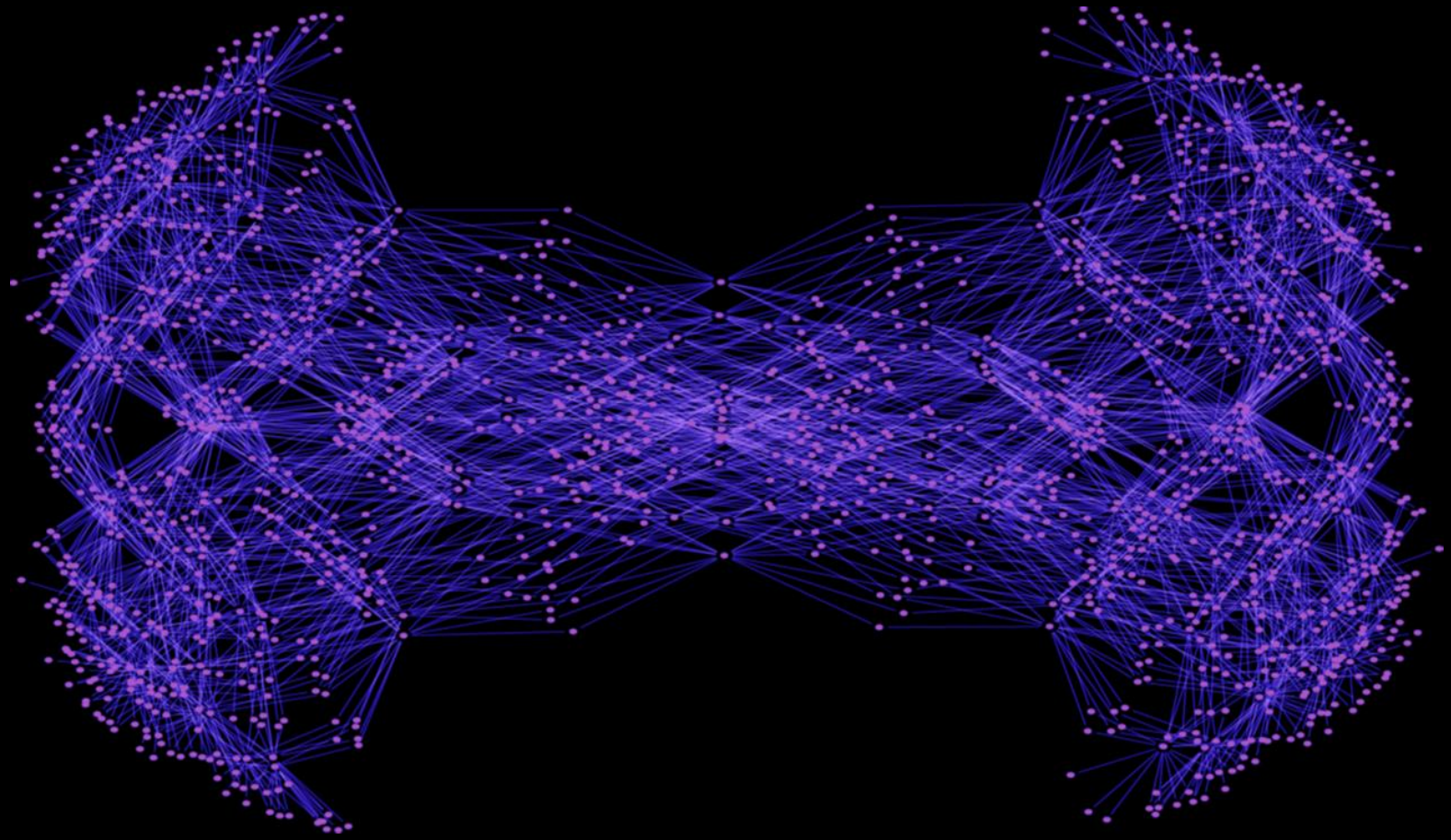
daniel nagaj & rcqi
centrum pre výskum kvantovej informácie
fyzikálny ústav slovenskej akadémie vied

SAS PRO

Čo počíta vesmír?

Vlastný vývoj.
Magnetické monopóly.
Kolotanec komét.
Vírenie vody.
Hojdanie hojdačiek.
Zvuk zvonov.
Rádioakivitu rádia.
Konfigurácie kvarkov.
Vibrácie vákua.

Čo počítame my?



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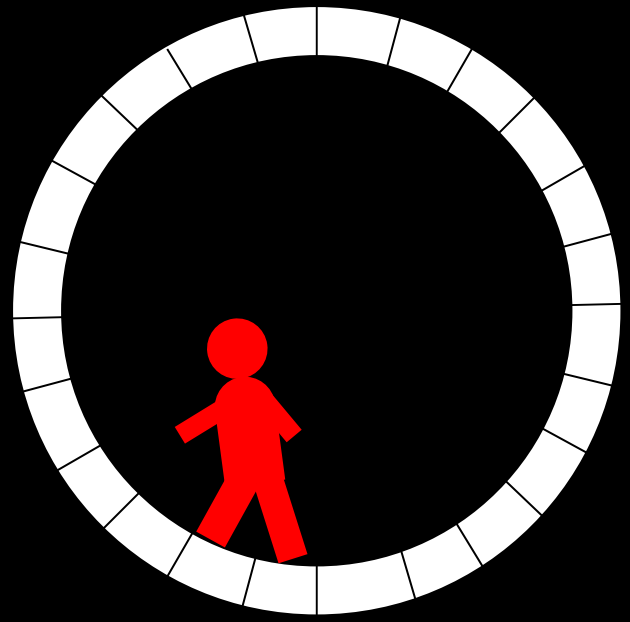

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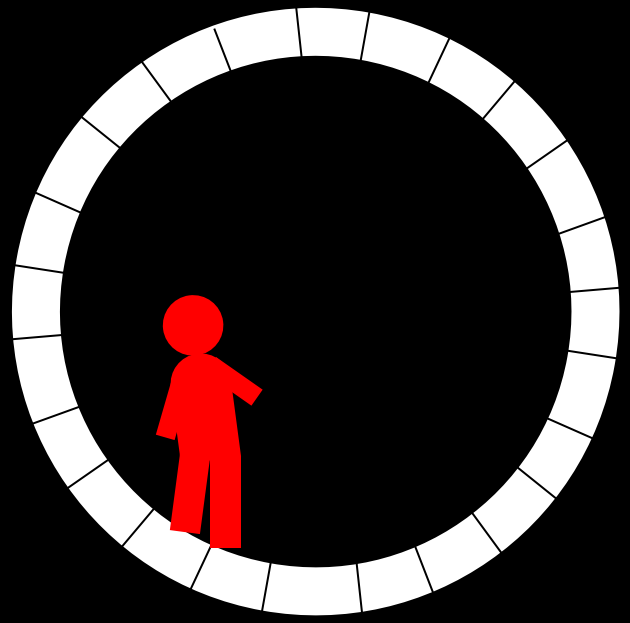

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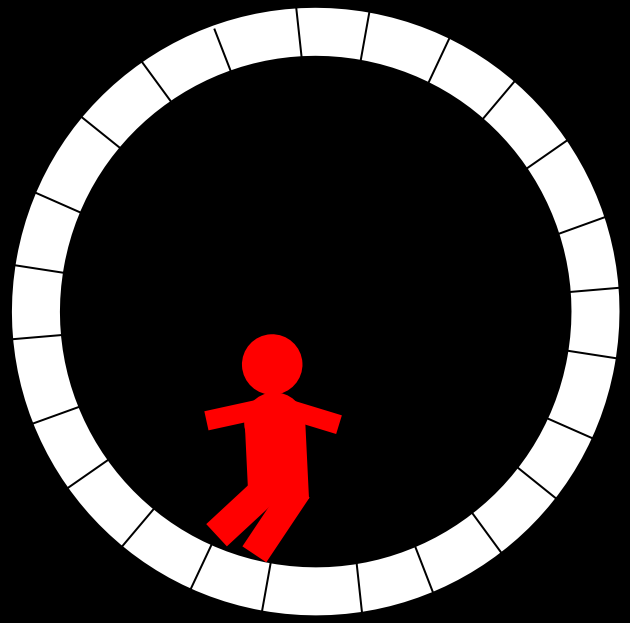
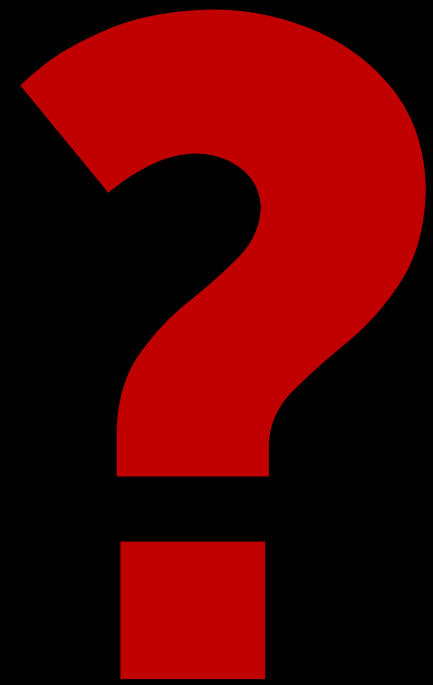


Čo počítame my?

dá sa
všetko
na svete
simulovať na
počítači



všetko fyzikálne
na svete
sa dá efektívne
simulovať na Turingovom
počítači

extended Church
Turing thesis

všetko fyzikálne
na svete
sa dá
simulovať na
počítači

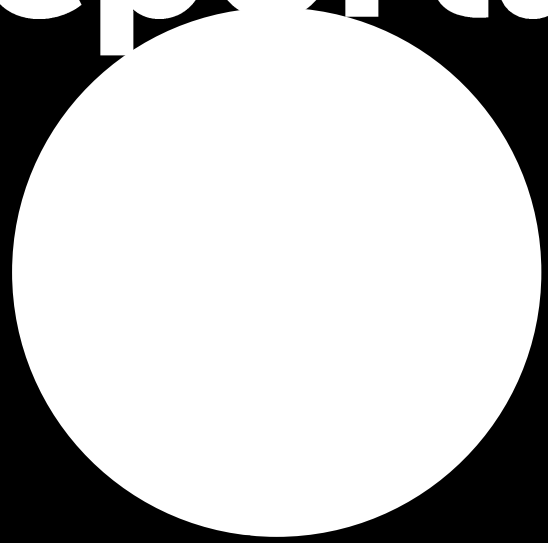
Church
Turing thesis

všetko fyzikálne
na svete
sa dá efektívne
simulovať na kvantovom
počítači

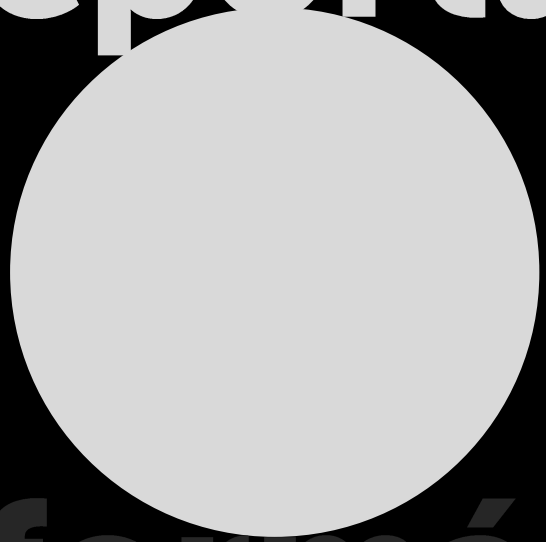
superpozícia

superpozícia

teleportácia

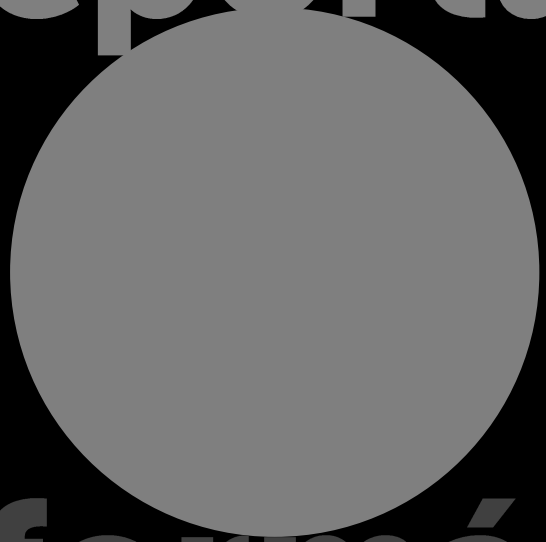


teleportácia



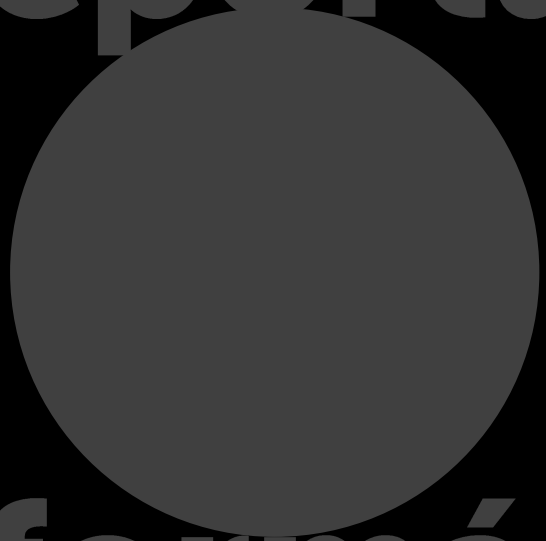
informácia

teleportácia



informácia

teleportácia



informácia

teleportácia

informácia

informácia

informácia
KVANTOVÁ

1 ťažké výpočty

čo chceme a čo príroda dovolí

[wikipedia]

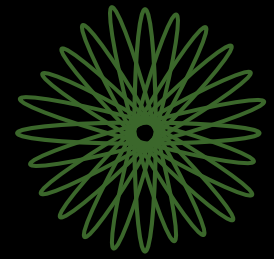
1 ťažké výpočty

čo chceme a čo príroda dovolí

[wikipedia]

2 zvláštna informácia

kvantové stavy a ich spracovanie



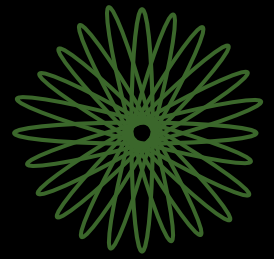
1 ťažké výpočty

čo chceme a čo príroda dovolí

[wikipedia]

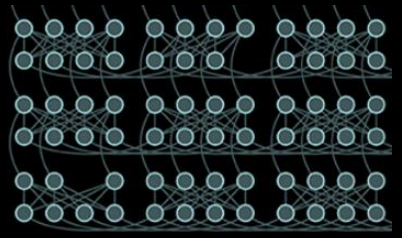
2 zvláštna informácia

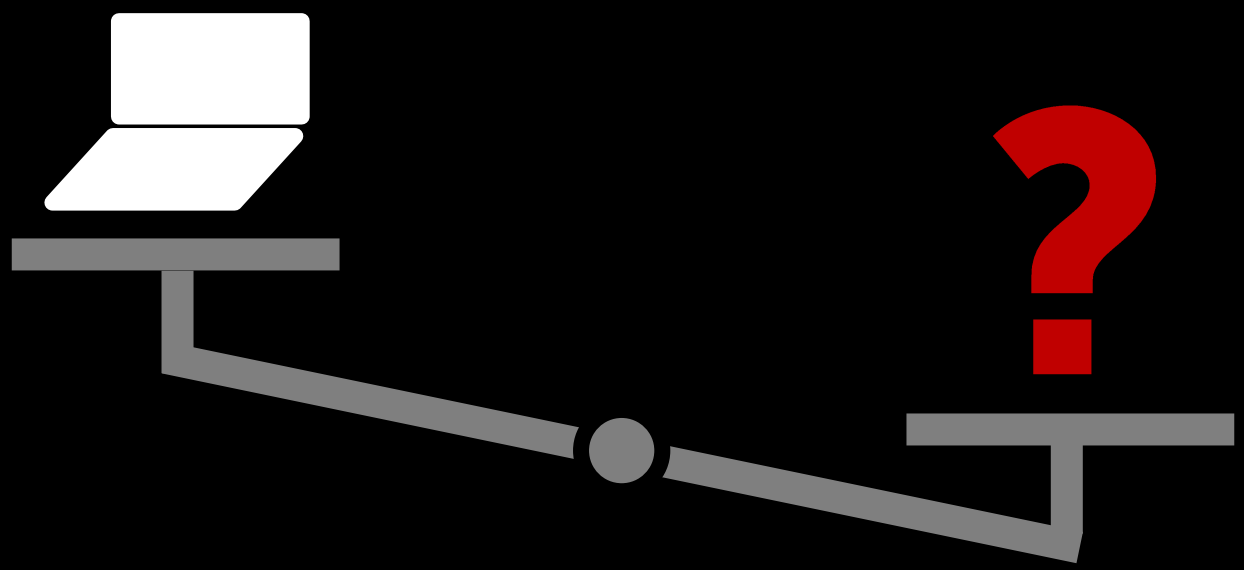
kvantové stavy a ich spracovanie



3 počítame kvantovo

optimalizujeme a simulujeme



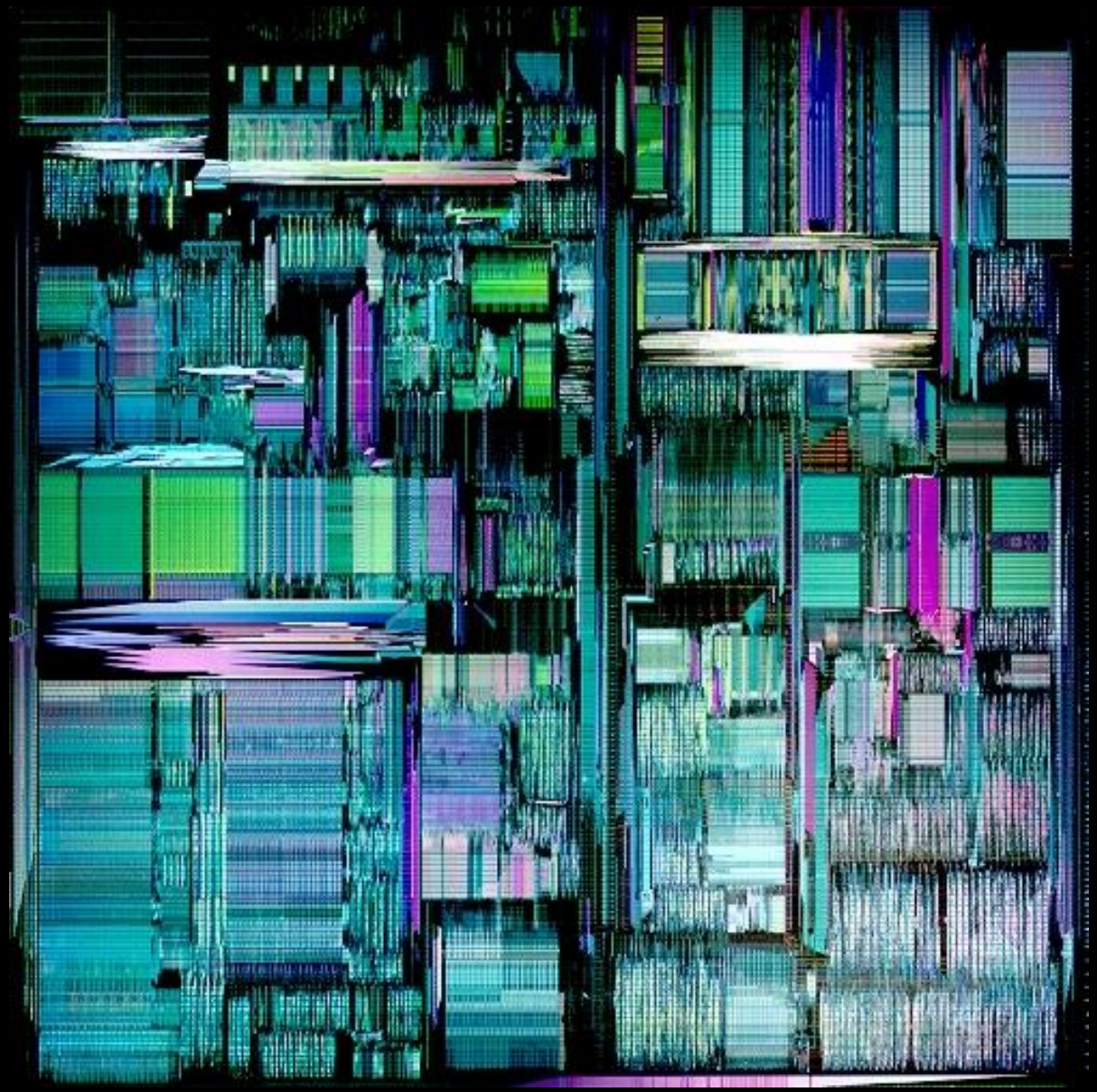


ťažké výpočty

[Nicolas Brodu]

[MIT museum]

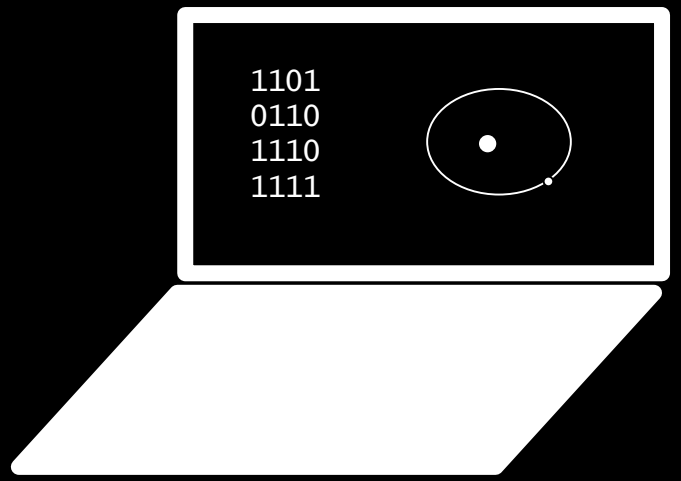
[Zdeněk Starý]

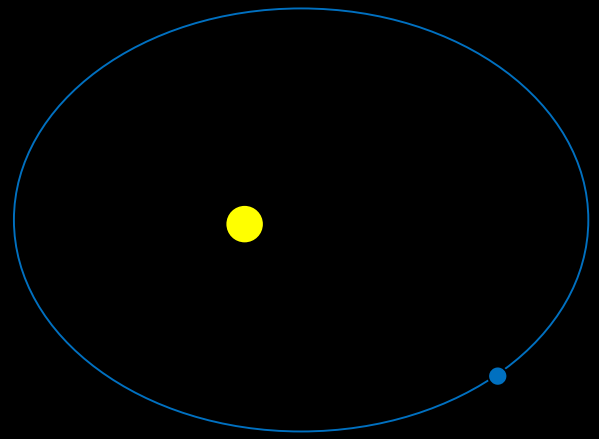


[www.tayloredge.com/museum]

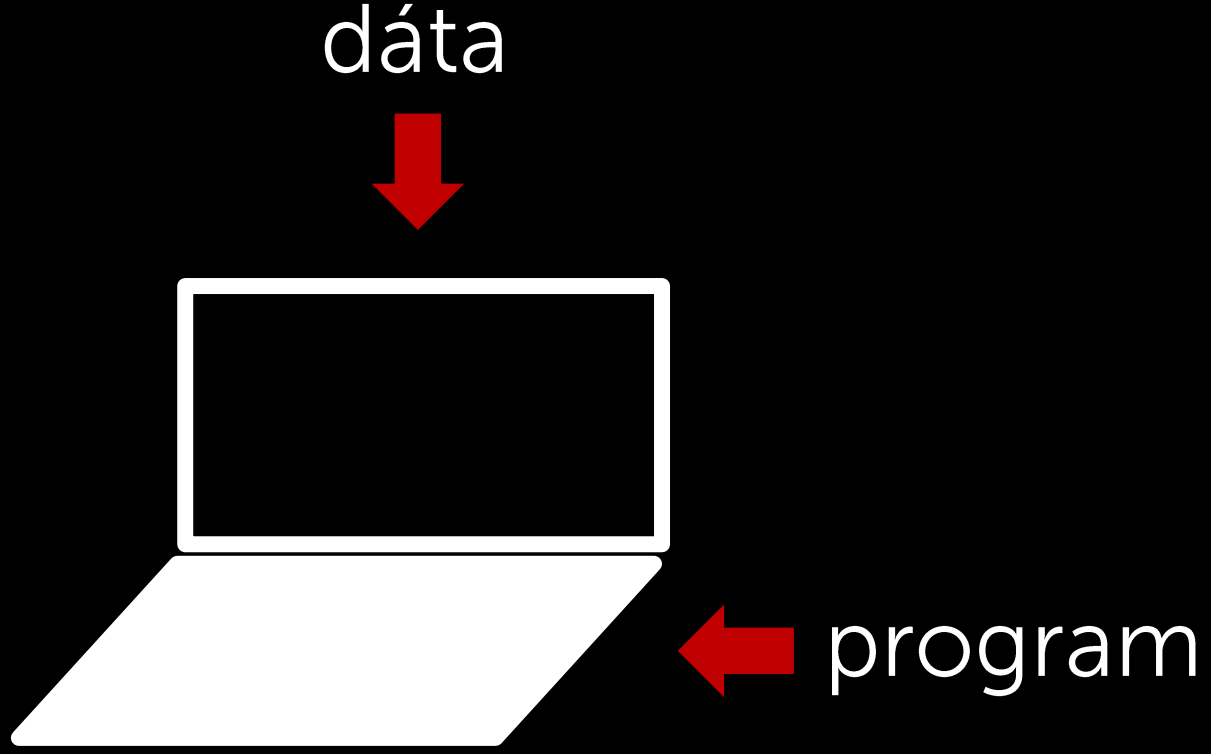
simulácia

realita



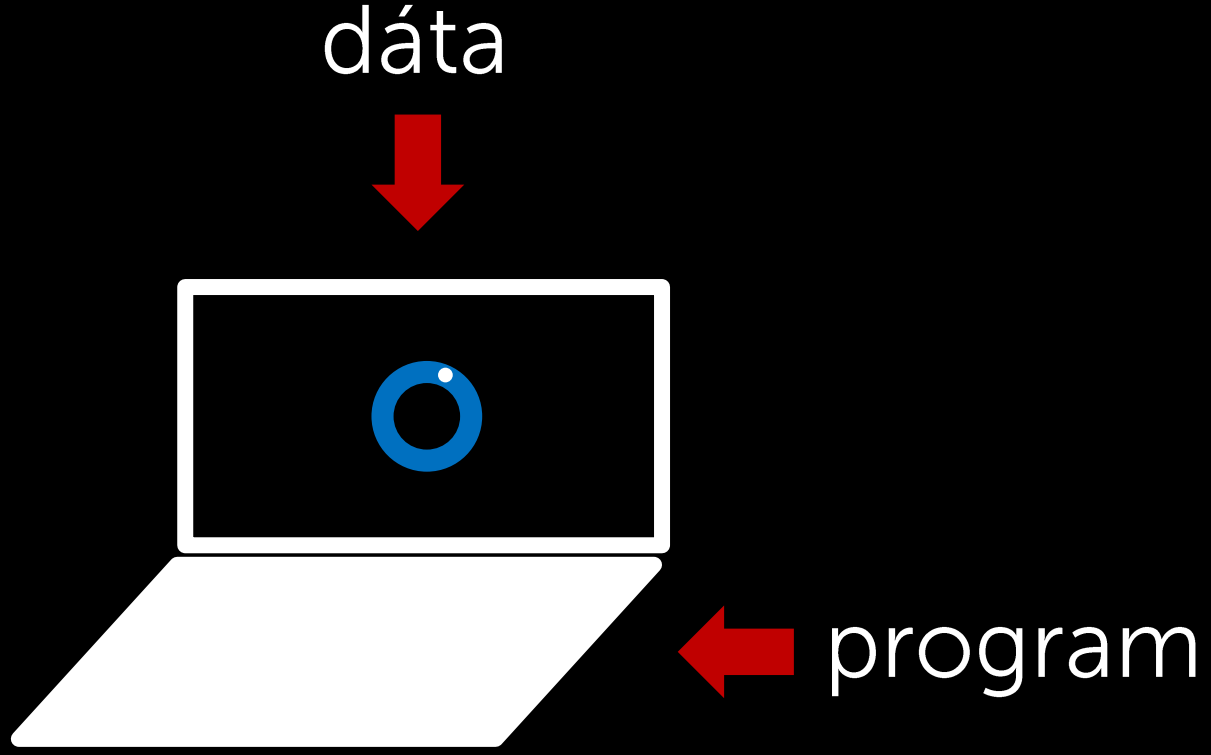


univerzálny počítač



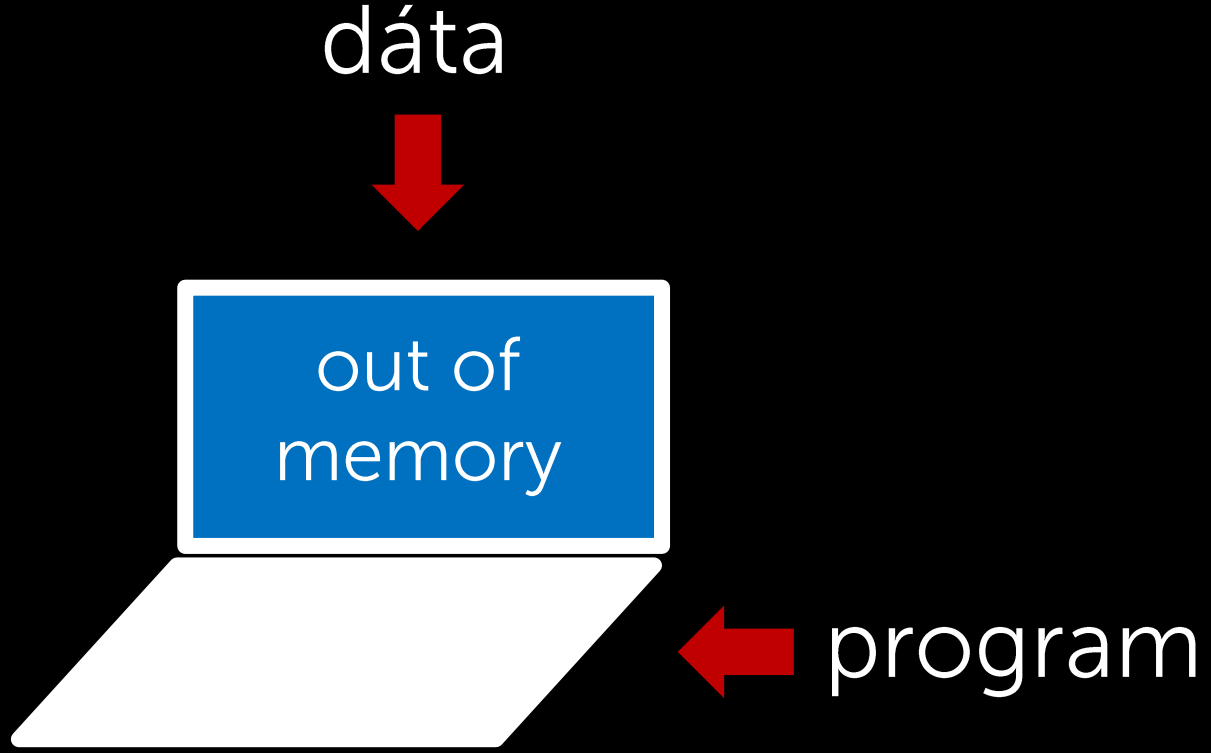
Alan Turing

univerzálny počítač



Alan Turing

univerzálny počítač



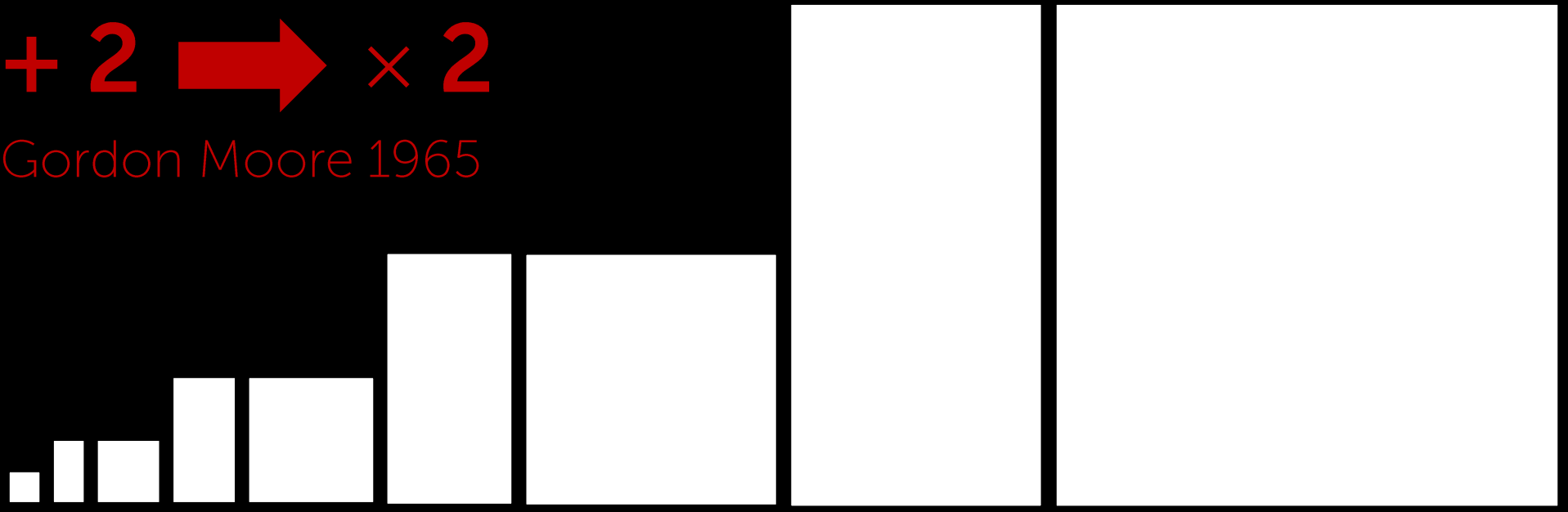
Alan Turing

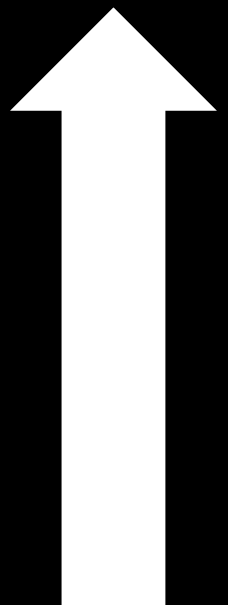
EXPONENCIÁLA

viac, rýchlejšie, lacnejšie (W, €)

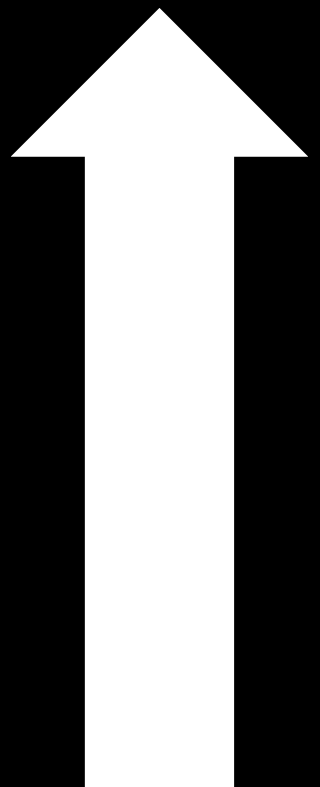
+ 2 ➡ × 2

Gordon Moore 1965

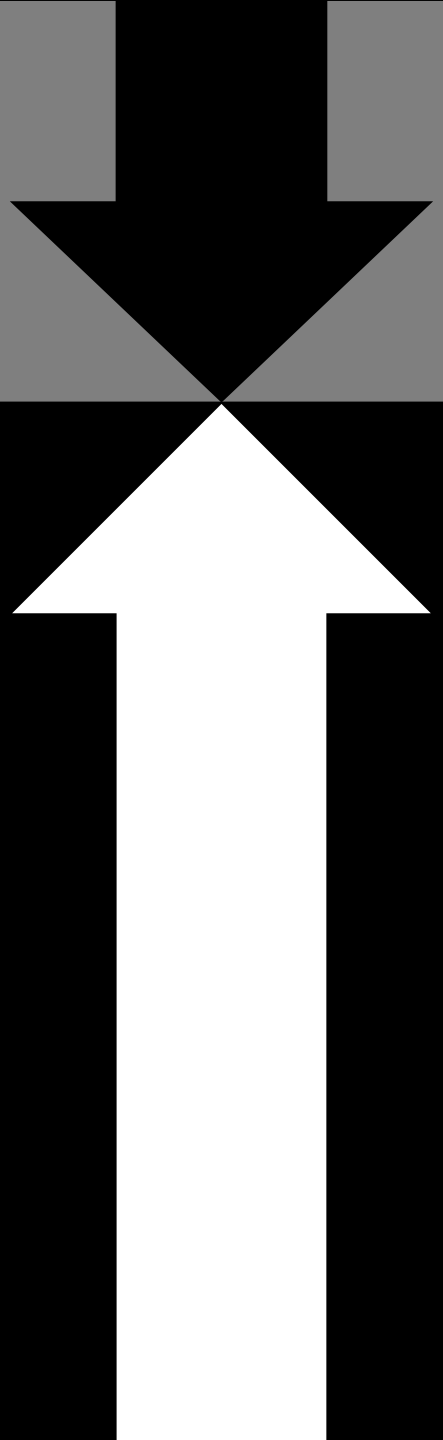




výpočtová sila (hardware)



nové algoritmy (software)
výpočtová sila (hardware)



fyzika

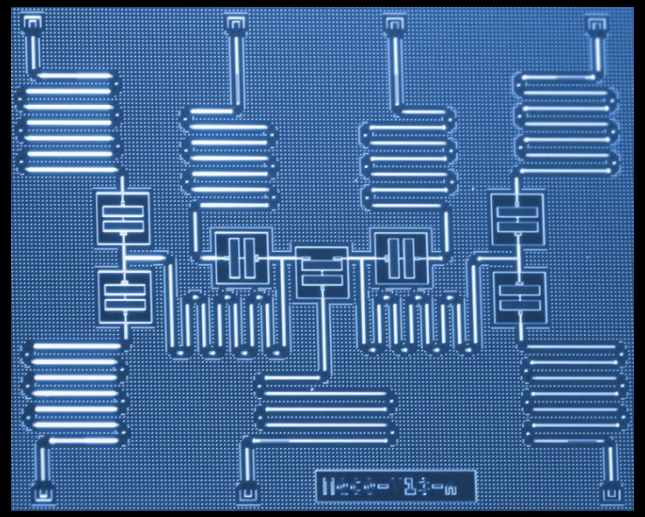
nové algoritmy (software)
výpočtová sila (hardware)

kvantová fyzika

Richard Feynman

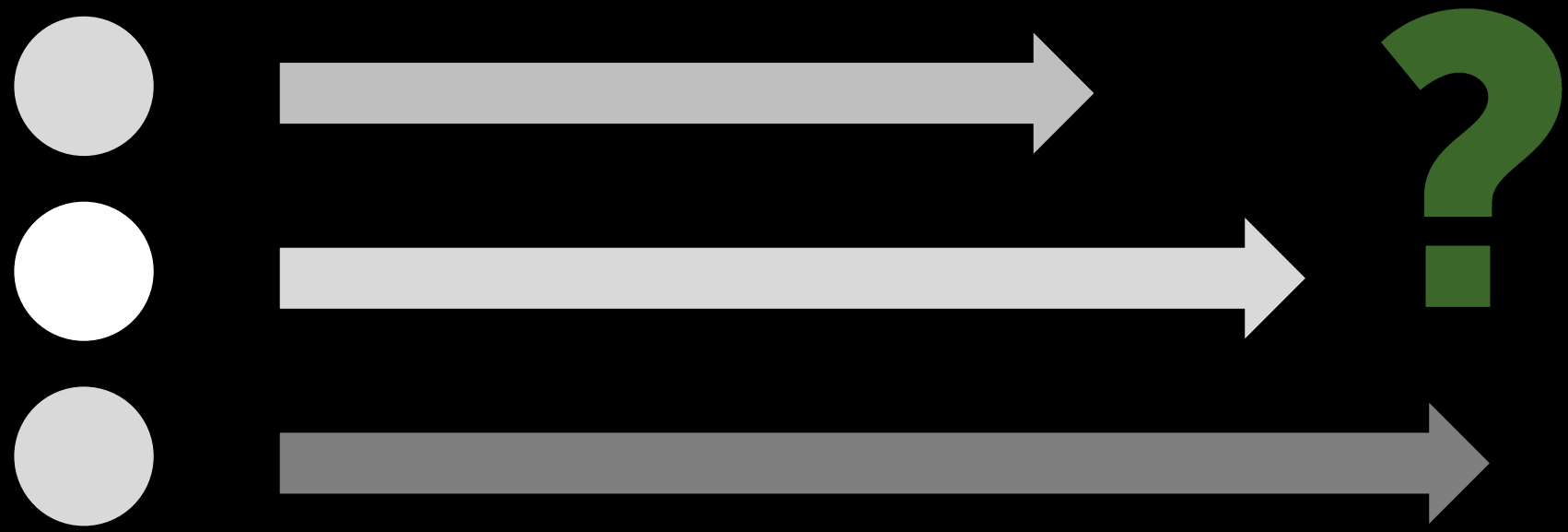
kvantová chémia (elek. štruktúra)
materiály (mnohočasticové systémy)

optimalizácia
kryptografia
štruktúra dát
strojové učenie



[IBM]

zvláštna
informácia

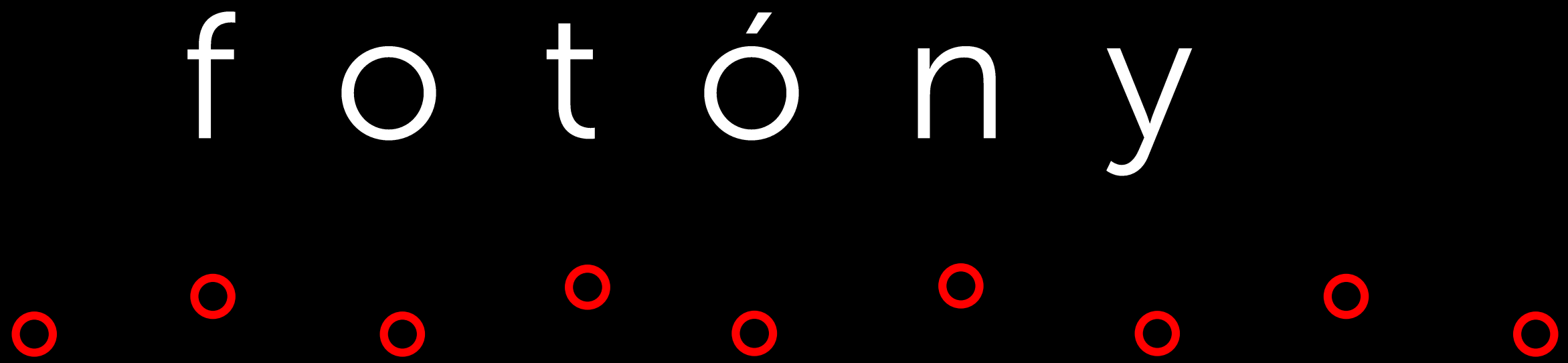


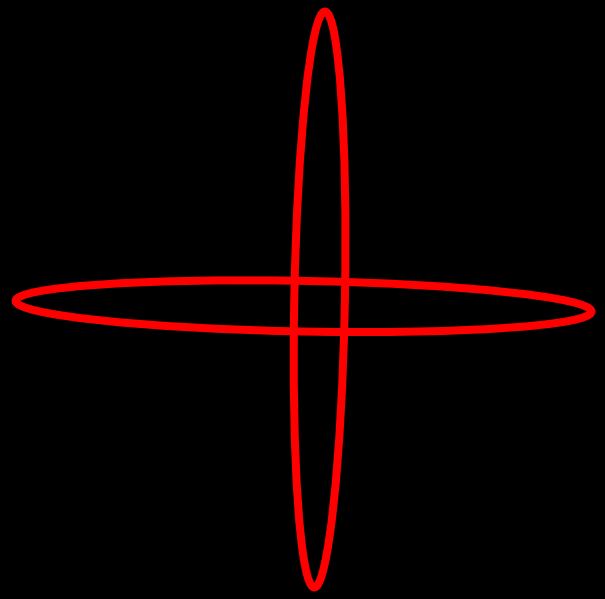
slabšie a slabšie svetlo

slabšie a slabšie svetlo

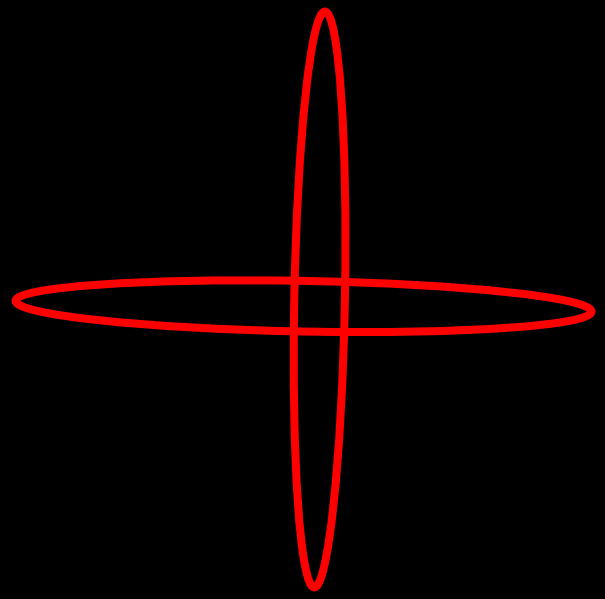
slabšie a slabšie svetlo

slabšie a slabšie svetlo


fotóny



bit



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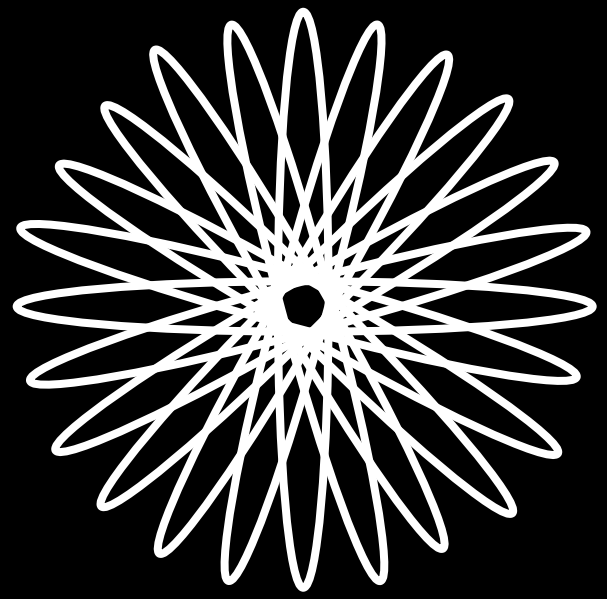
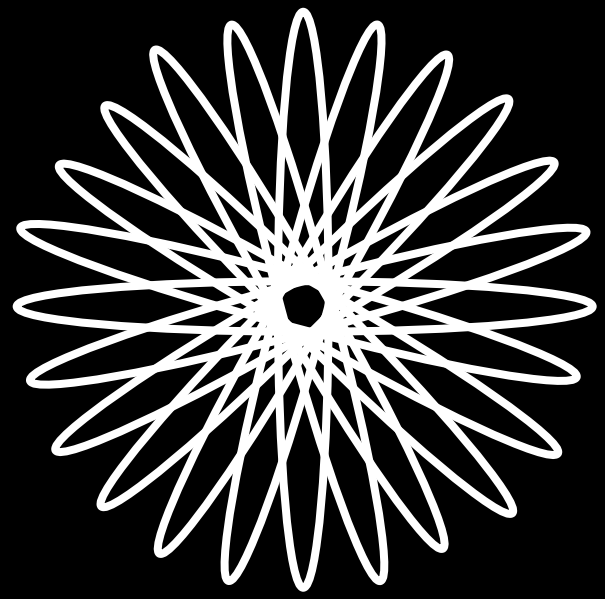
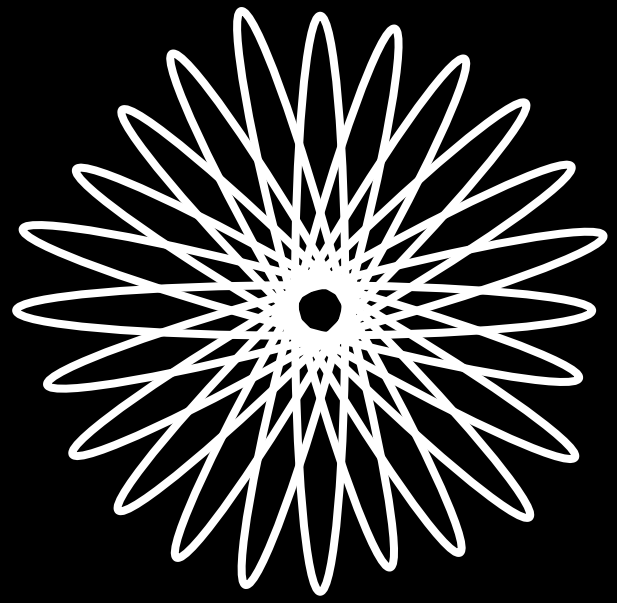


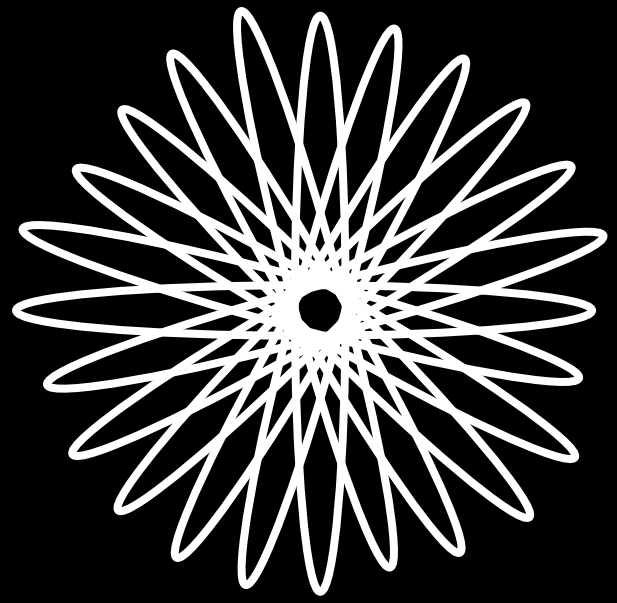
qubit

fotón
atóm
obvod
molekula
nanooscilátor
kvantová bodka

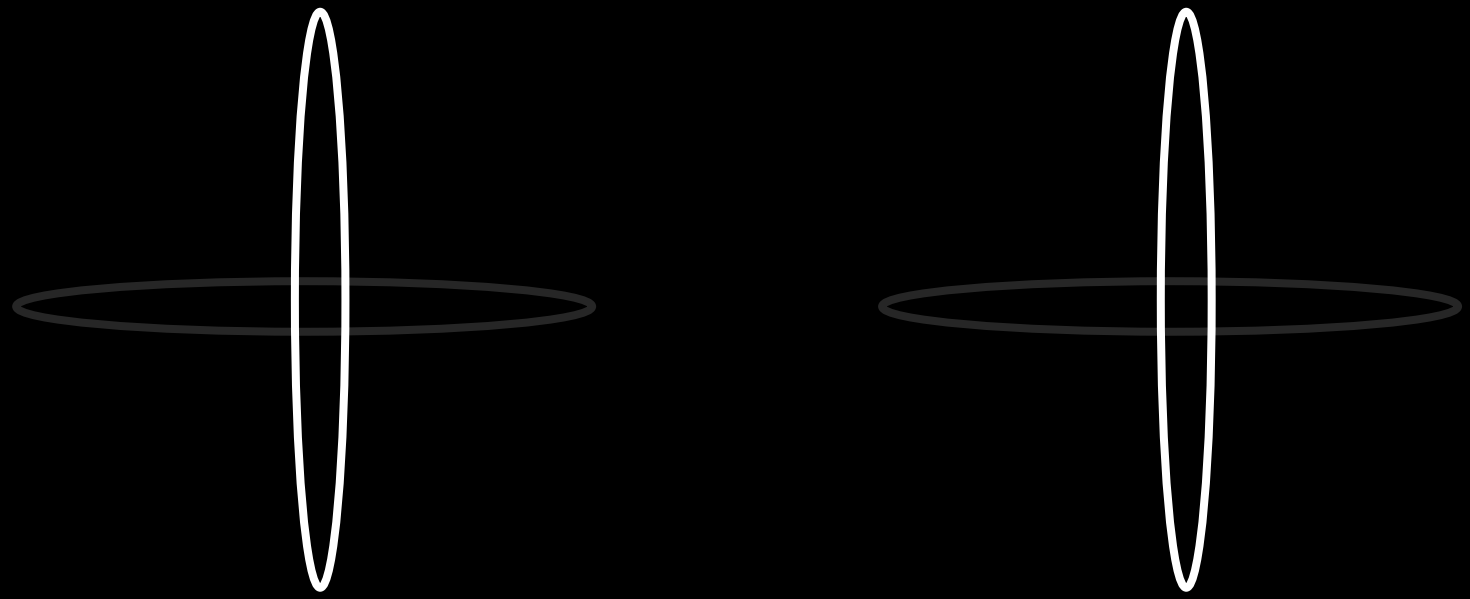


qubit

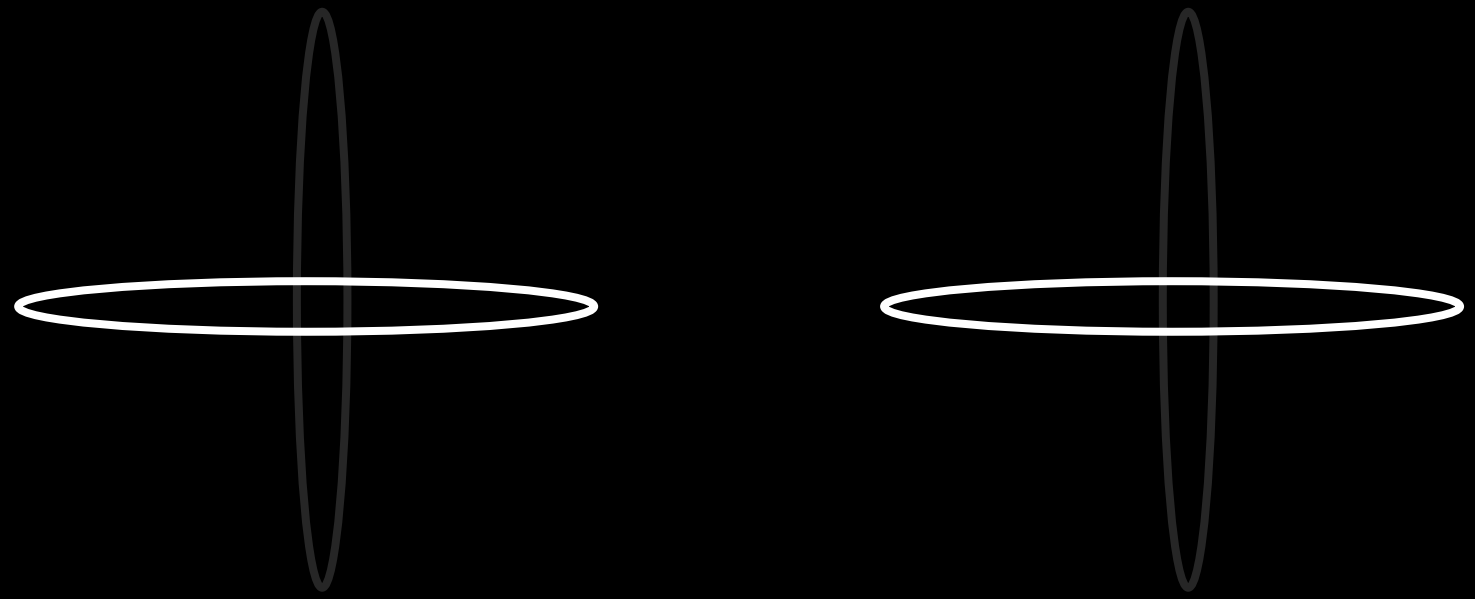




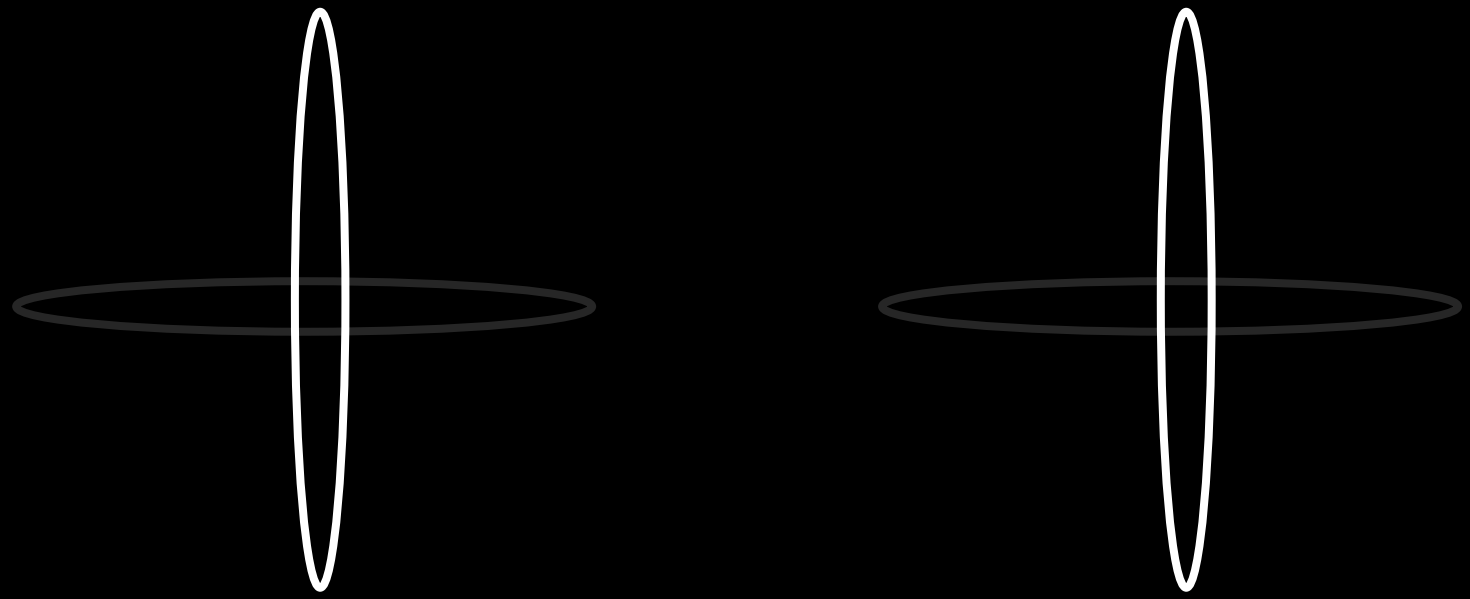
qubit + qubit



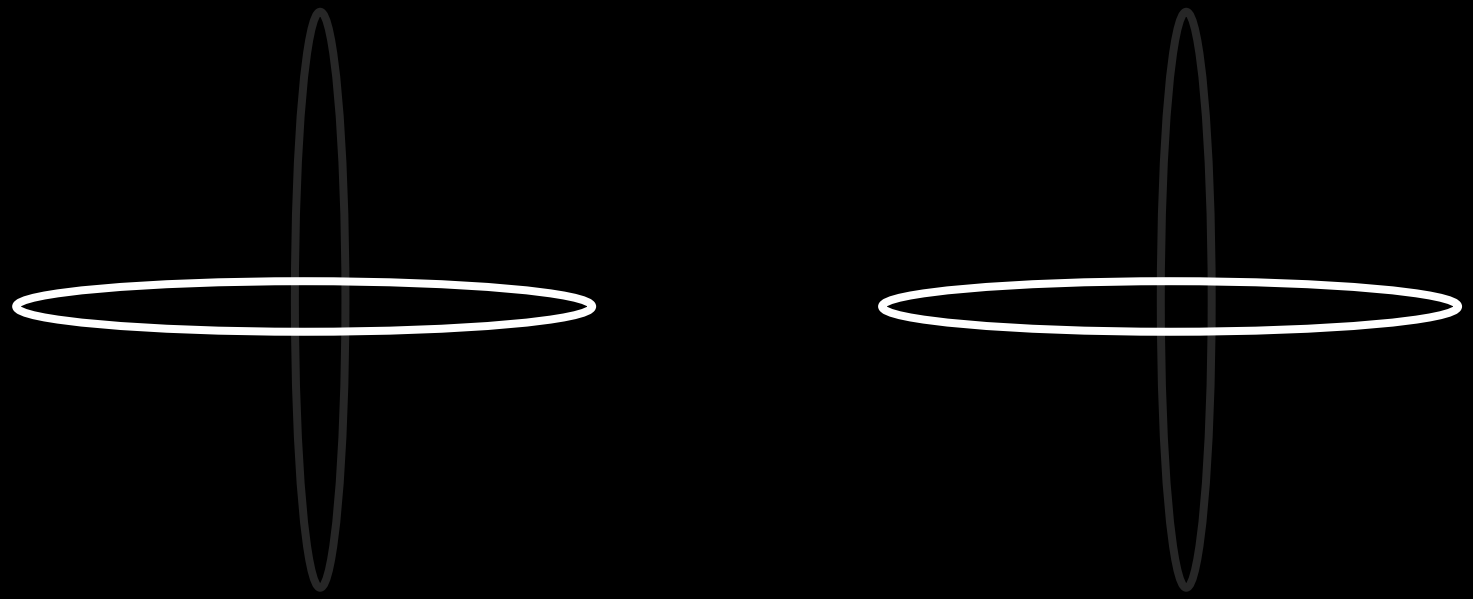
qubit + qubit



qubit + qubit



superpozícia 2 qubitov

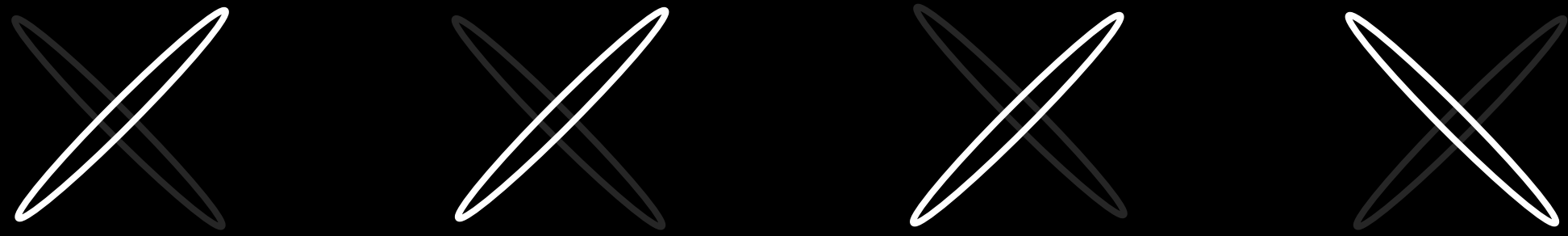


superpozícia 2 qubitov

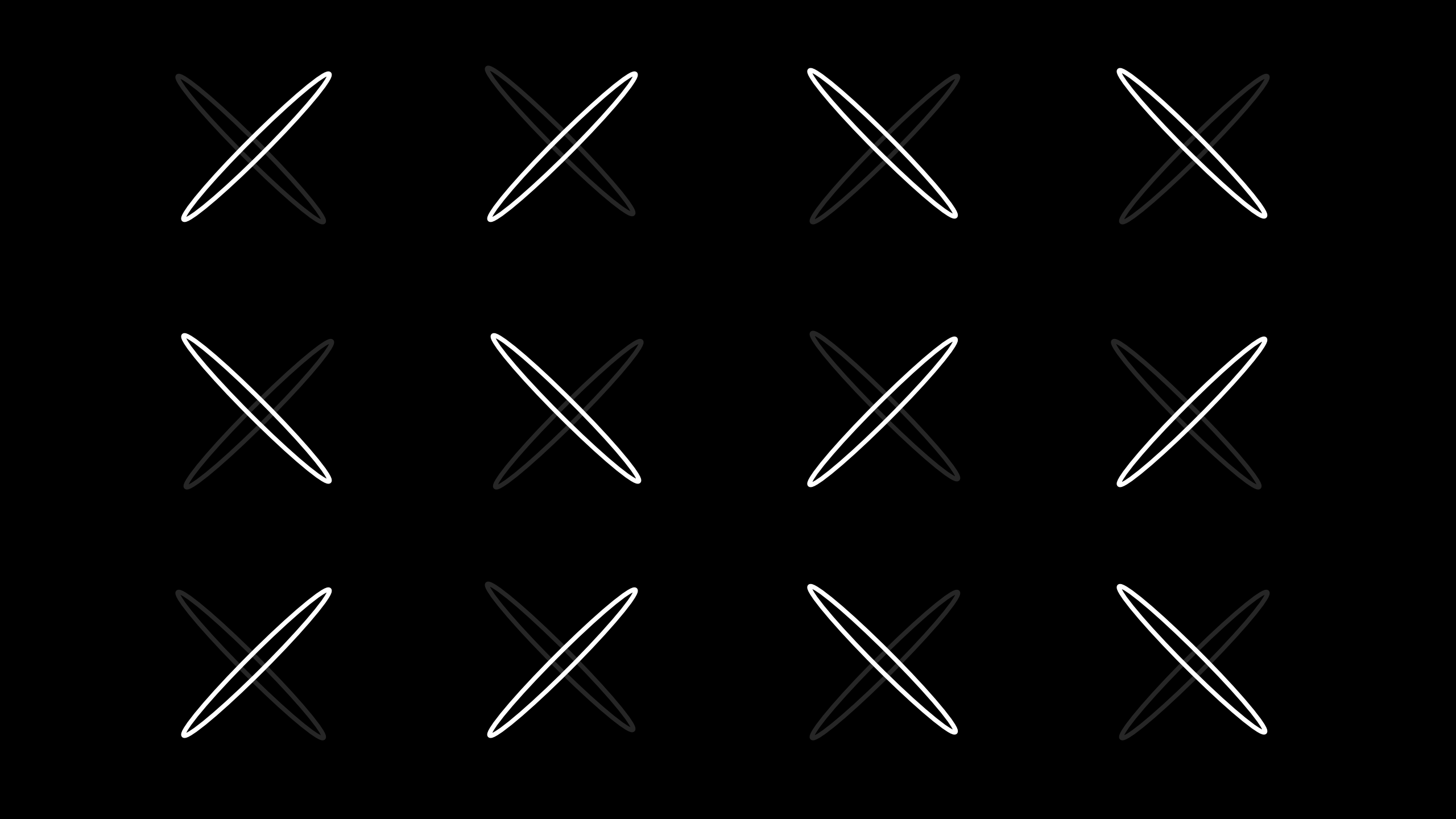
superpozícia N qubitov

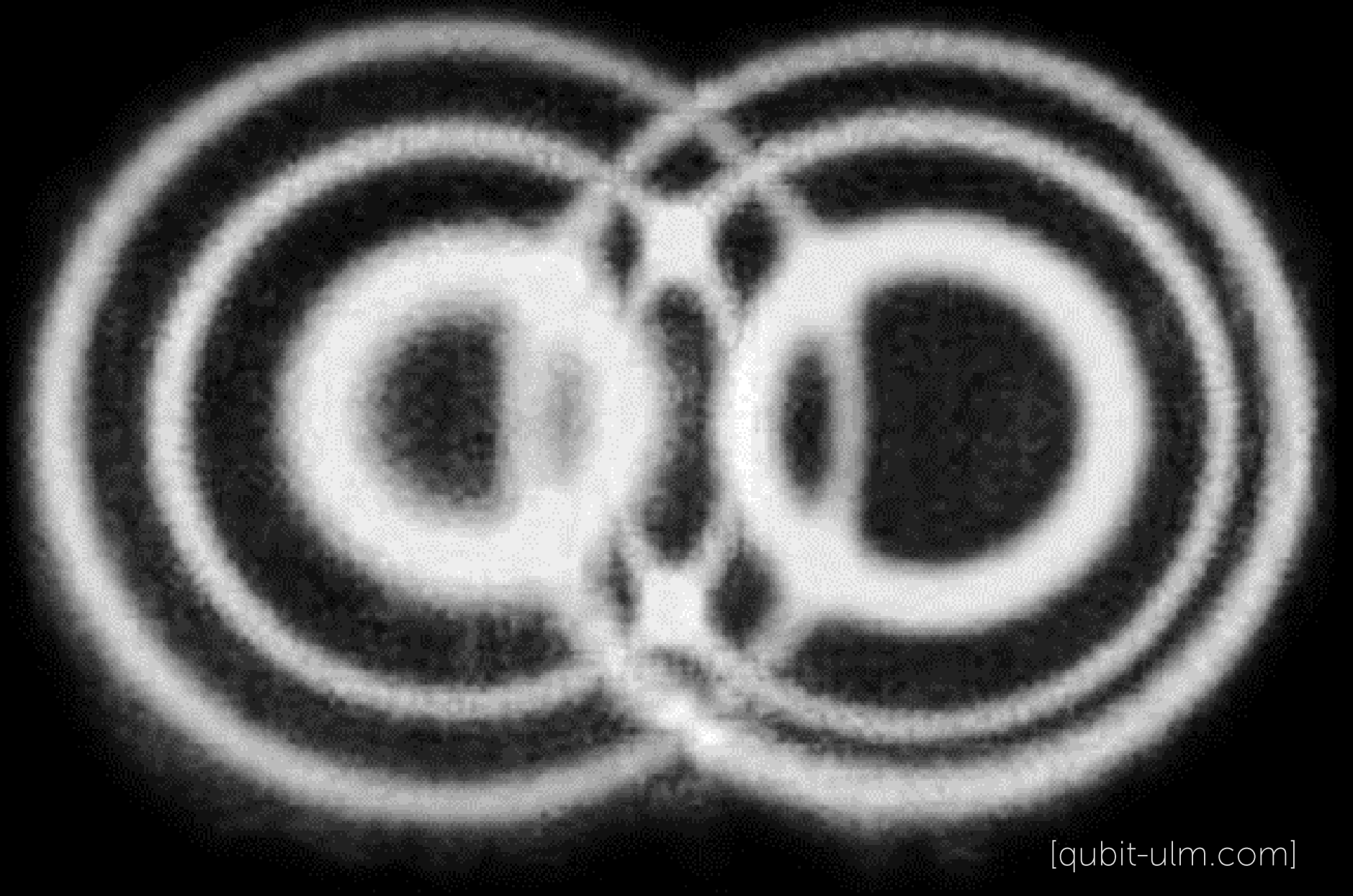
superpozícia N qubitov

superpozícia N qubitov



superpozícia N qubitov

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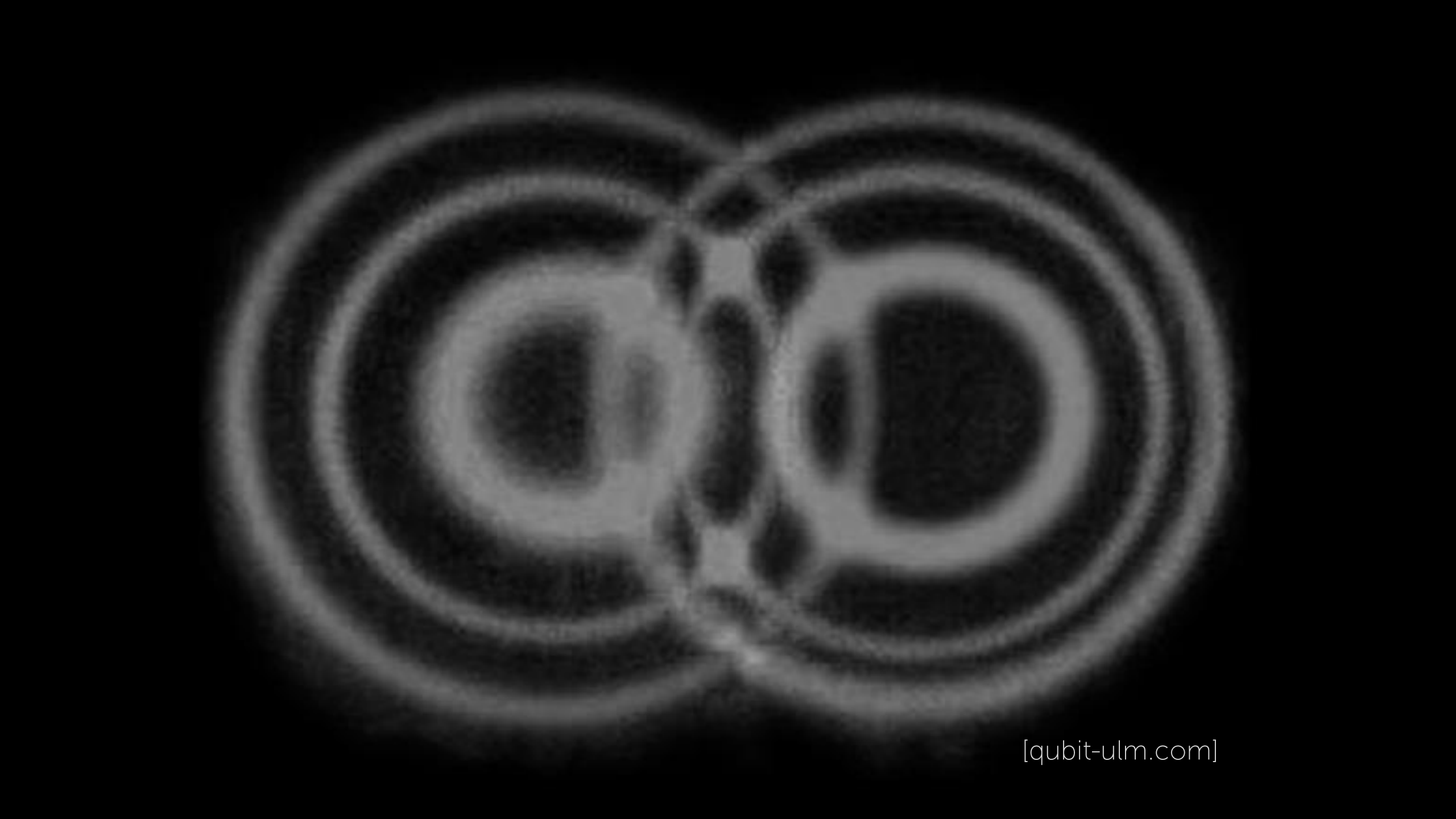
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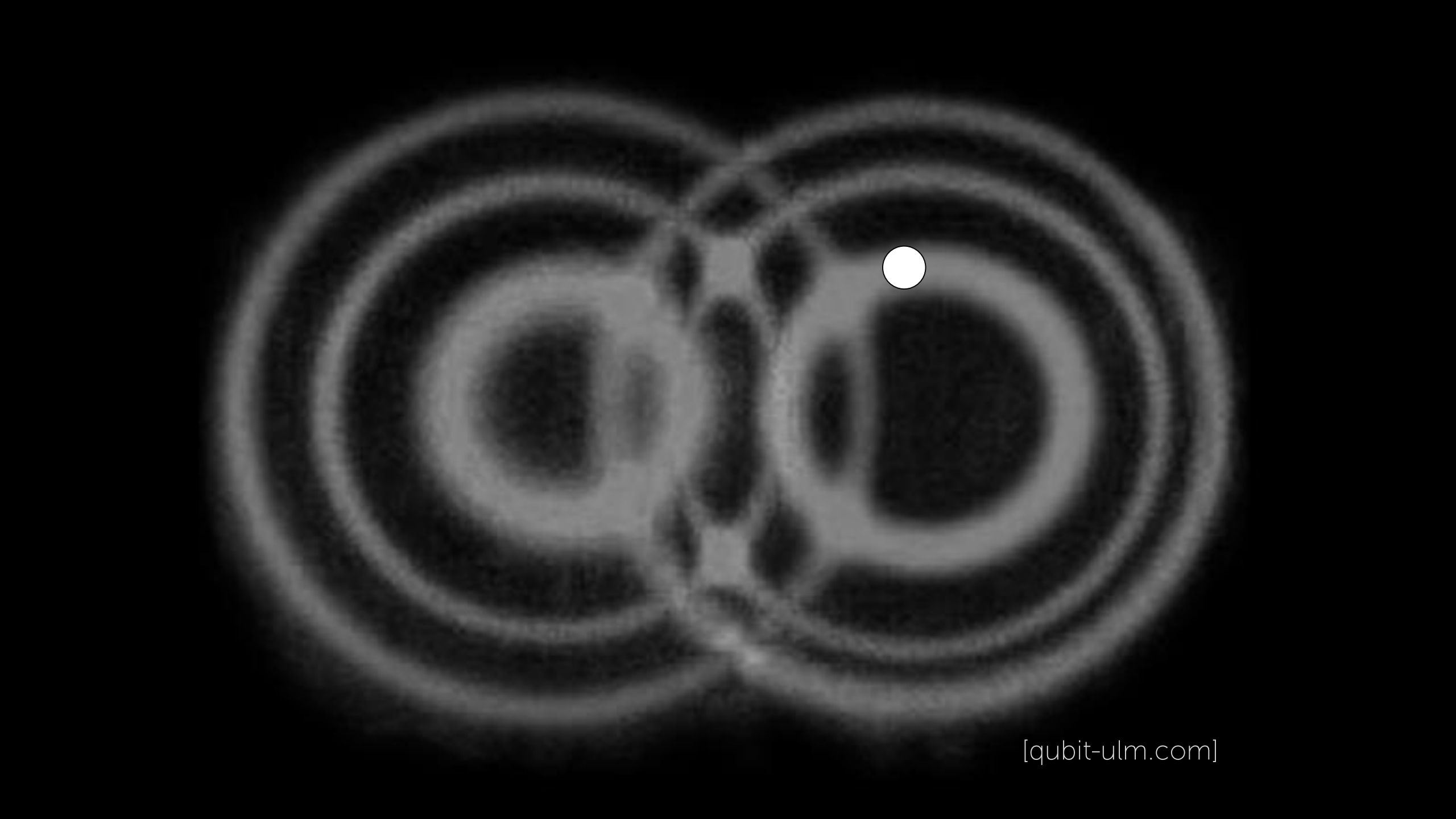
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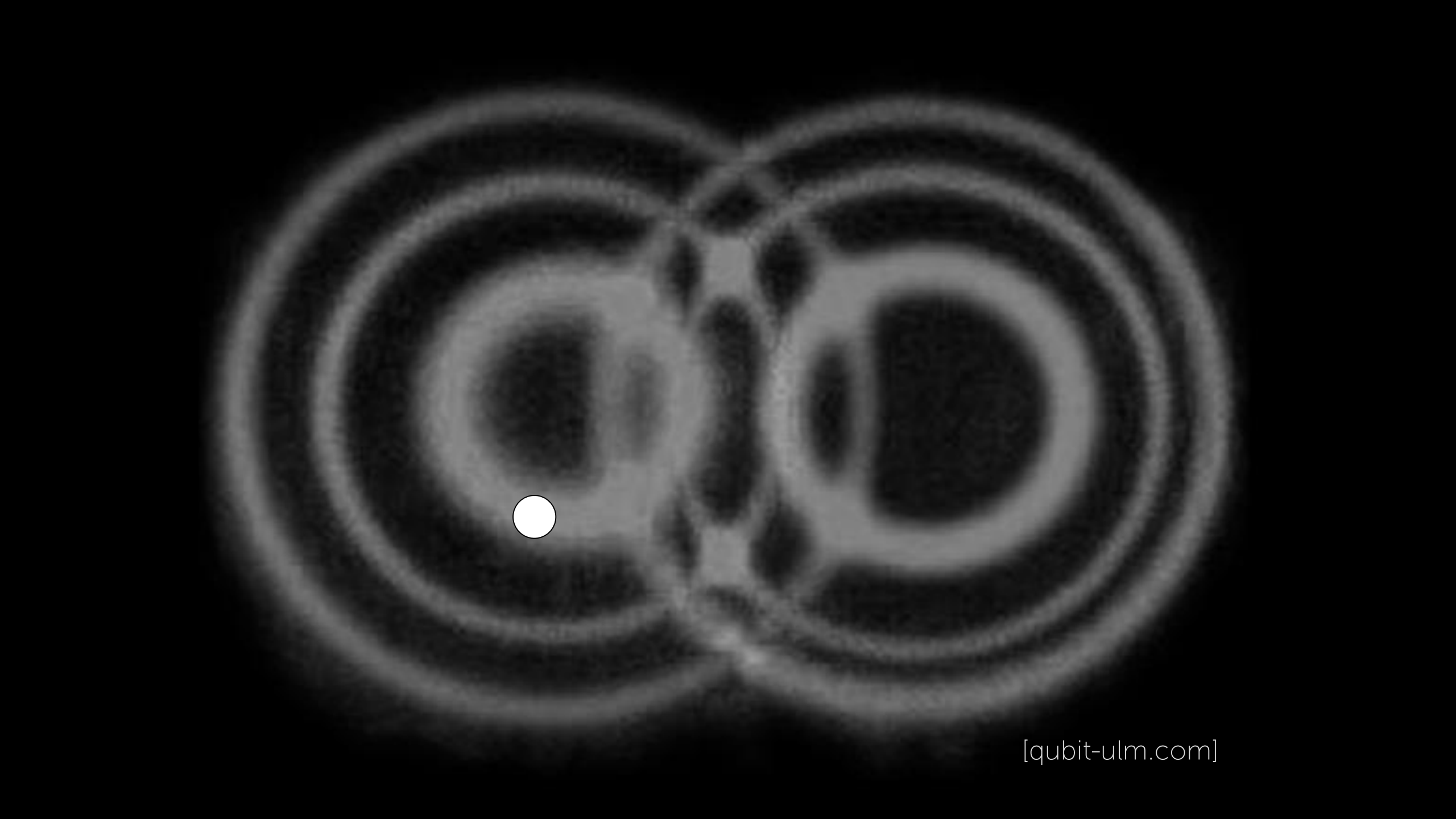
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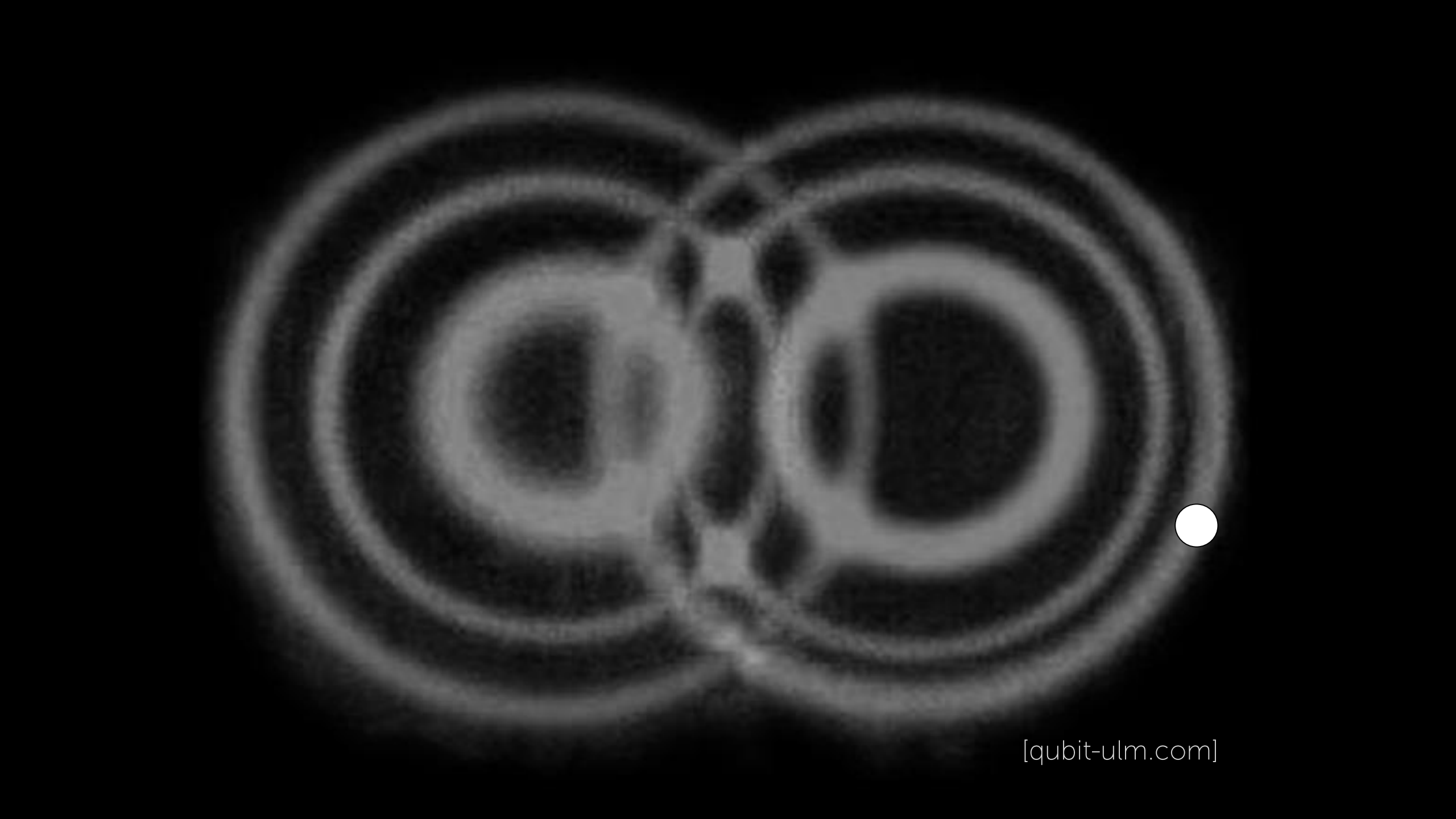
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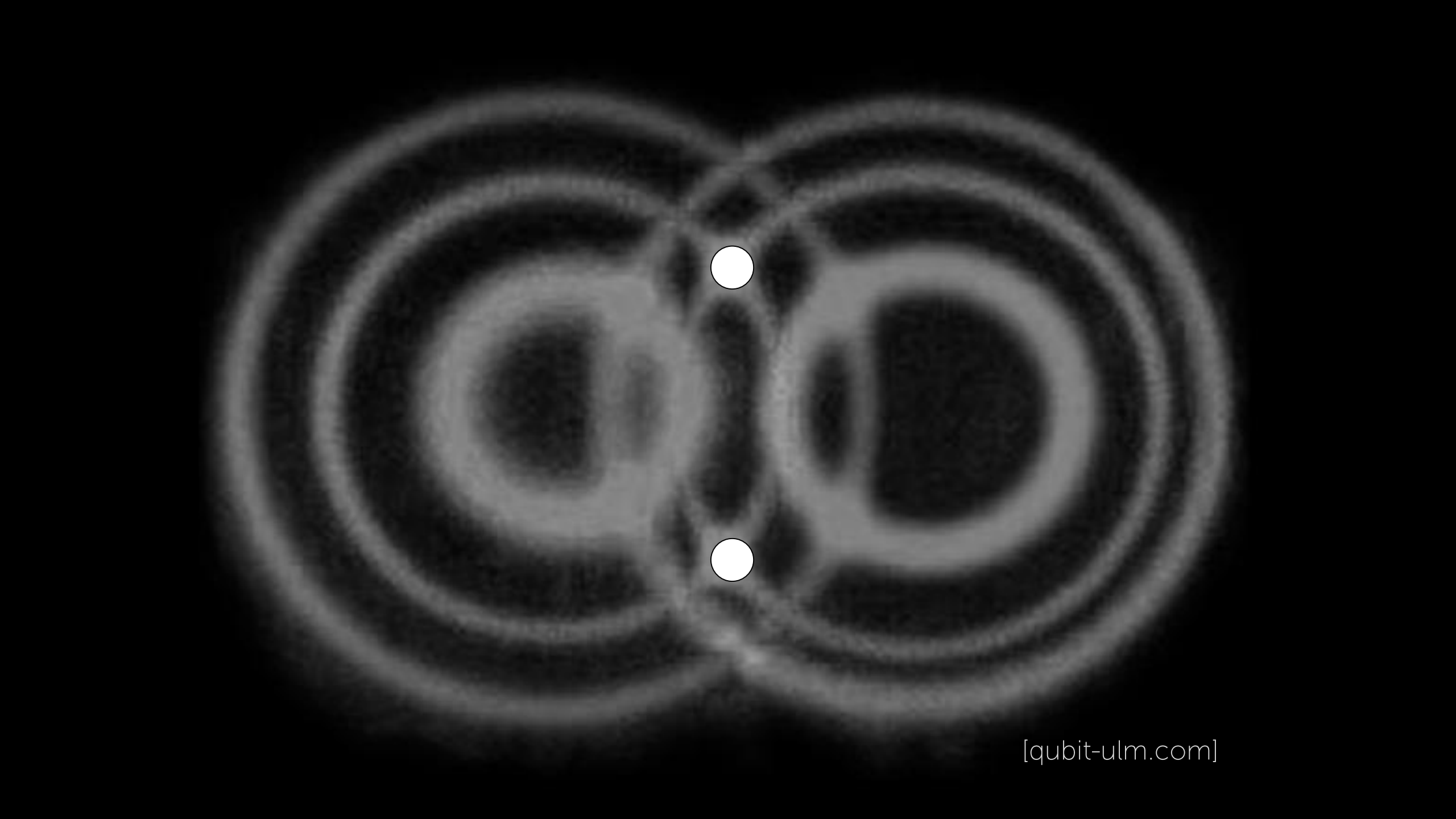
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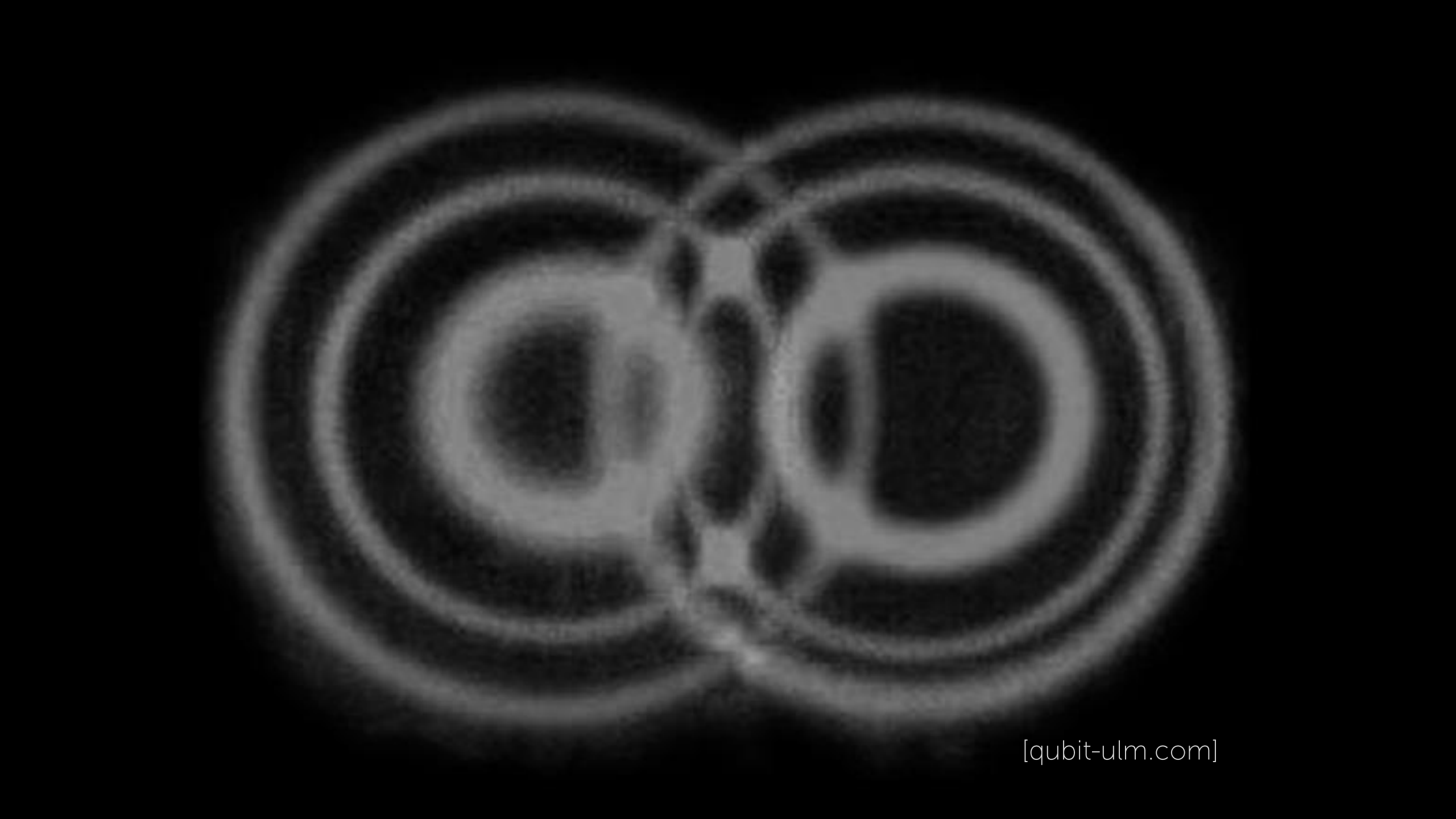
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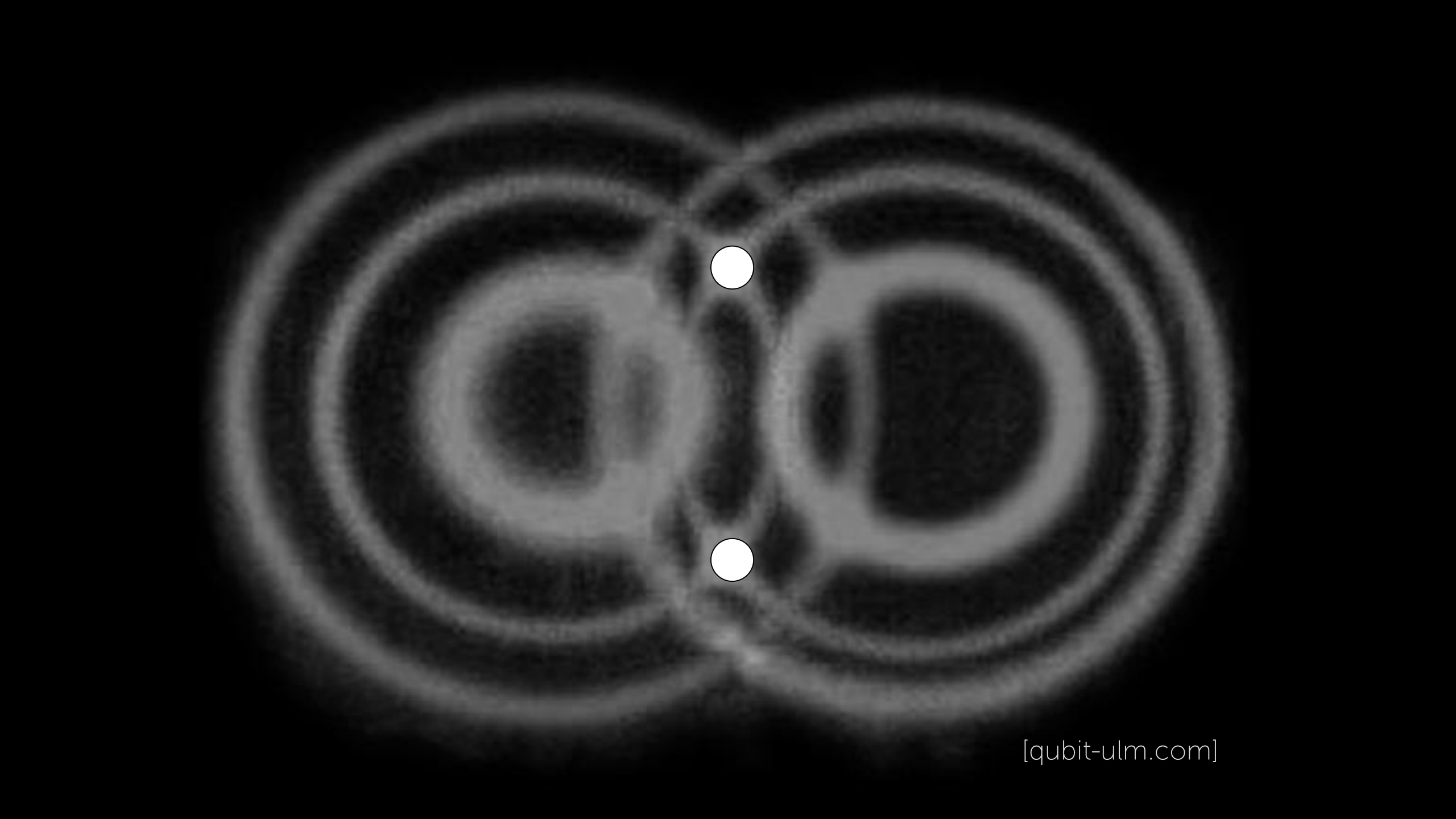
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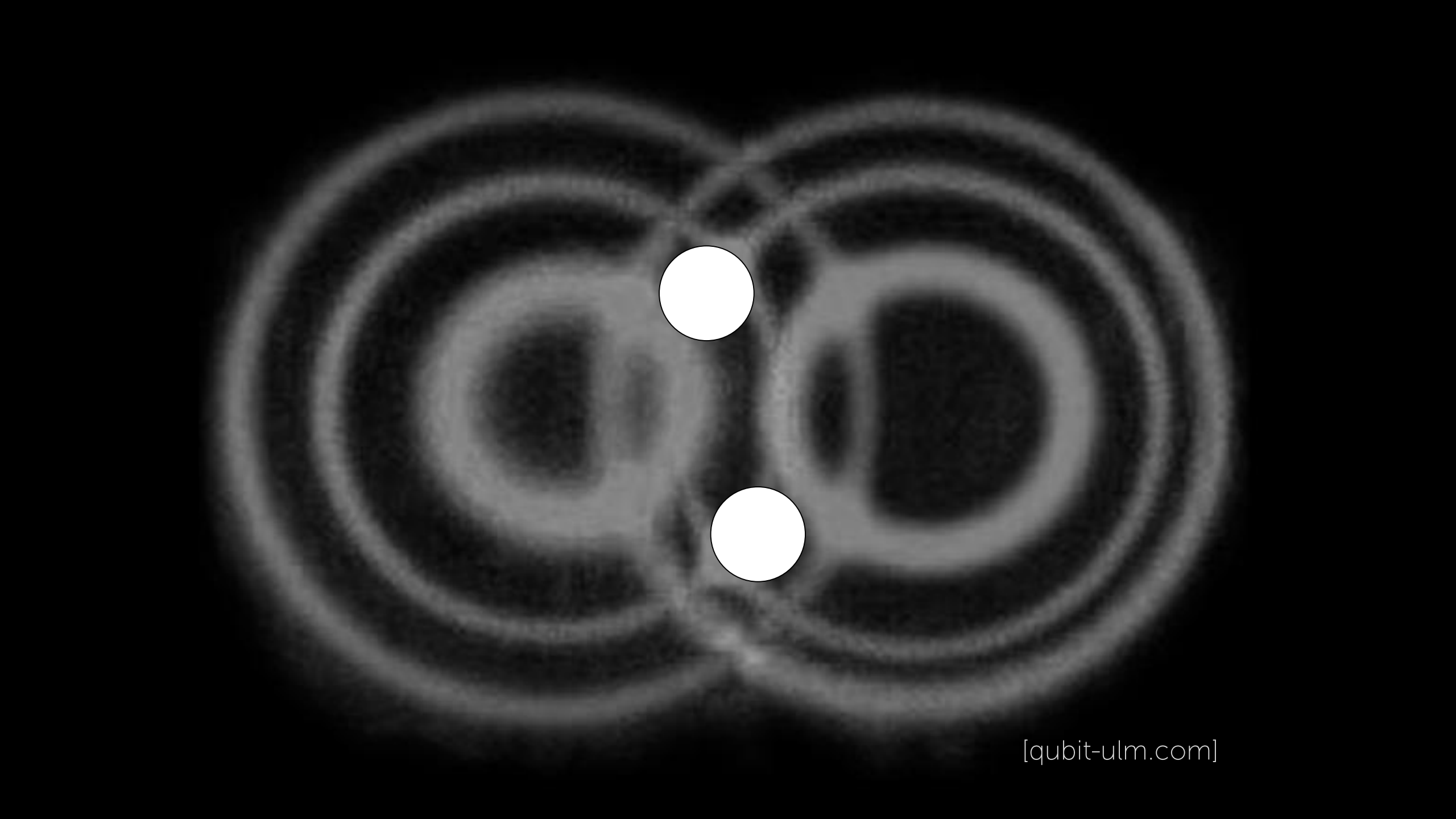
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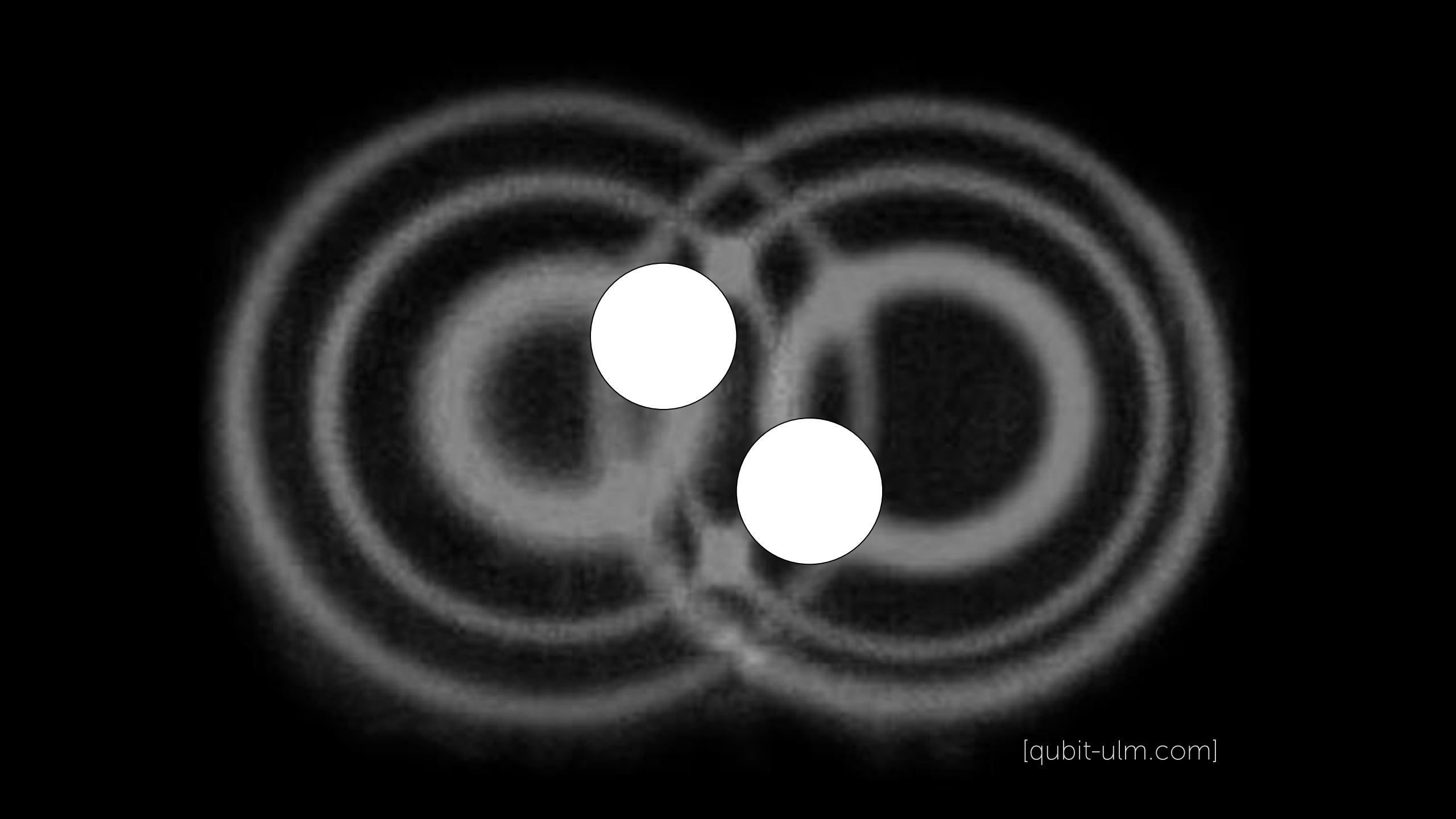
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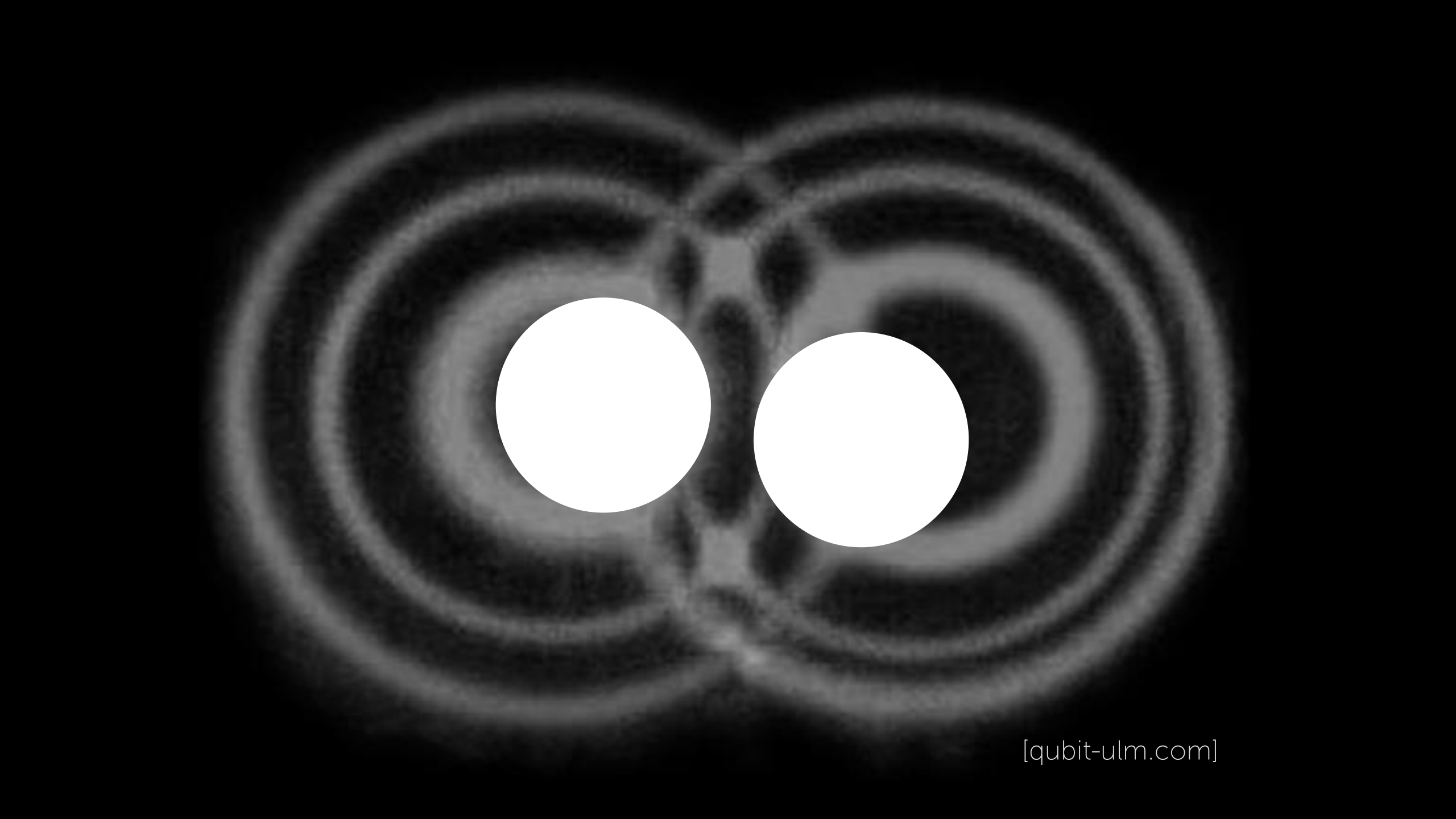
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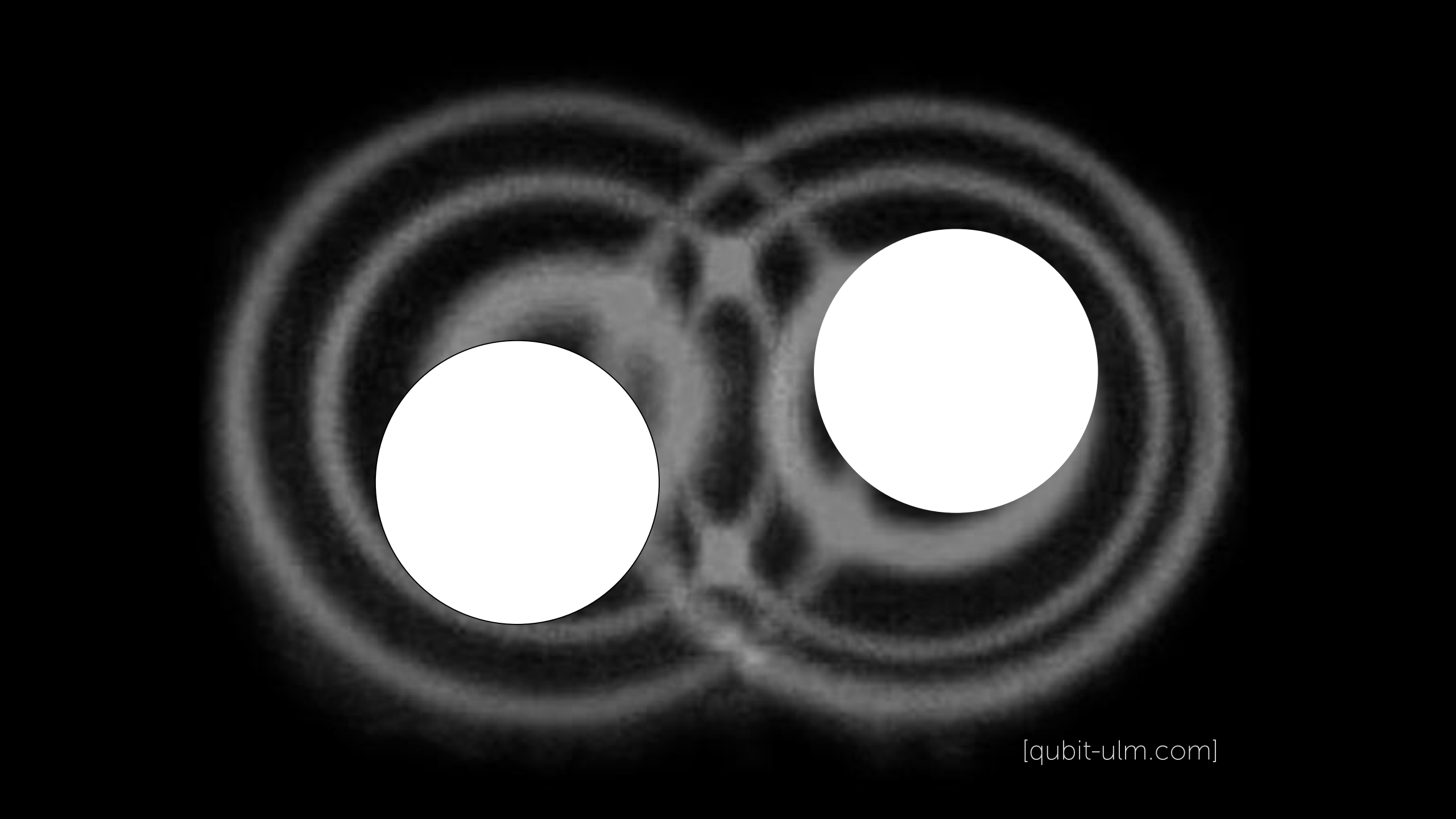
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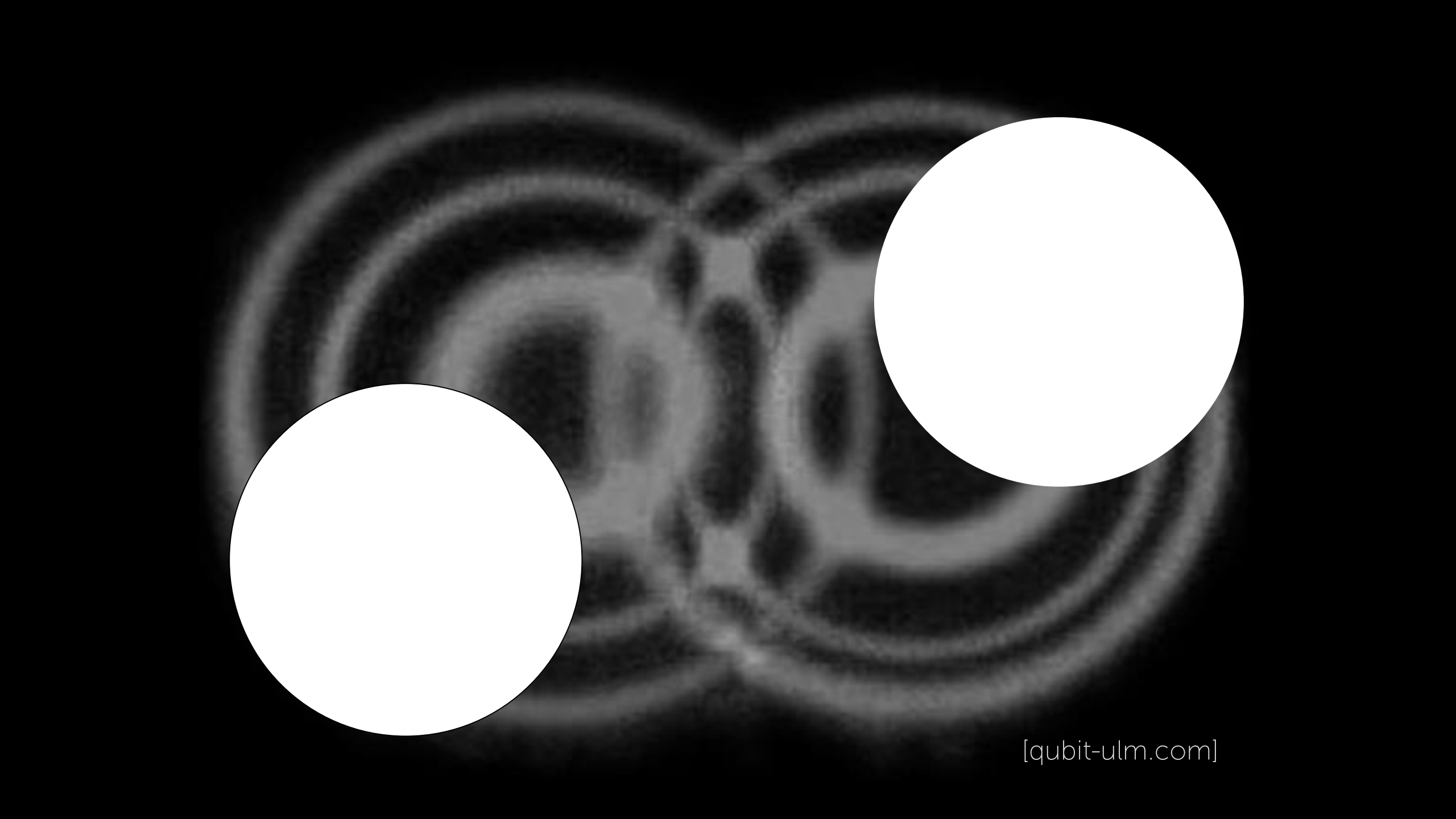
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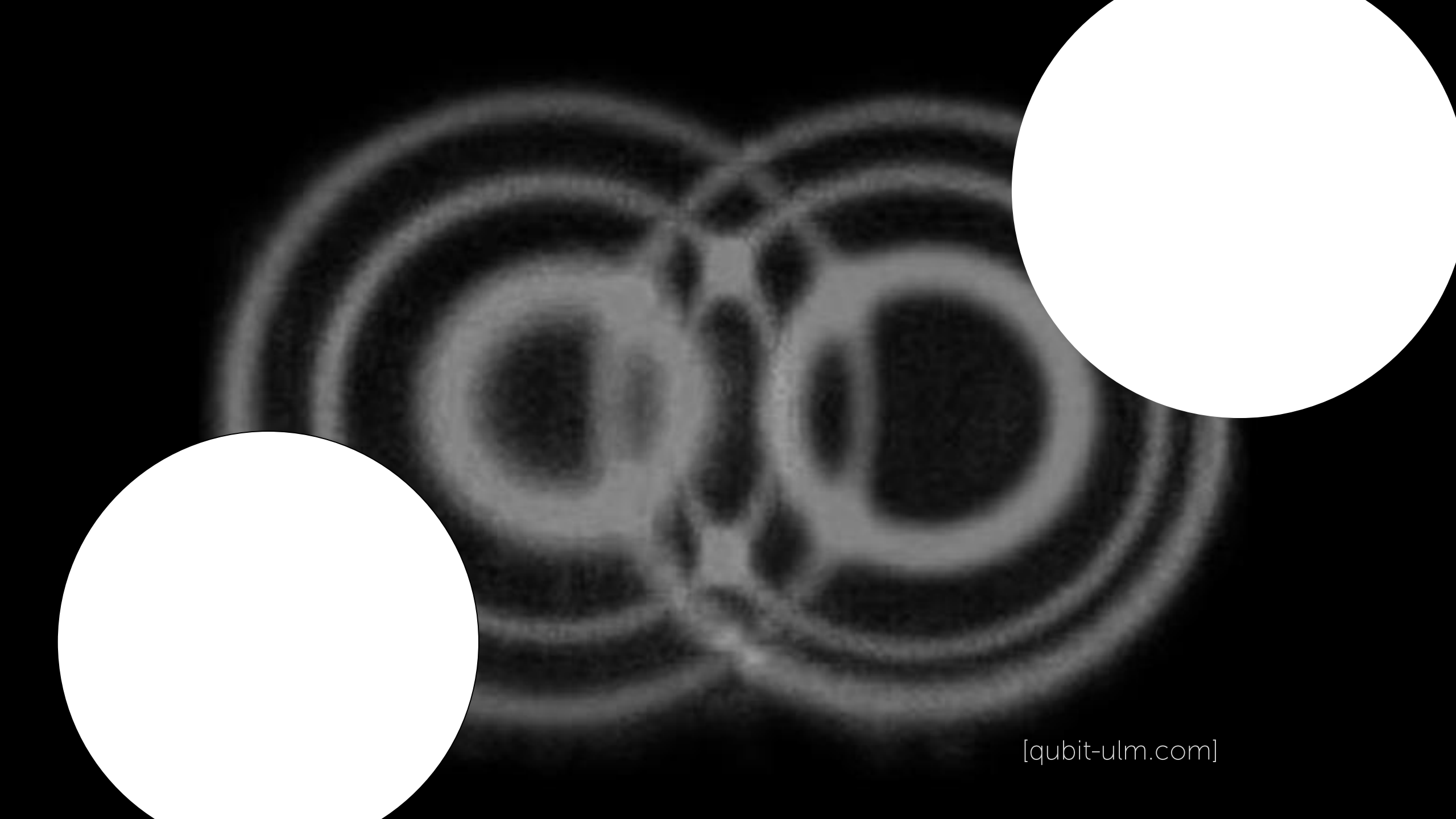
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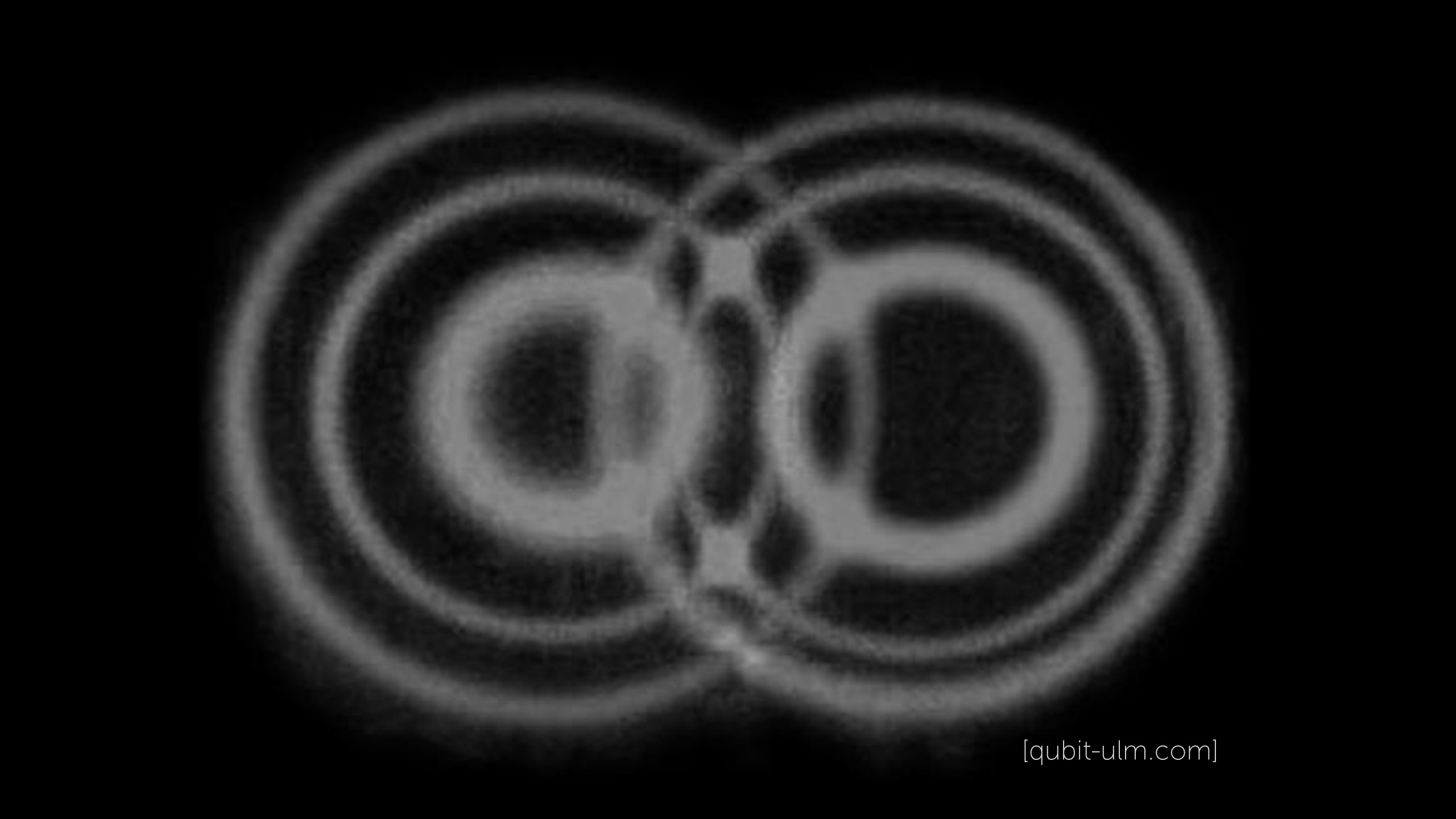
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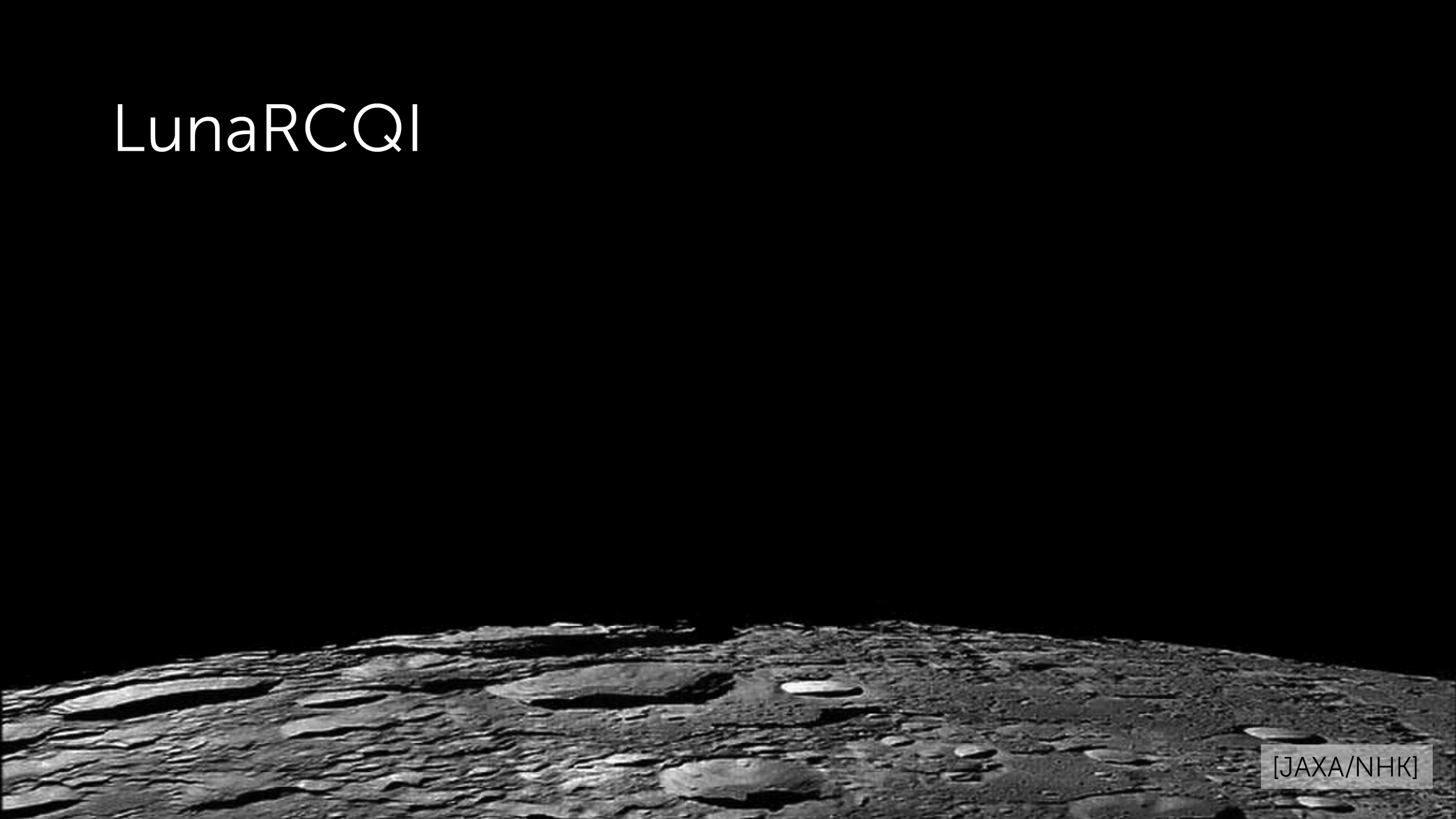
fundamental
fysiks group,
[City magazine]

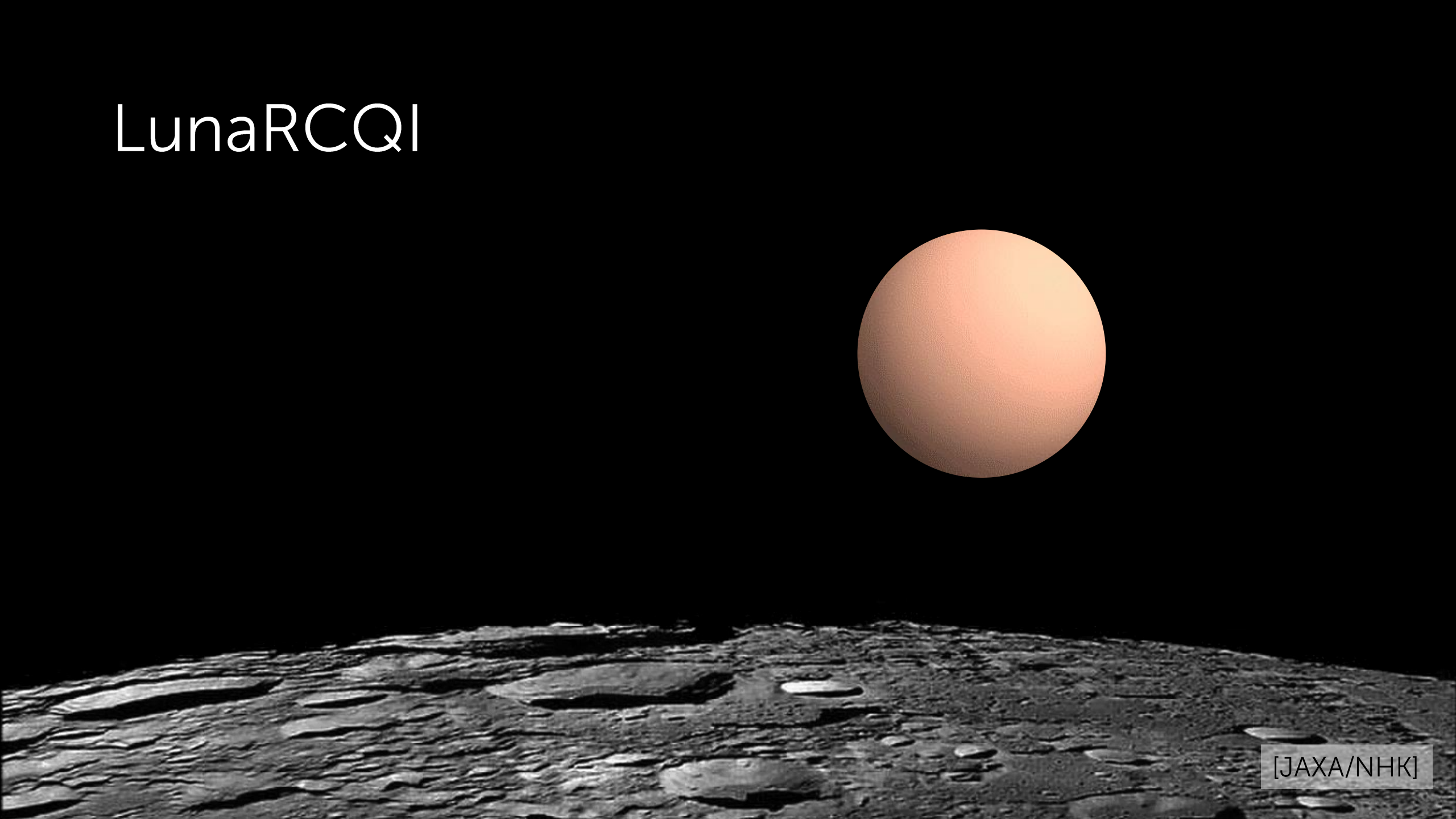
kvantová TELEPORTÁCIA

LunaRCQI



[JAXA/NHK]

LunaRCQI



[JAXA/NHK]

LunaRCQI

[JAXA/NHK]

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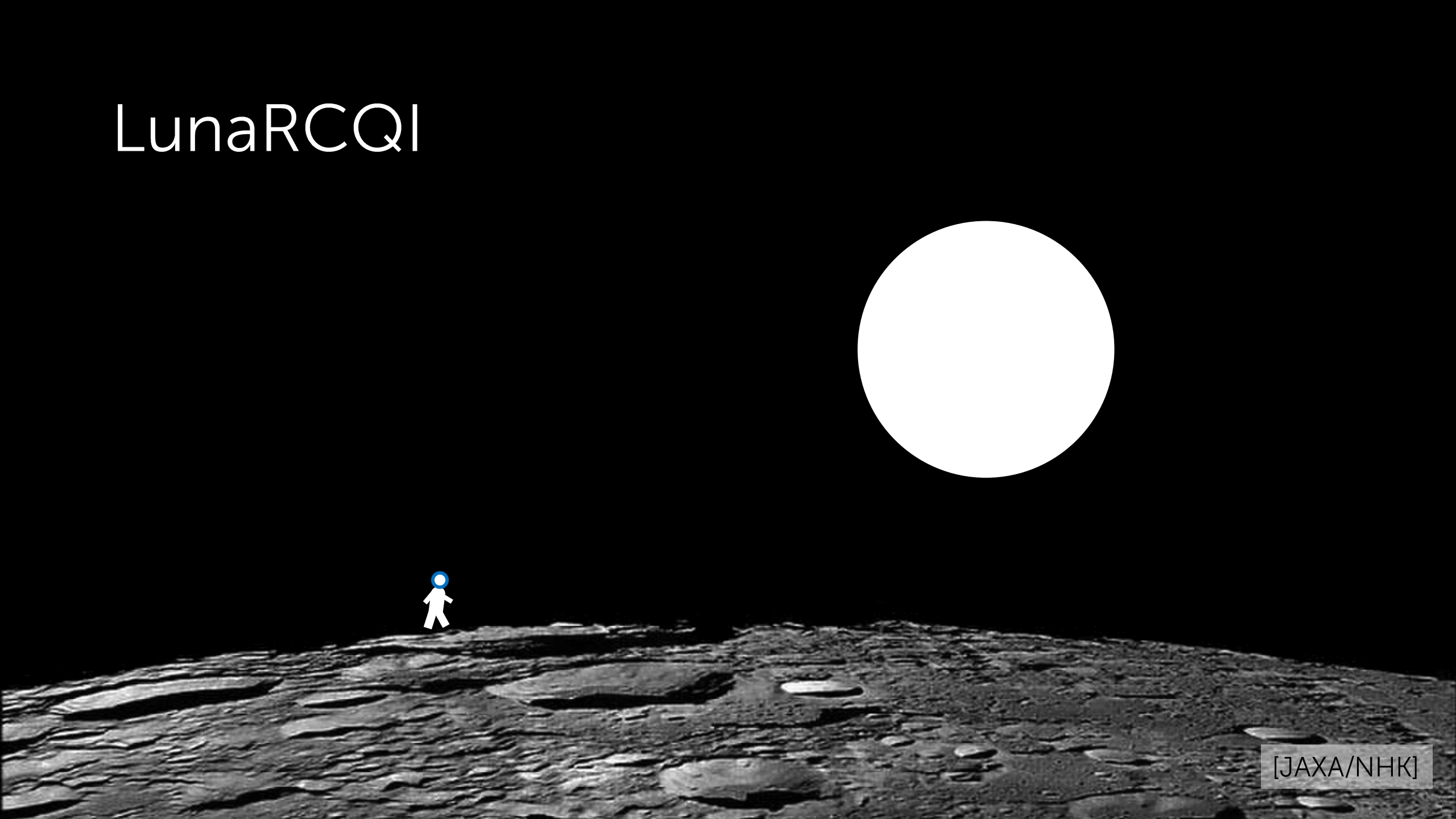

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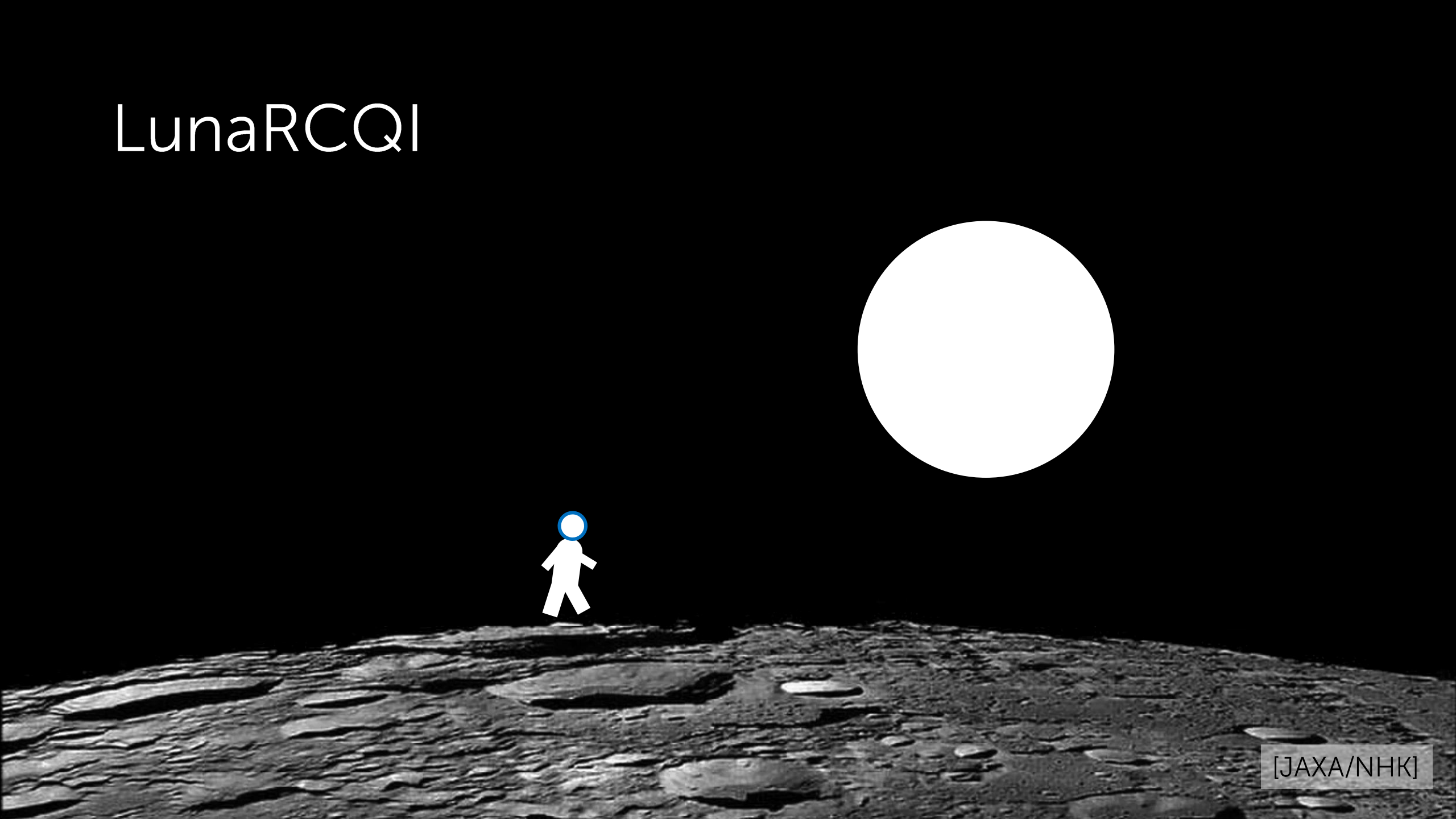

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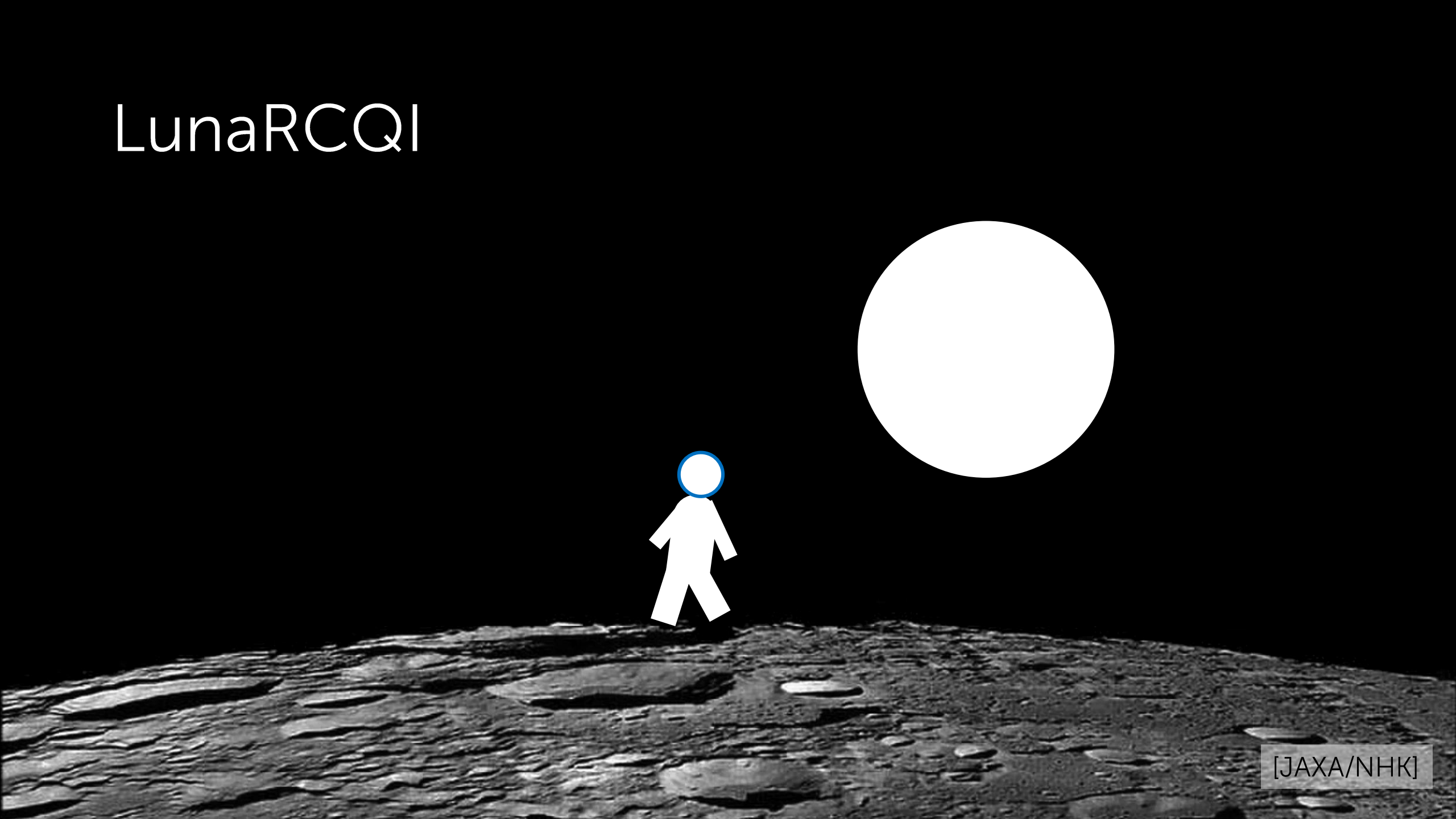

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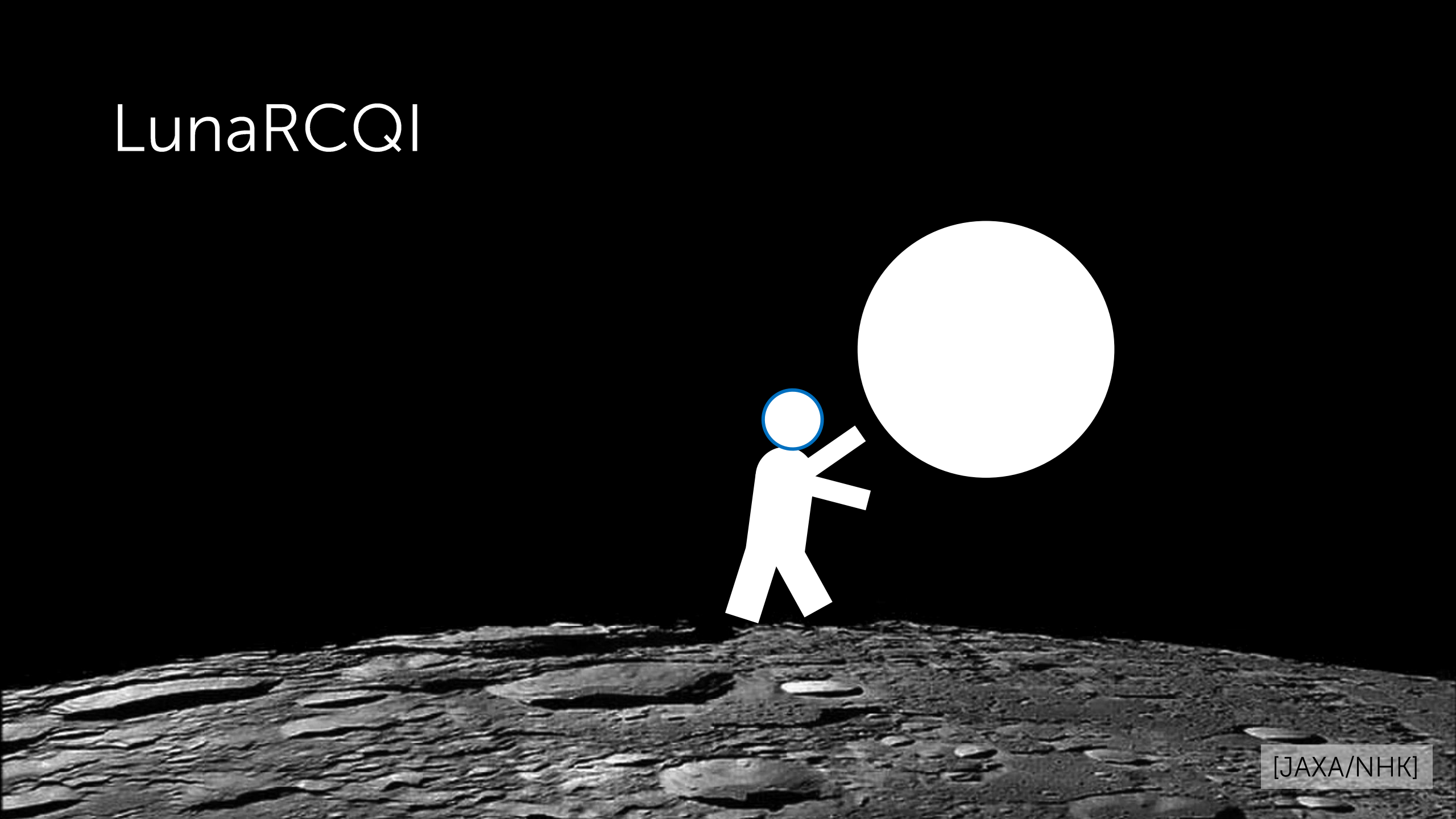

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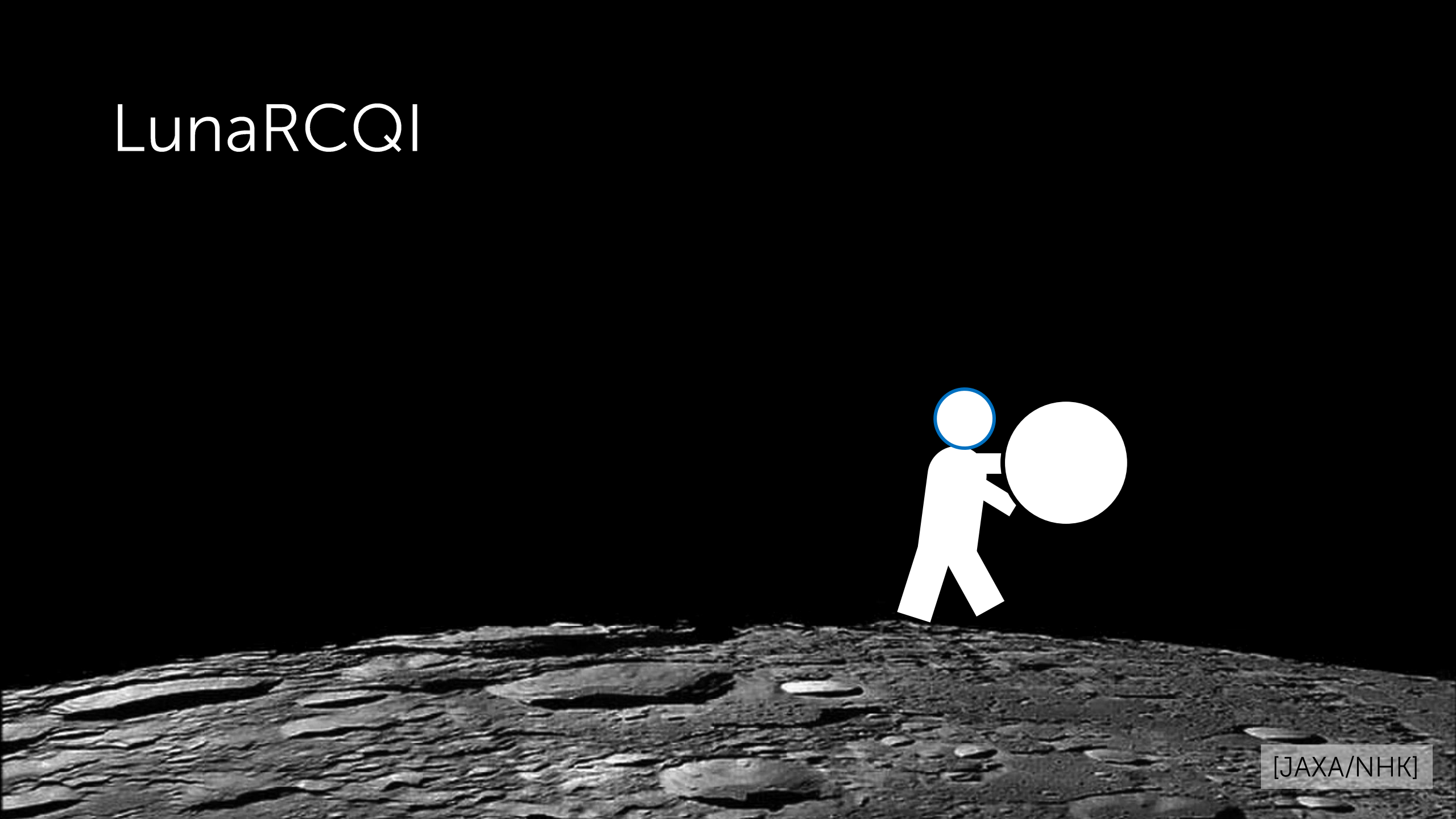

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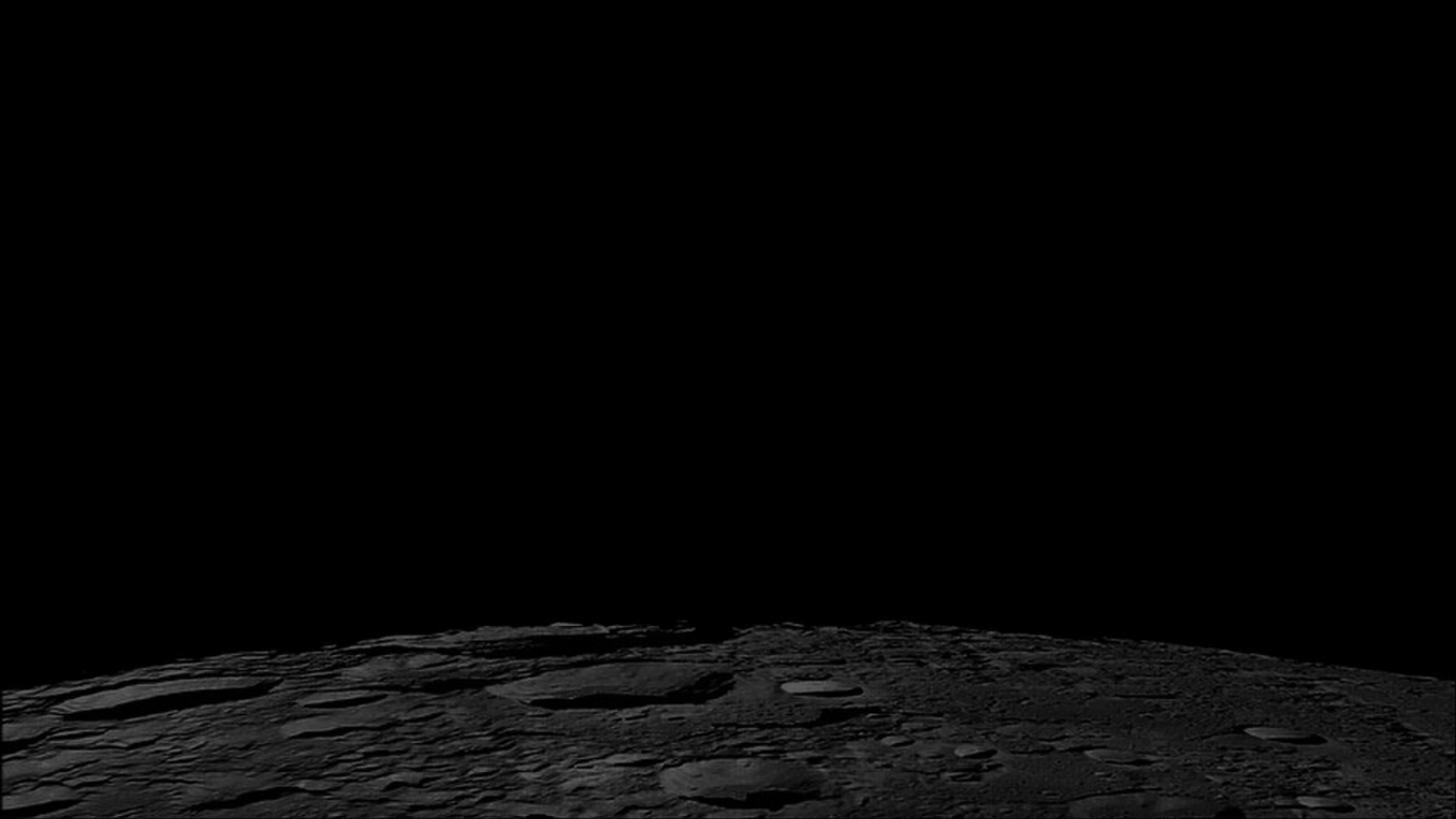
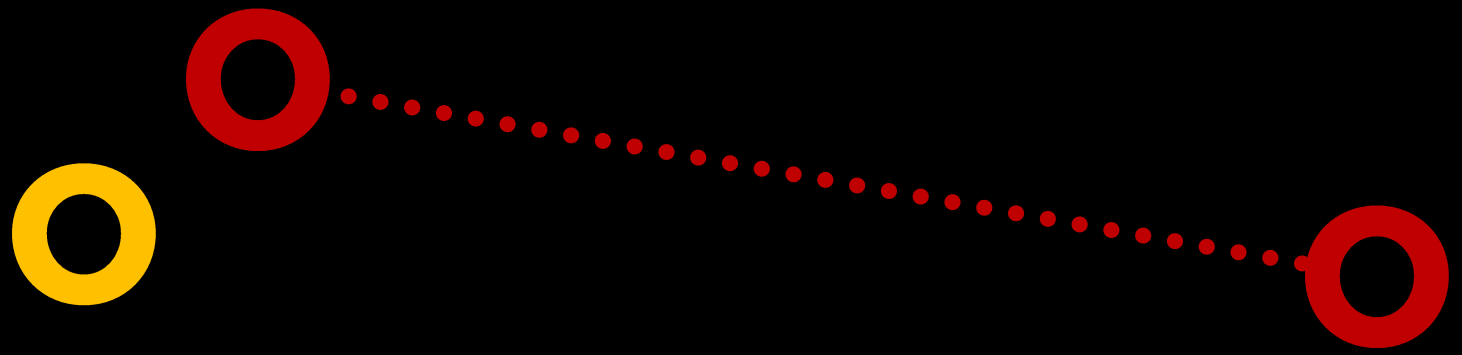
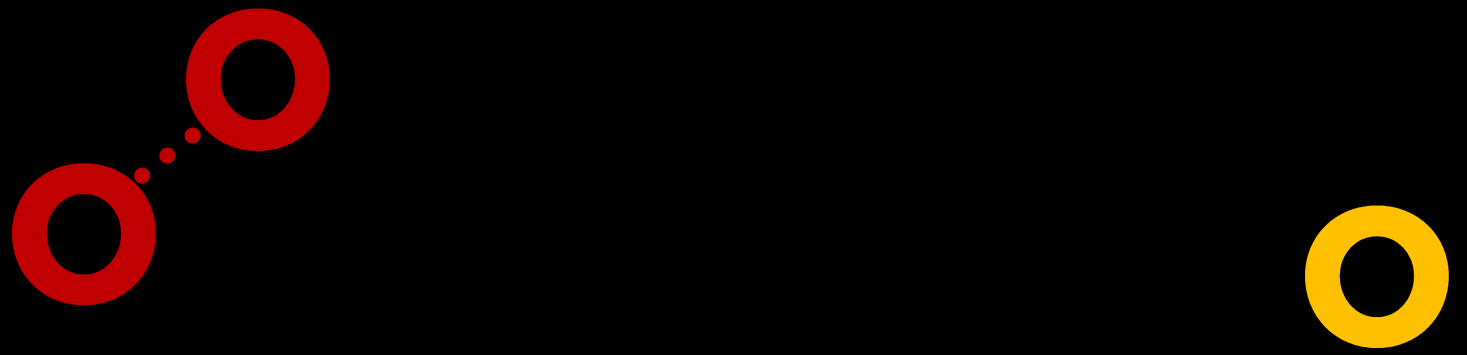


príliš fantastické?



príliš fantastické?



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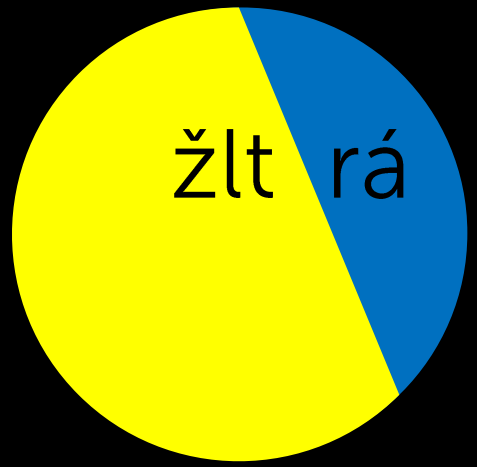
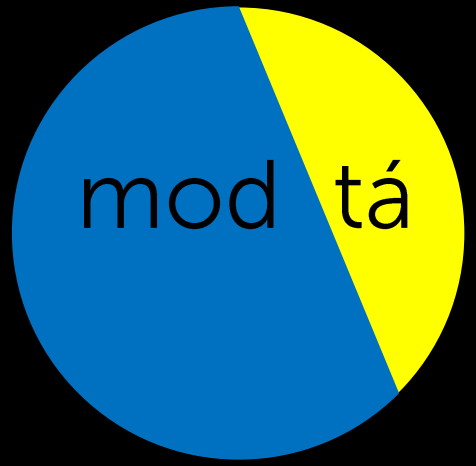


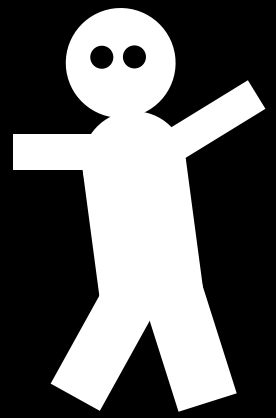
Často na druhej
strane výjde správa
nejako popletená
a treba ju opraviť.



kvantové počítanie

server

2017 = ? × ?

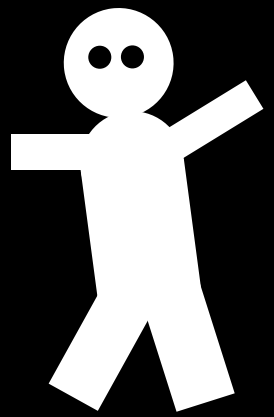


kvantové počítanie

server

2017 = ? × ?

je to prvočíslo



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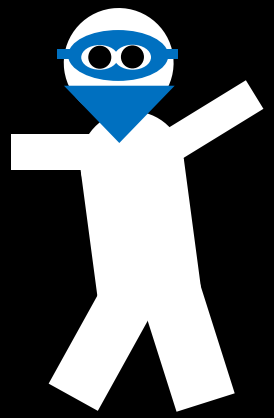
kdjtntrkncvskmnk



slepé kvantové počítanie

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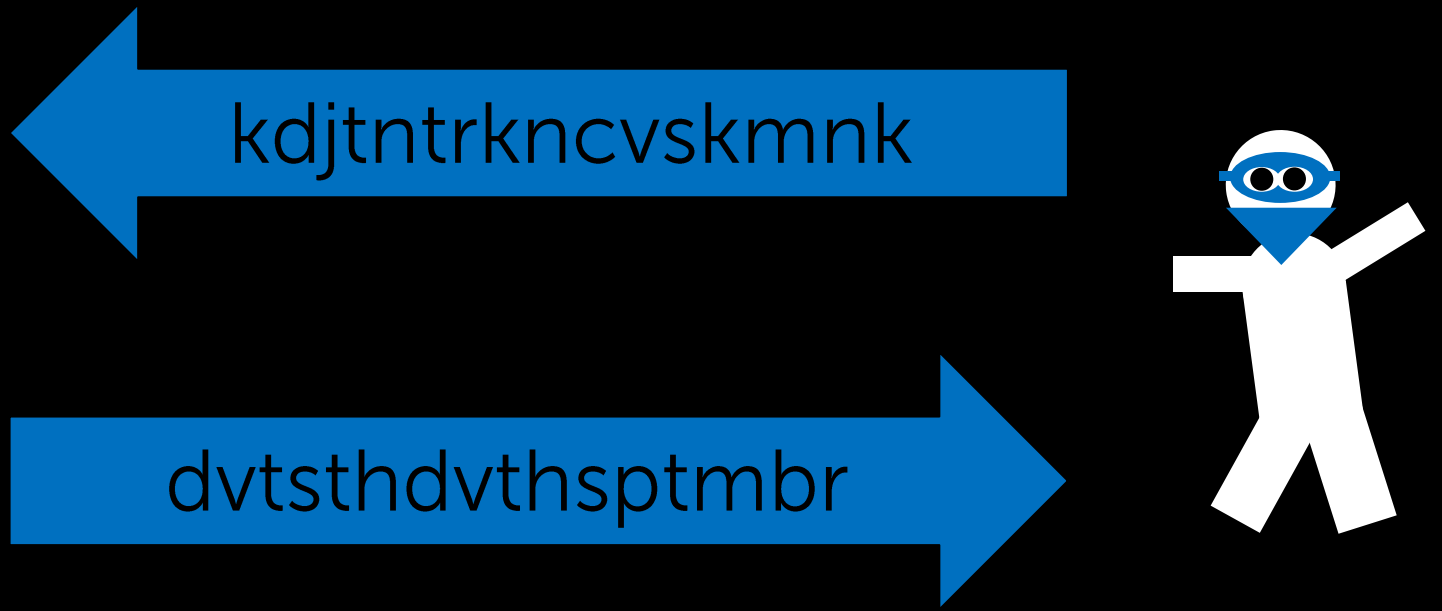
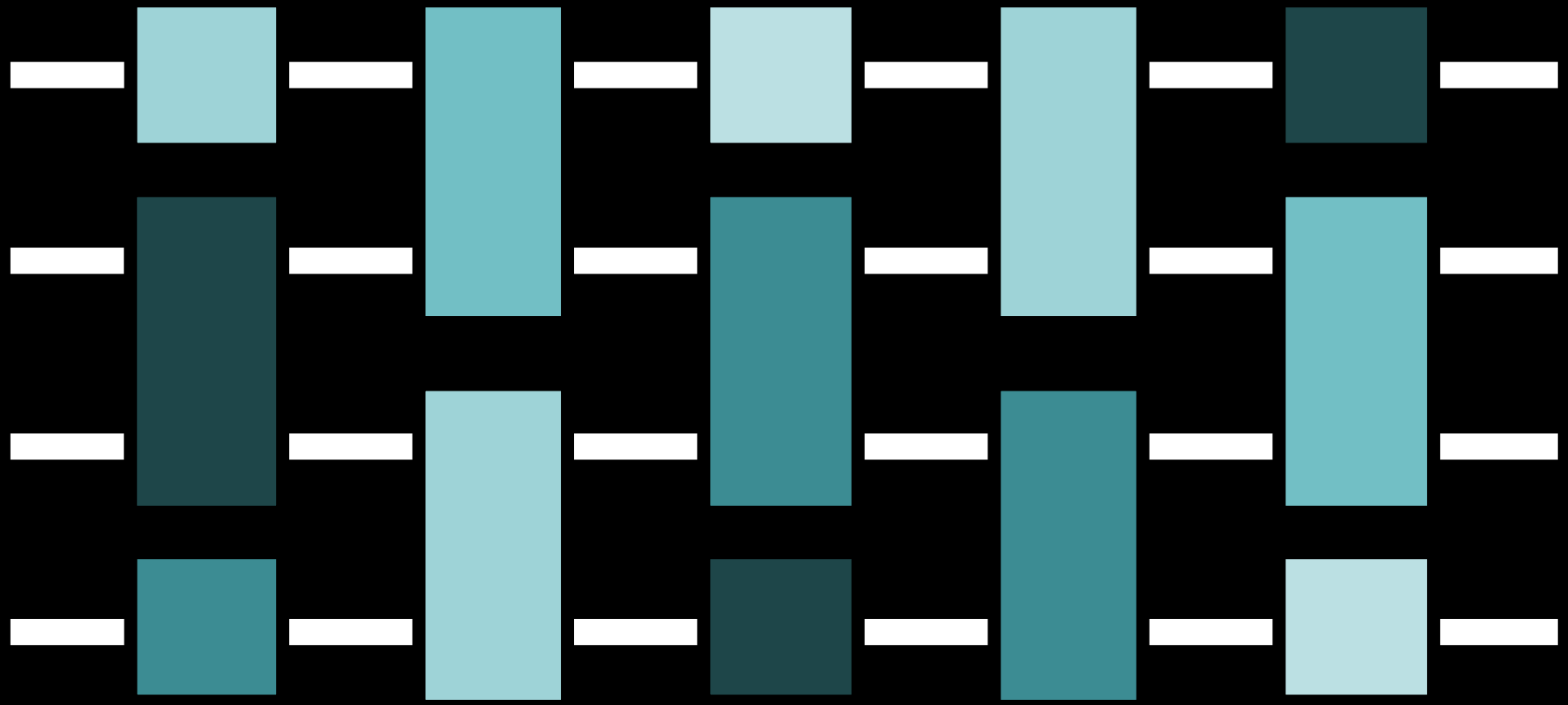




počítame kvantovo

simulácia

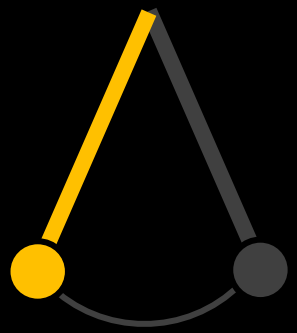
zdroj

Daniel Nagaj
je fascinovaný
hlavolamami.

preklad

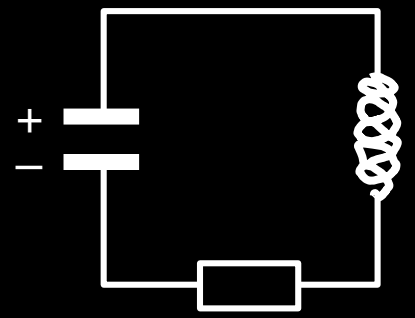
Daniel Nagaj
is fascinated
by puzzles.

reálna fyzika



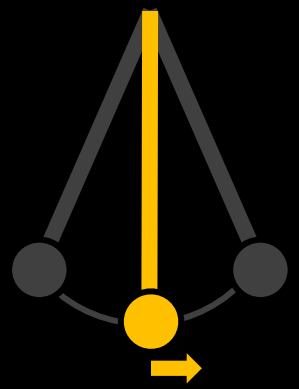
m, l, g

simulácia



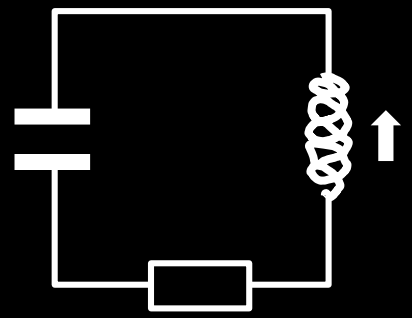
R, L, C

reálna fyzika



m, l, g

simulácia



R, L, C

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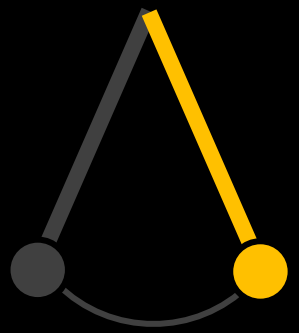

m, l, g

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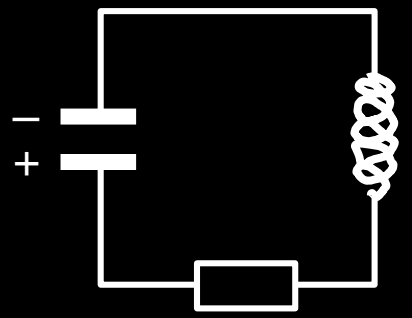

R, L, C

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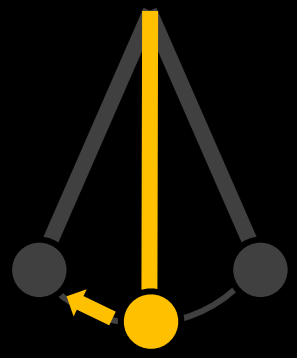

m, l, g

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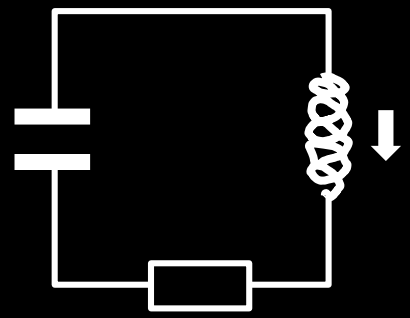

R, L, C

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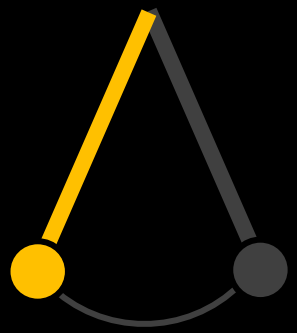

m, l, g

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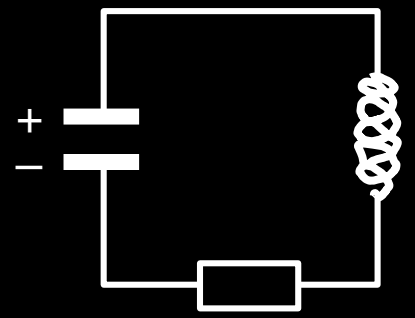

R, L, C

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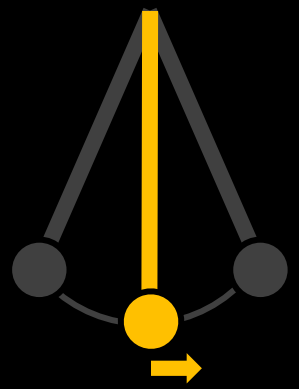
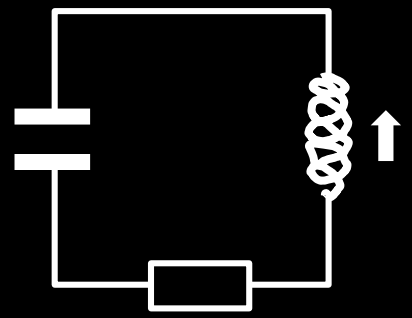


m, l, g

simulácia



R, L, C

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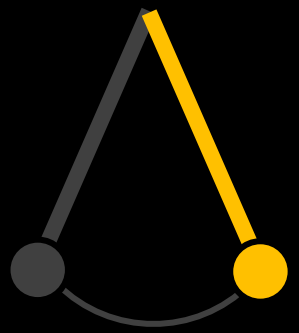
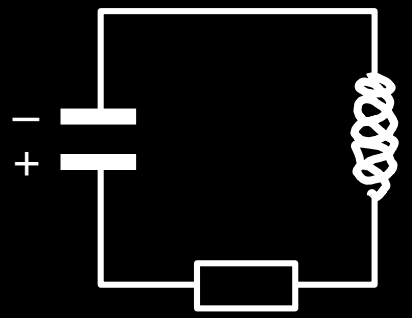


m, l, g

simulácia



R, L, C

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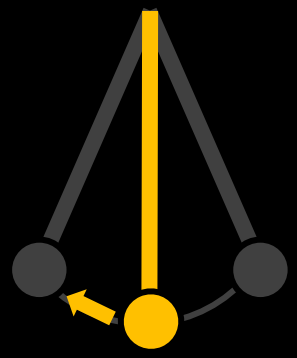

m, l, g

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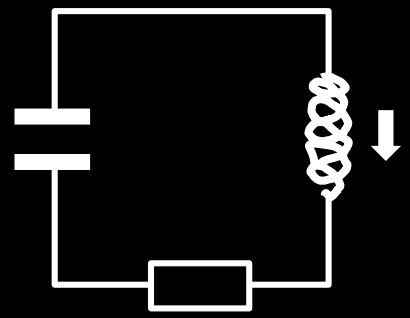

R, L, C

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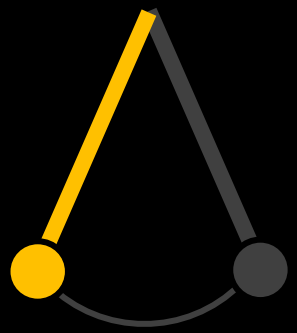

m, l, g

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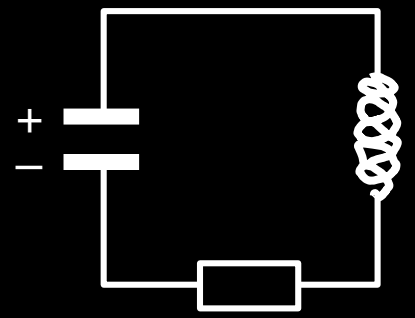
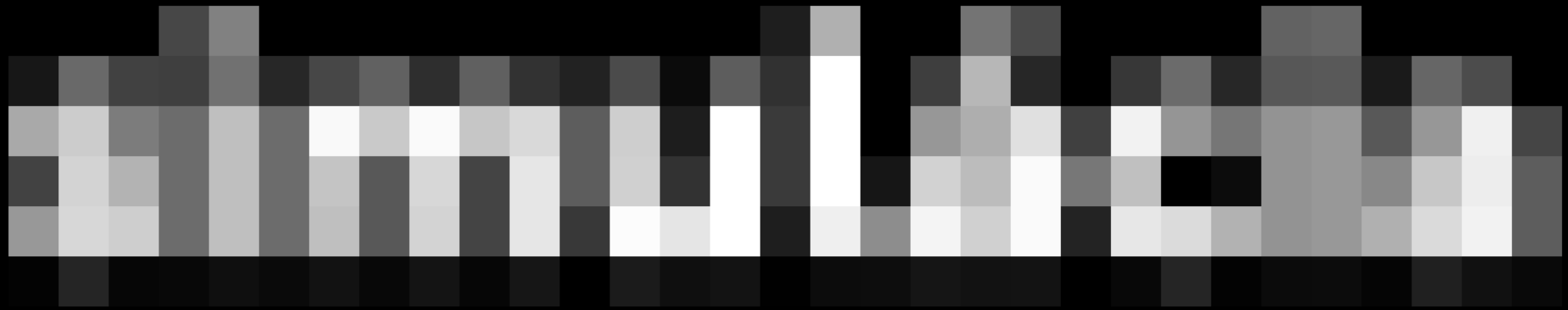
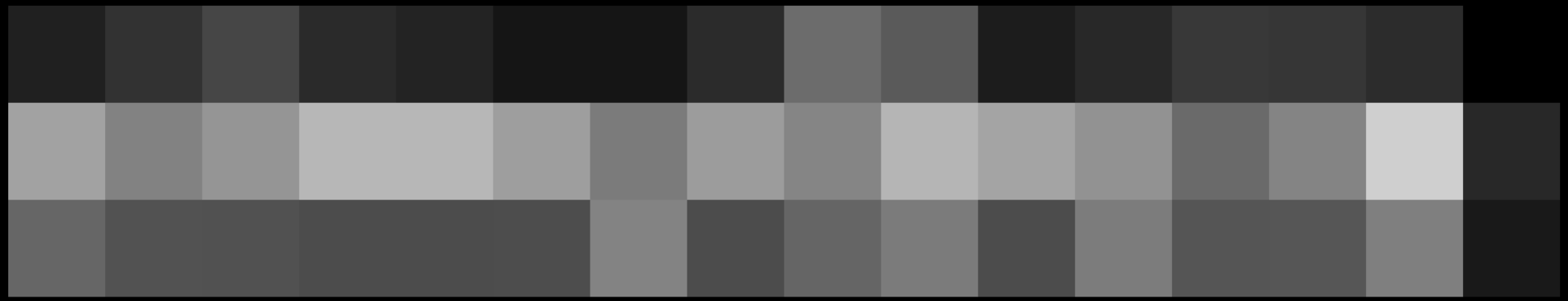


R, L, C

simulácia


simulácia





^{87}Rb

[Endres et al., Science 354, 2016]

ihla v kope sena ihla v kope sena ihla
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pe sena ihla v kope sena ihla v kope s
ena ihla v kope sena ihla v kope sena
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ihla v kope sena ihla v kope sena ihla v kope sena ihla v kope sena ihla v ko pe sena ihla v kope sena ihla v kope s ena ihla v kope sena ihla v kope sena i hla v kope sena ihla v kope sena ihla v kope sena ihla v ko pe sena ihla v kope sena ihla v kope s

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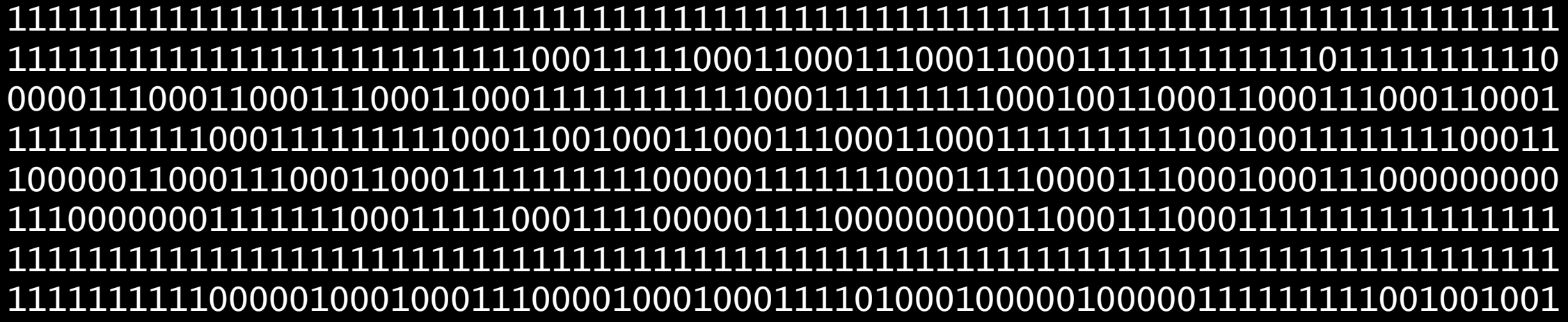

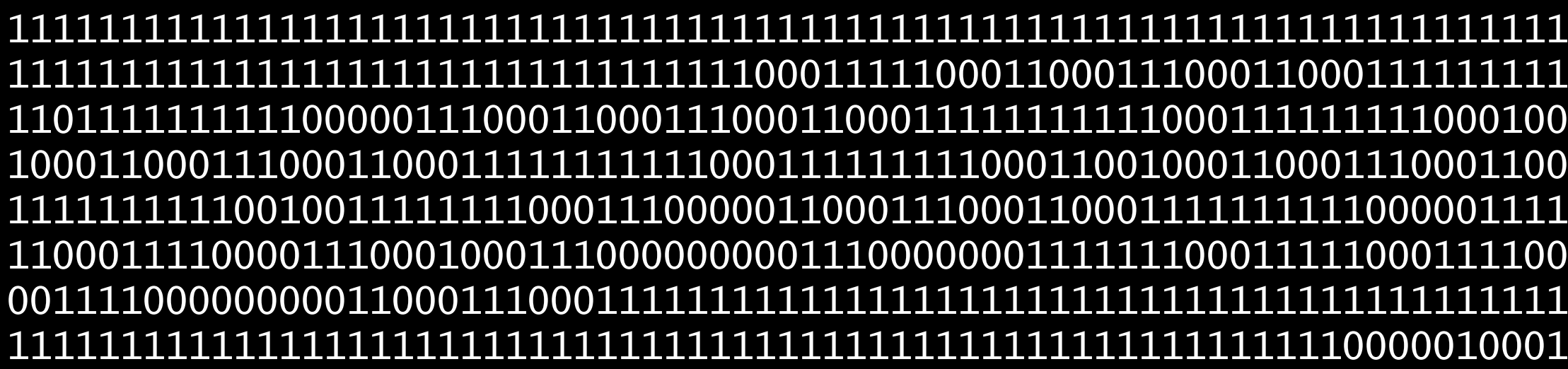
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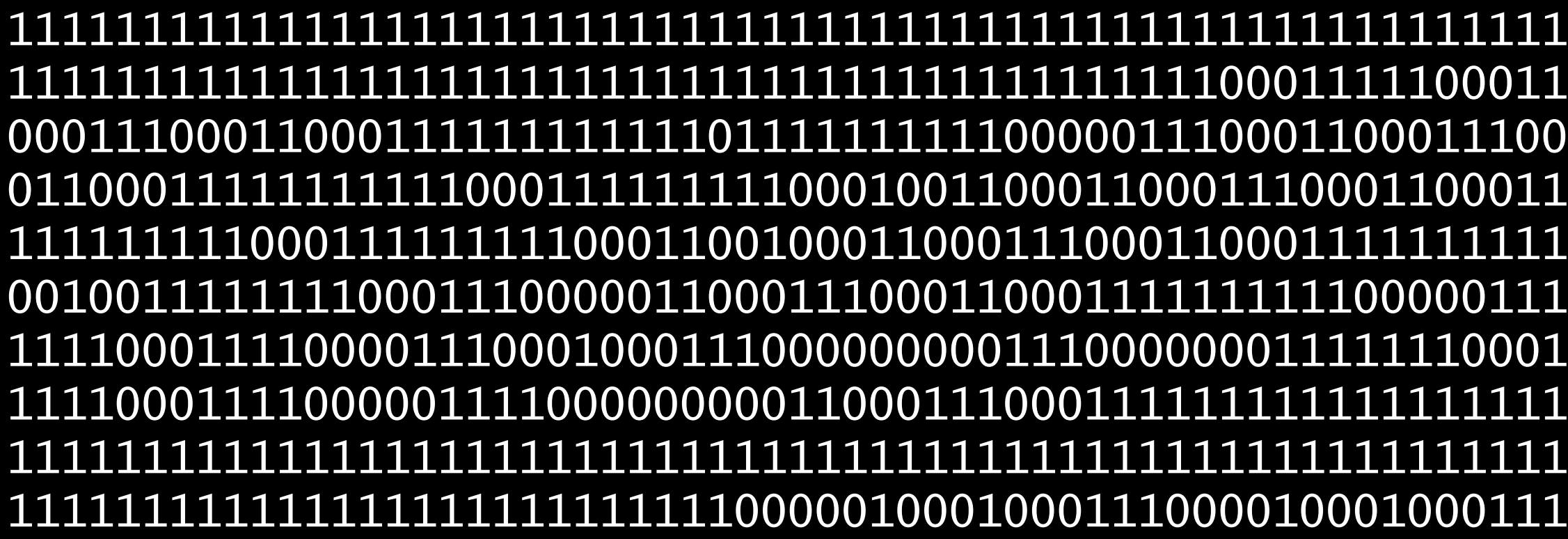
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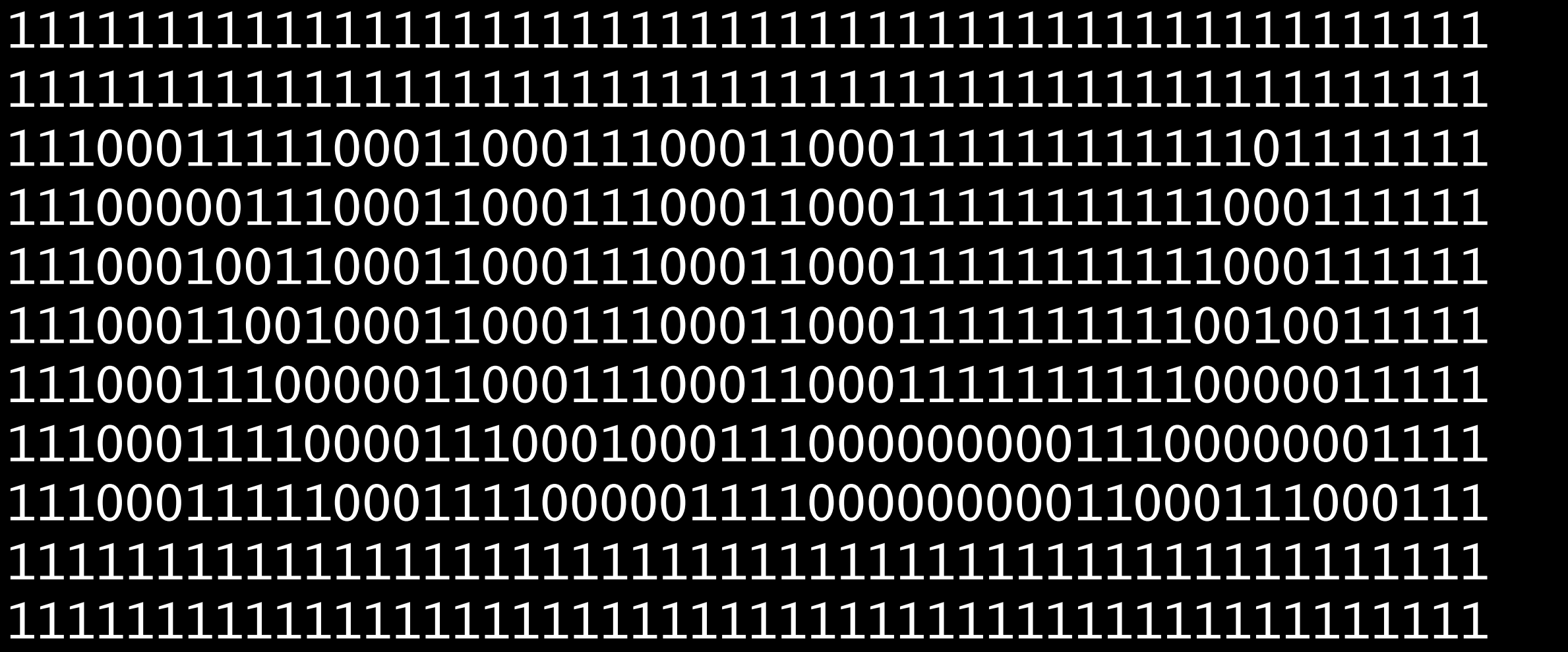
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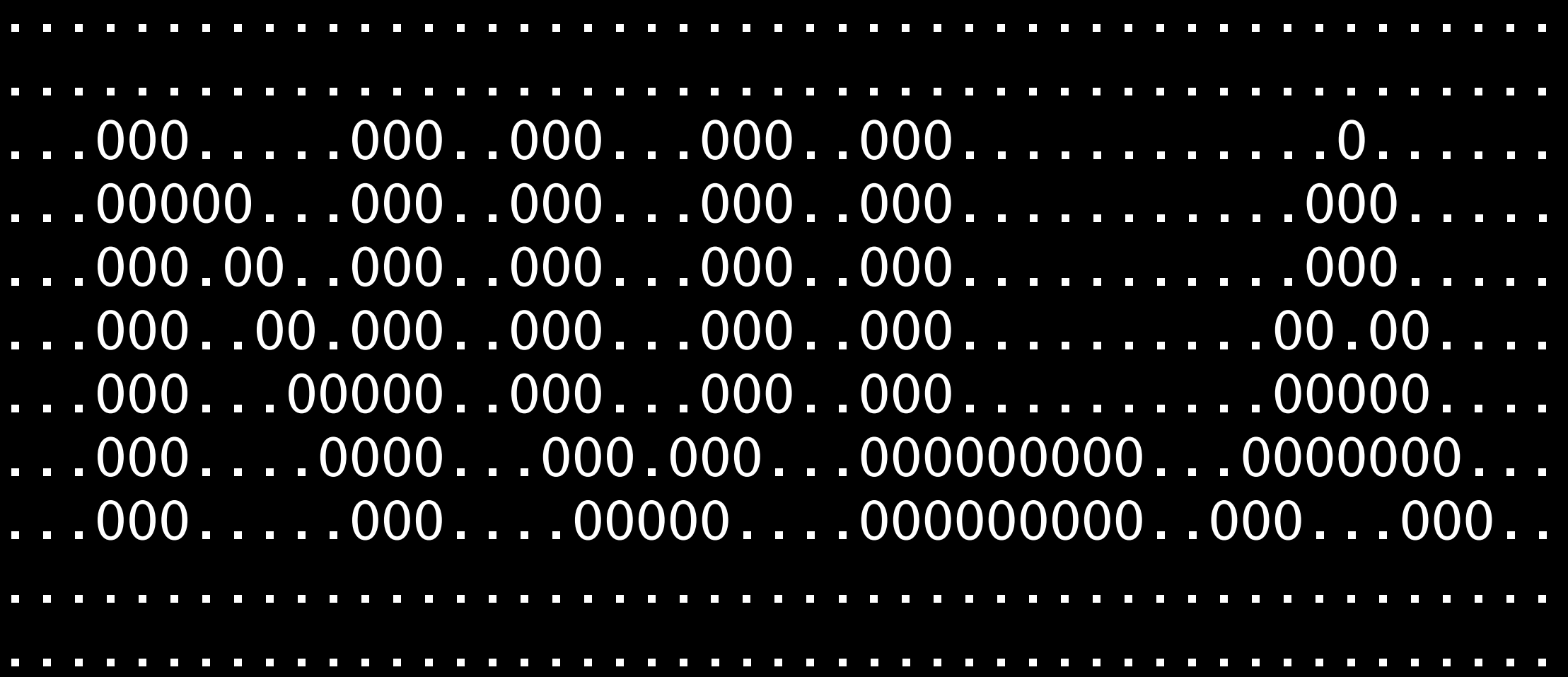
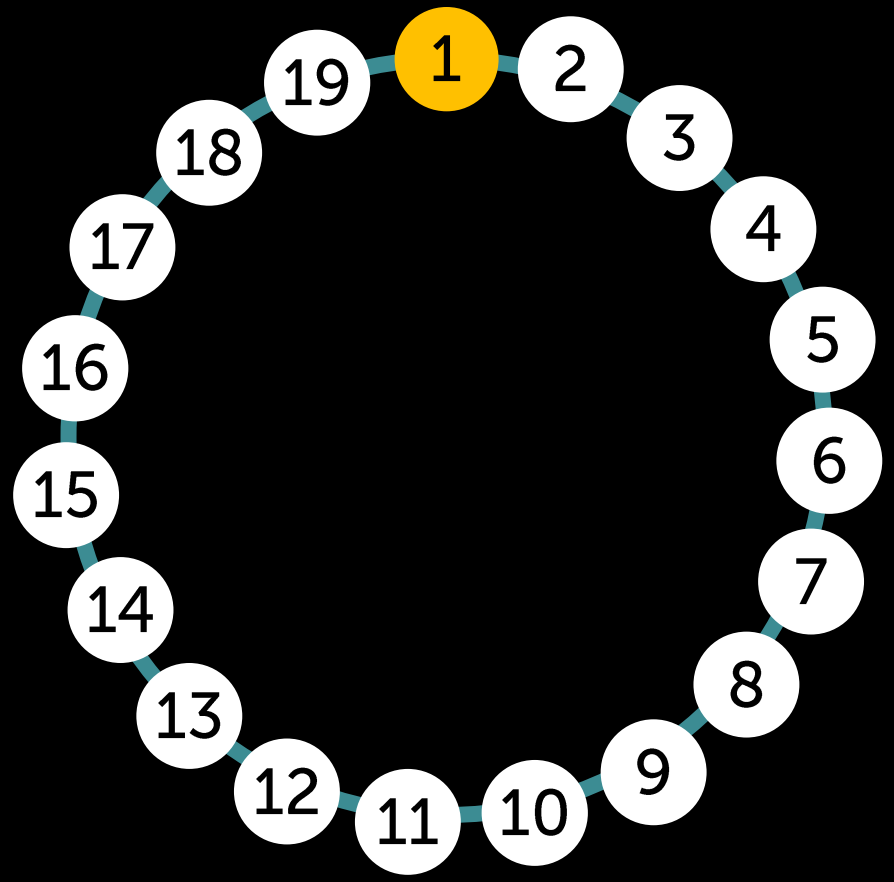


Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?



Kruh 19 čísel,
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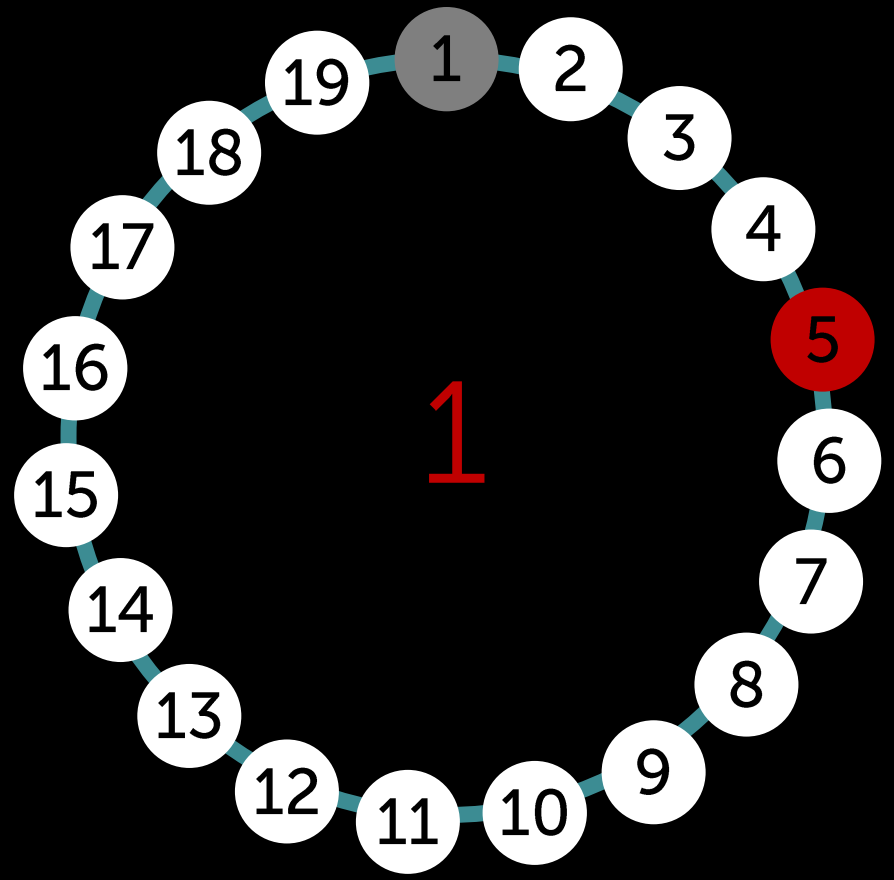
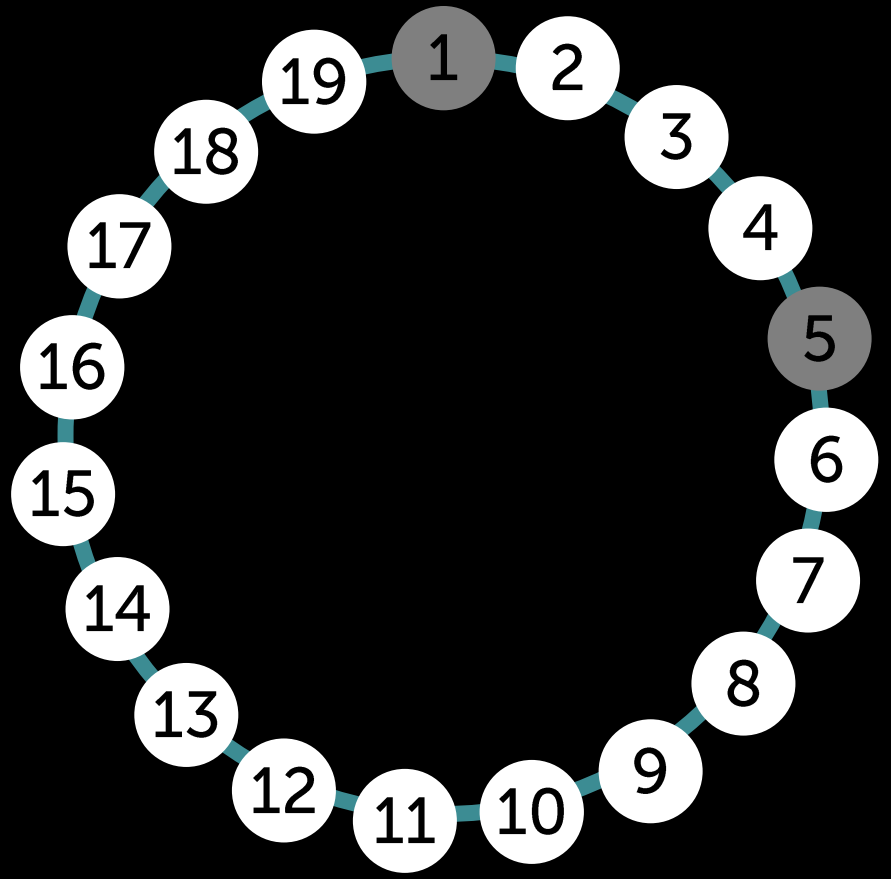
Kedy sa vrátim?



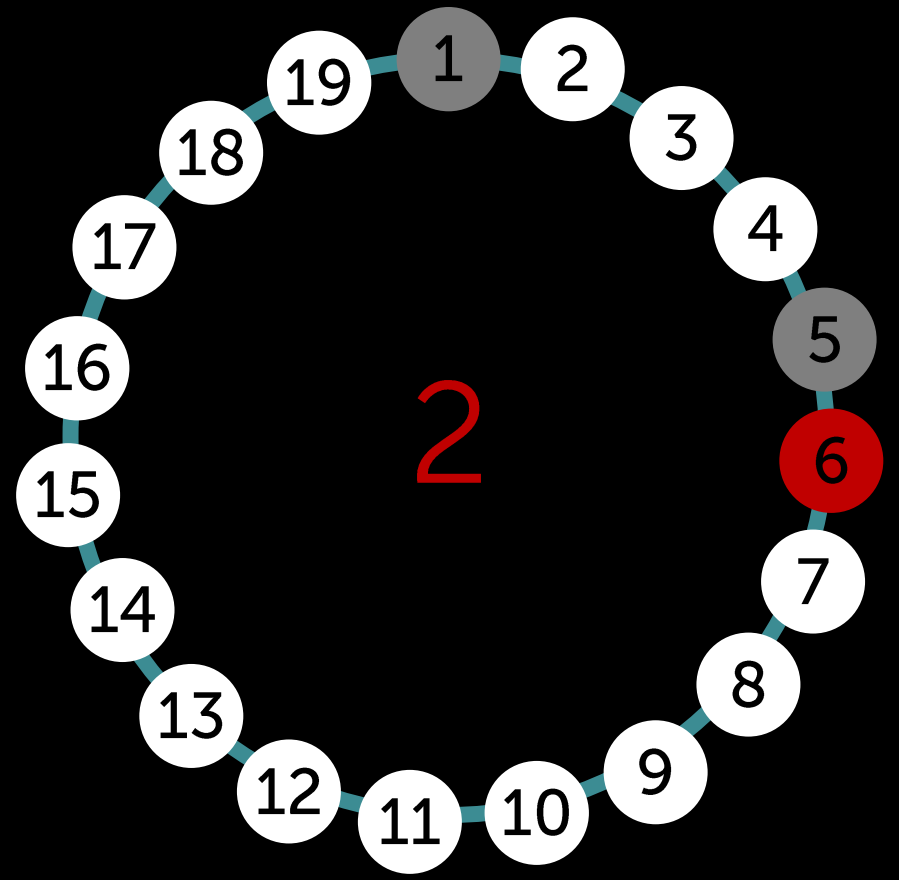
Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?

$5 \times 5 = 25$



Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?

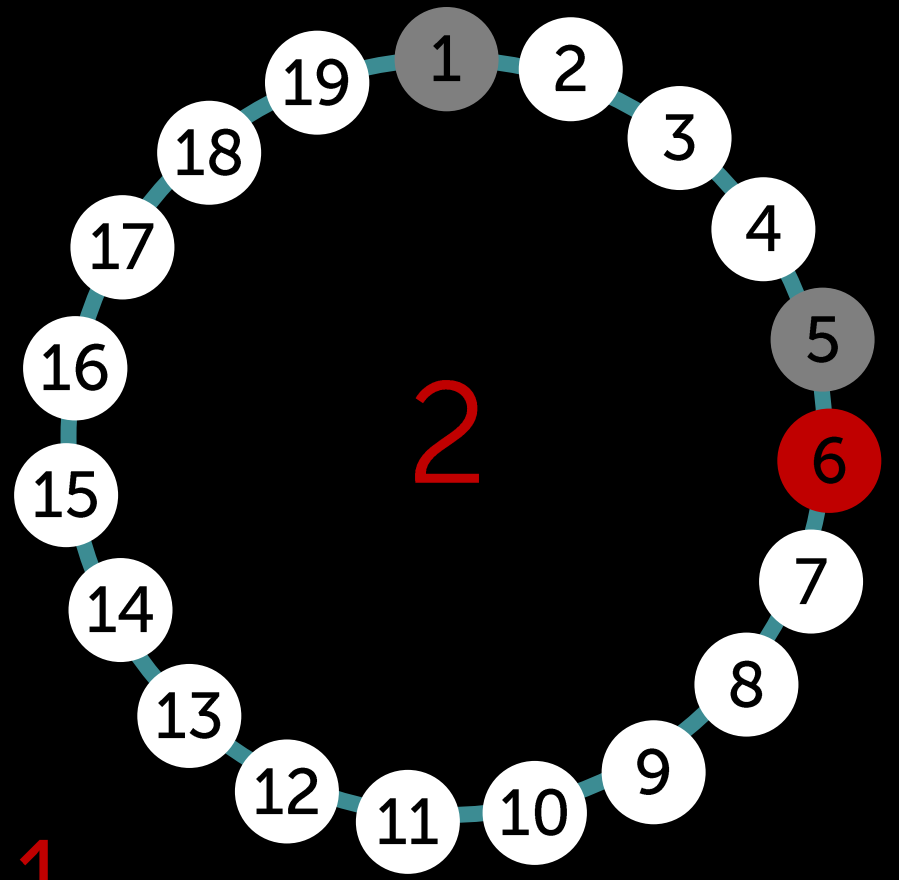
$5 \times 5 = 19 + 6$



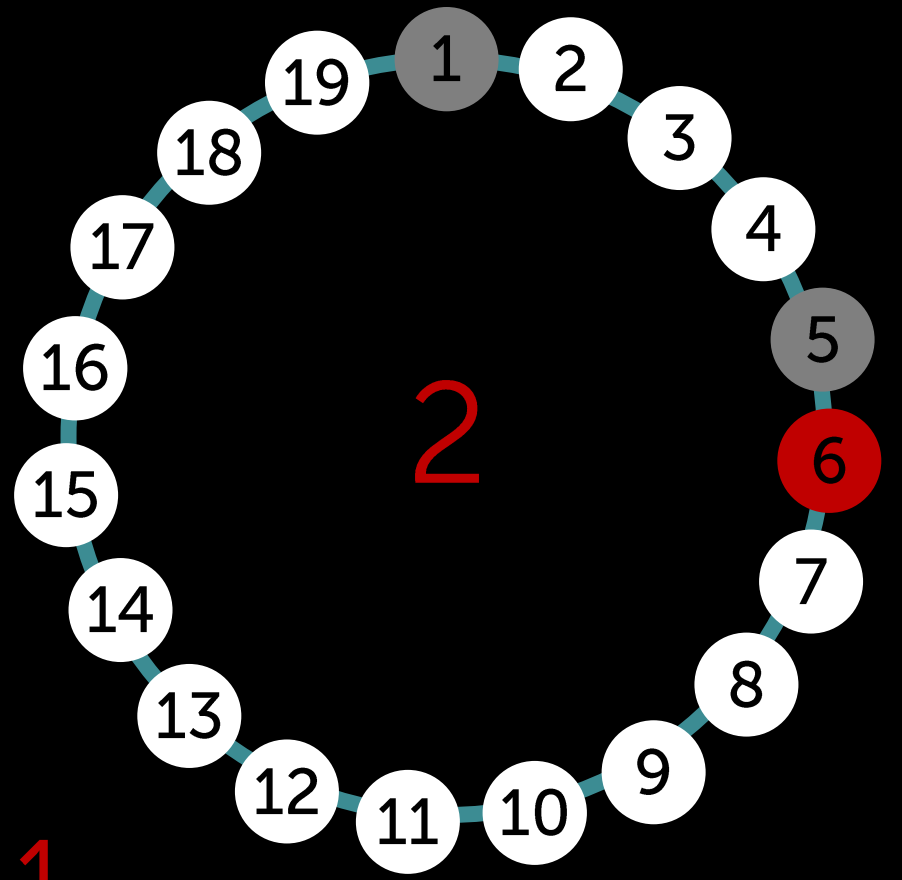
Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?

$$5 \times 5 = 19 + 6$$

$$25 \times 5 = 19 \times \ldots + 11$$



Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?

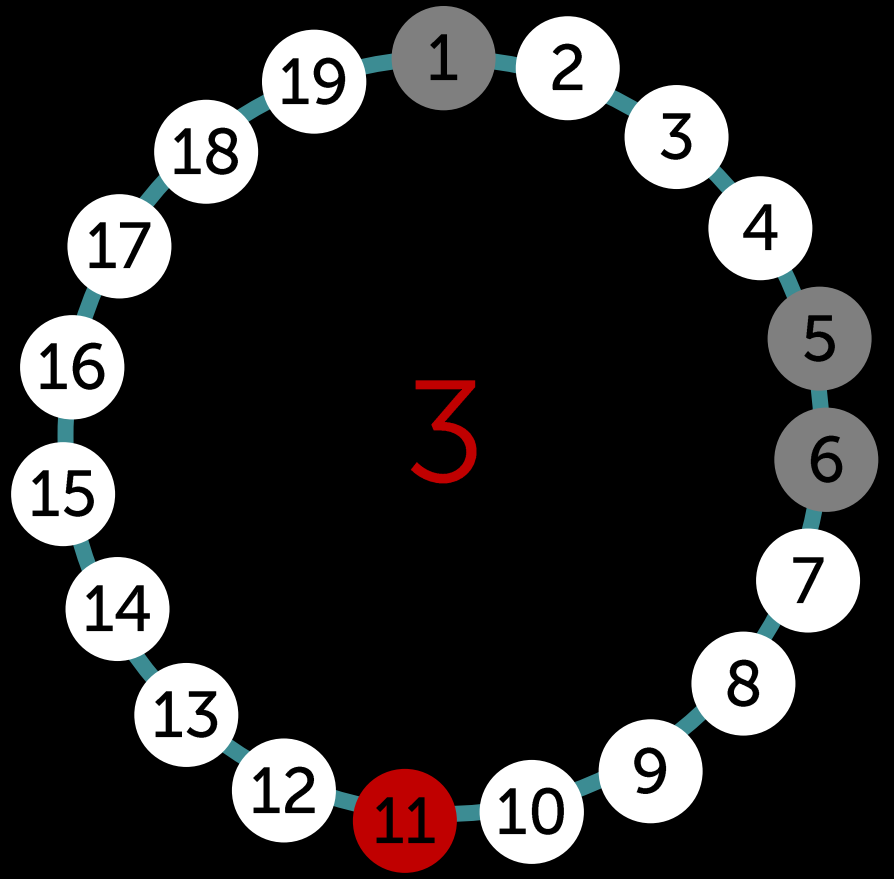


$5 \times 5 = 19 + 6$

$25 \times 5 = 19 \times \ldots + 11$

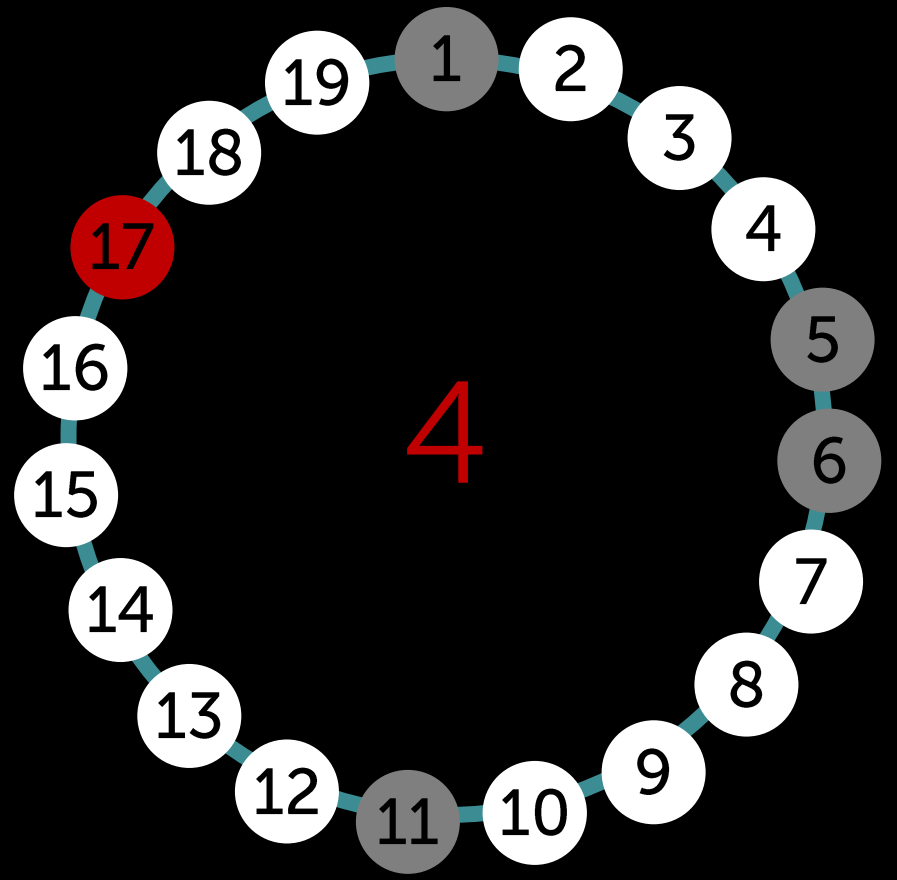
$6 \times 5 = 19 \times \ldots + 11$

Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?



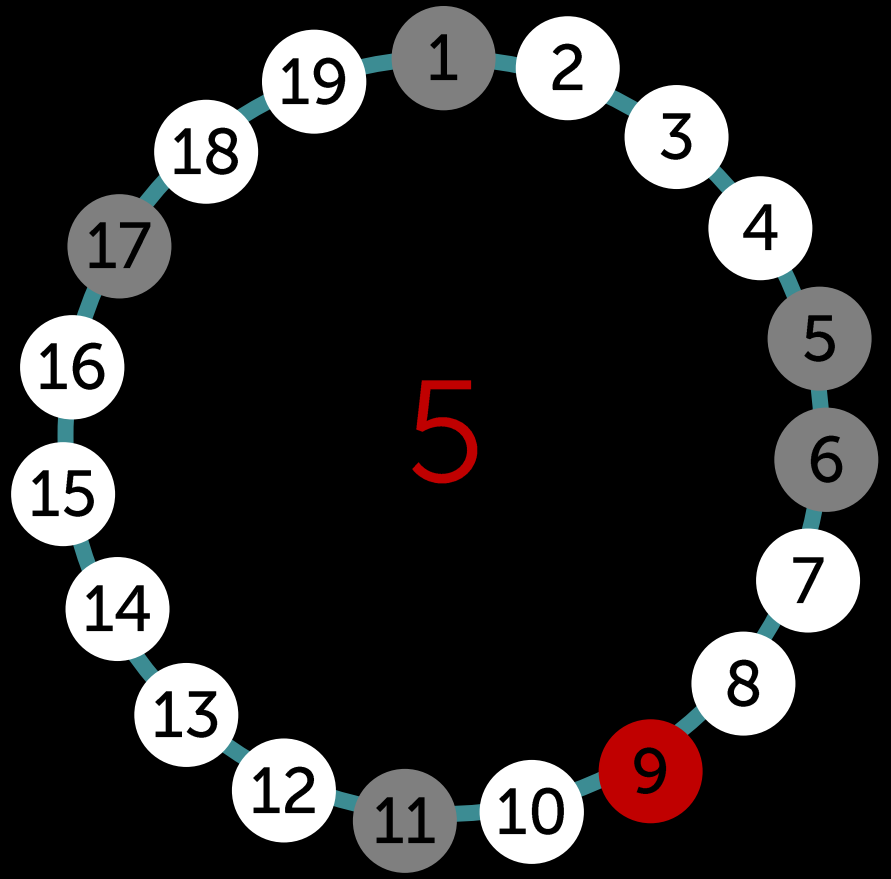
$5^3 = 19 \times \ldots + 11$

Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?



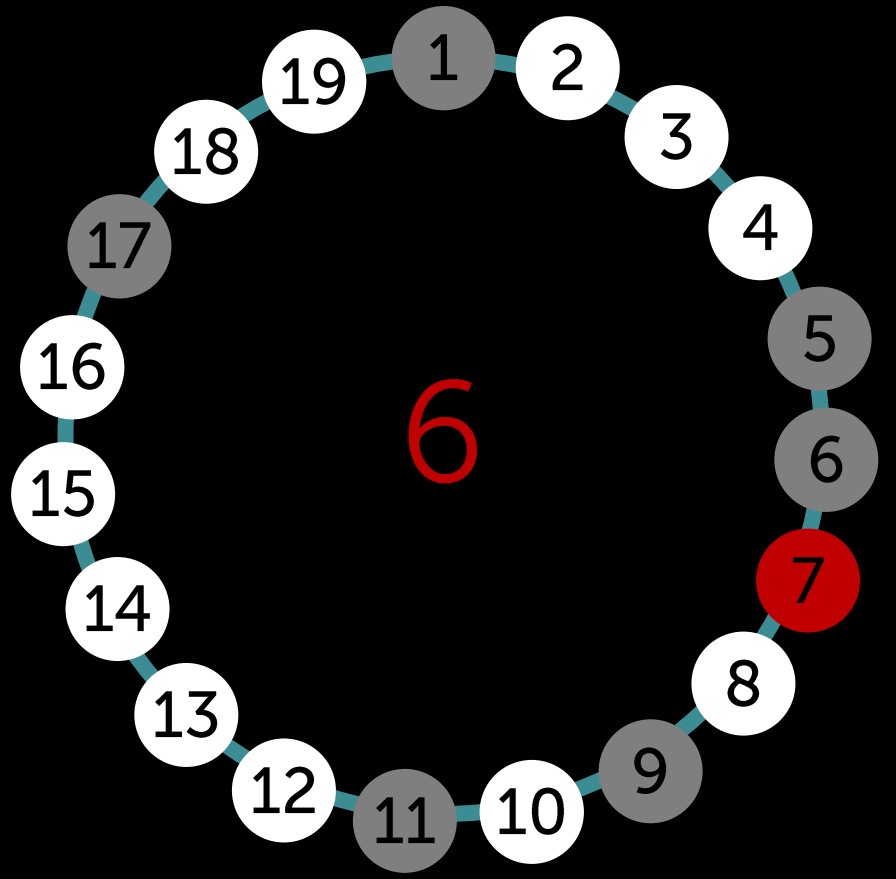
$5^4 = 19 \times \ldots + 17$

Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?



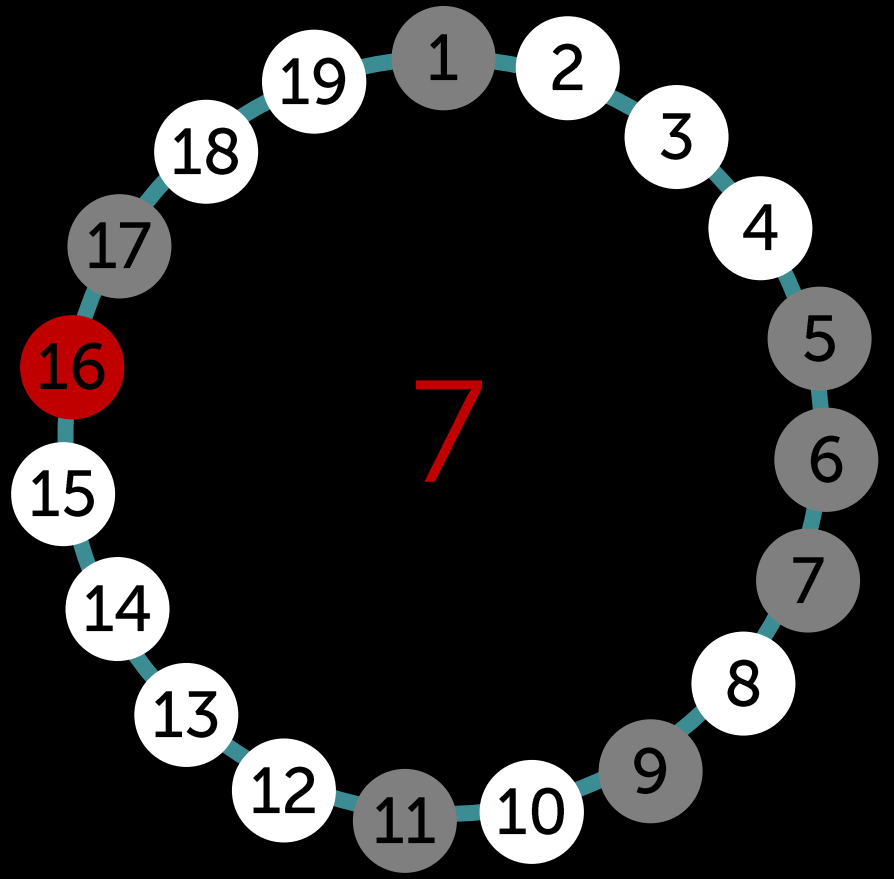
$5^5 = 19 \times \ldots + 9$

Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?



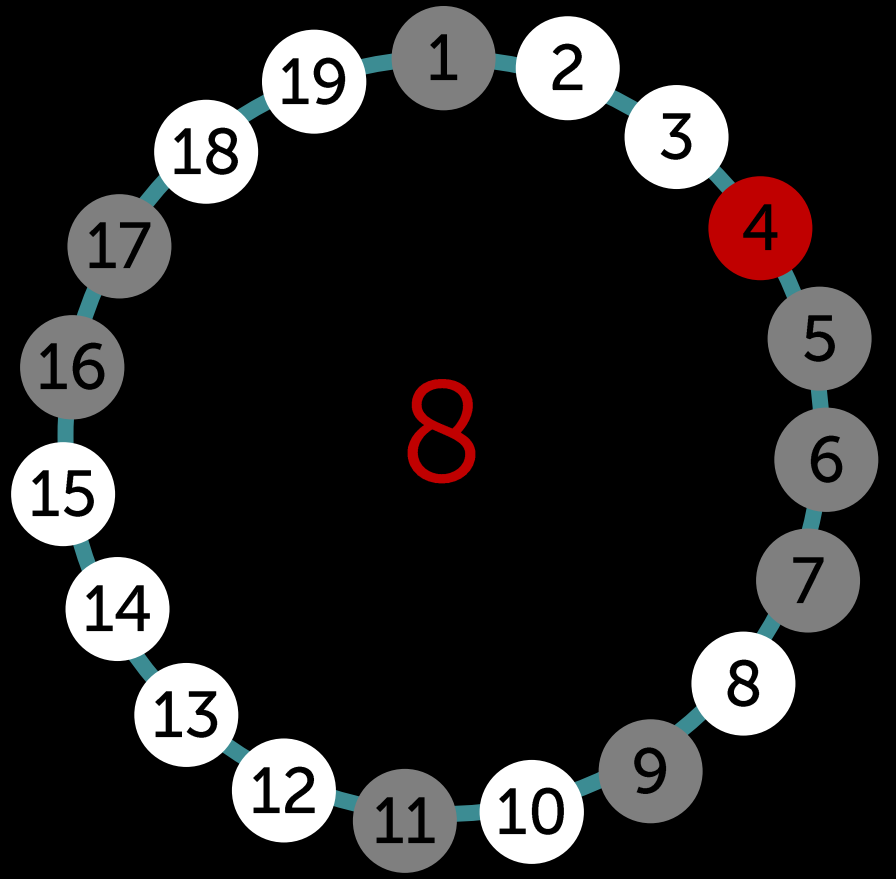
$5^6 = 19 \times \ldots + 7$

Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?



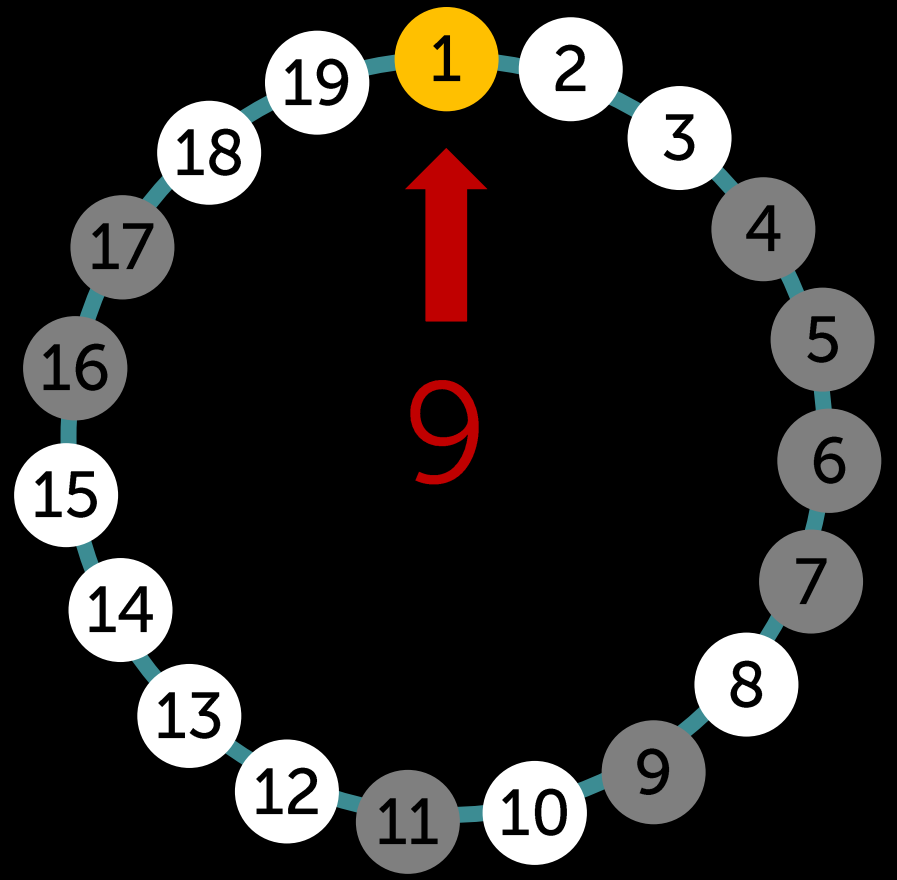
$5^7 = 19 \times \ldots + 16$

Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?



$5^8 = 19 \times \ldots + 4$

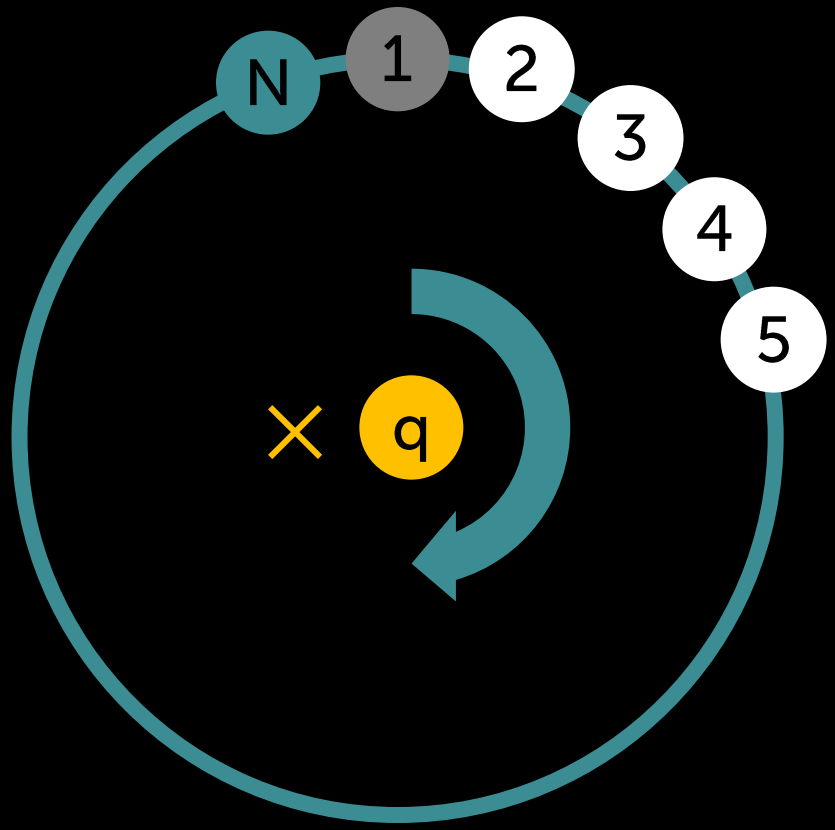
Kruh 19 čísel,
násobím 5.
Kedy sa vrátim?



$5^9 = 19 \times \ldots + 1$

$$q^r = 1 \bmod N$$

$$r = ?$$



ťažká úloha: faktorizácia

teória čísel

superpozície a Fourier

super kvantový algoritmus

Peter Shor

RSA ☹

$21 = 3 \times 7$

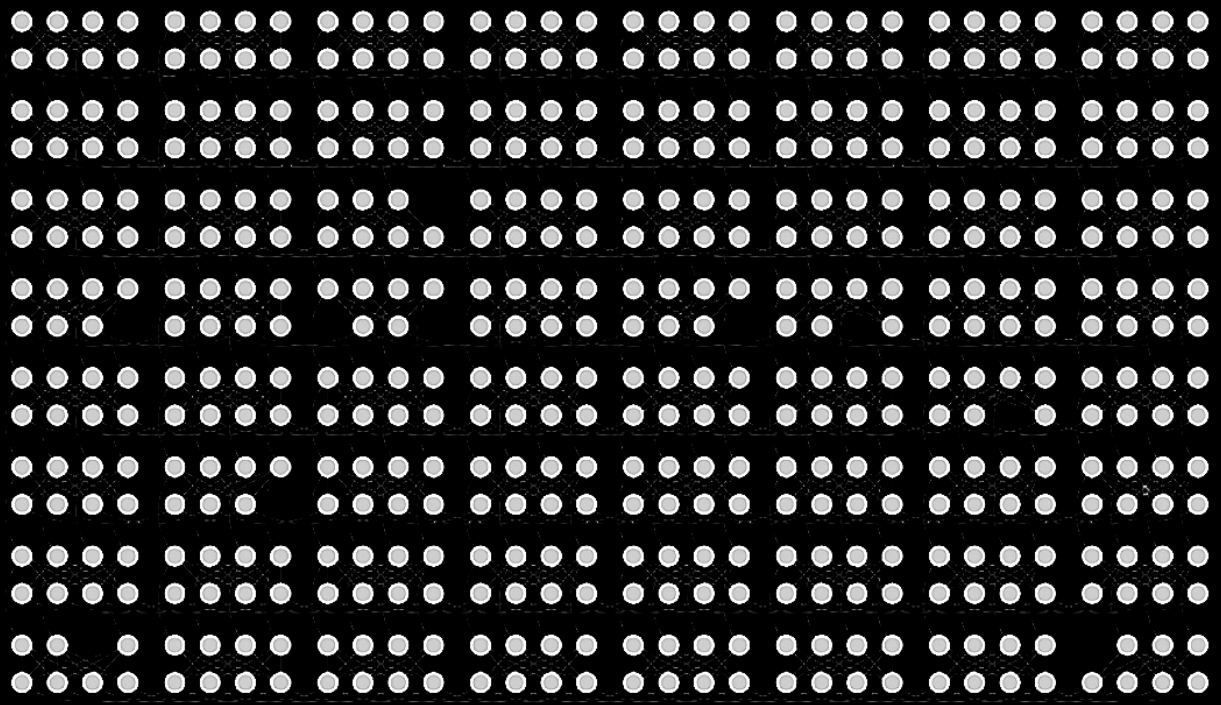
optimalizácia

pm
optimalizácia

optimalizácia na kvantovom ihrisku

adiabatické počítanie

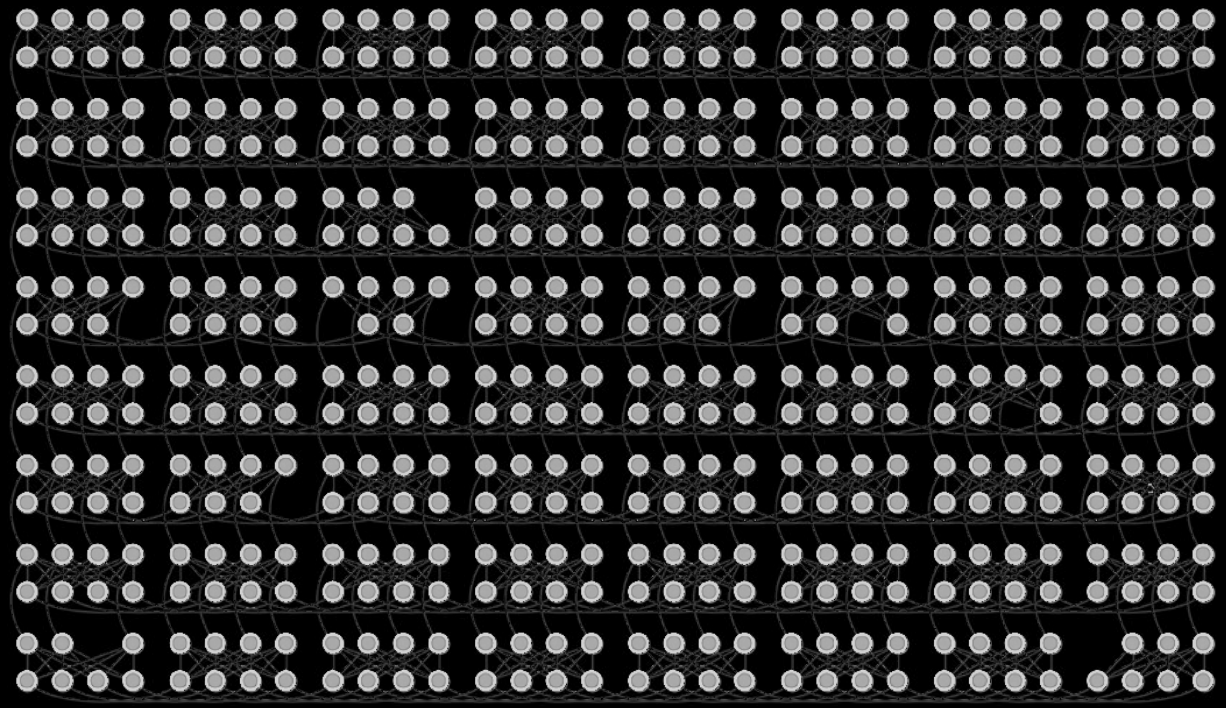
Farhi, Goldstone, Gutmann



optimalizácia na kvantovom ihrisku

adiabatické počítanie

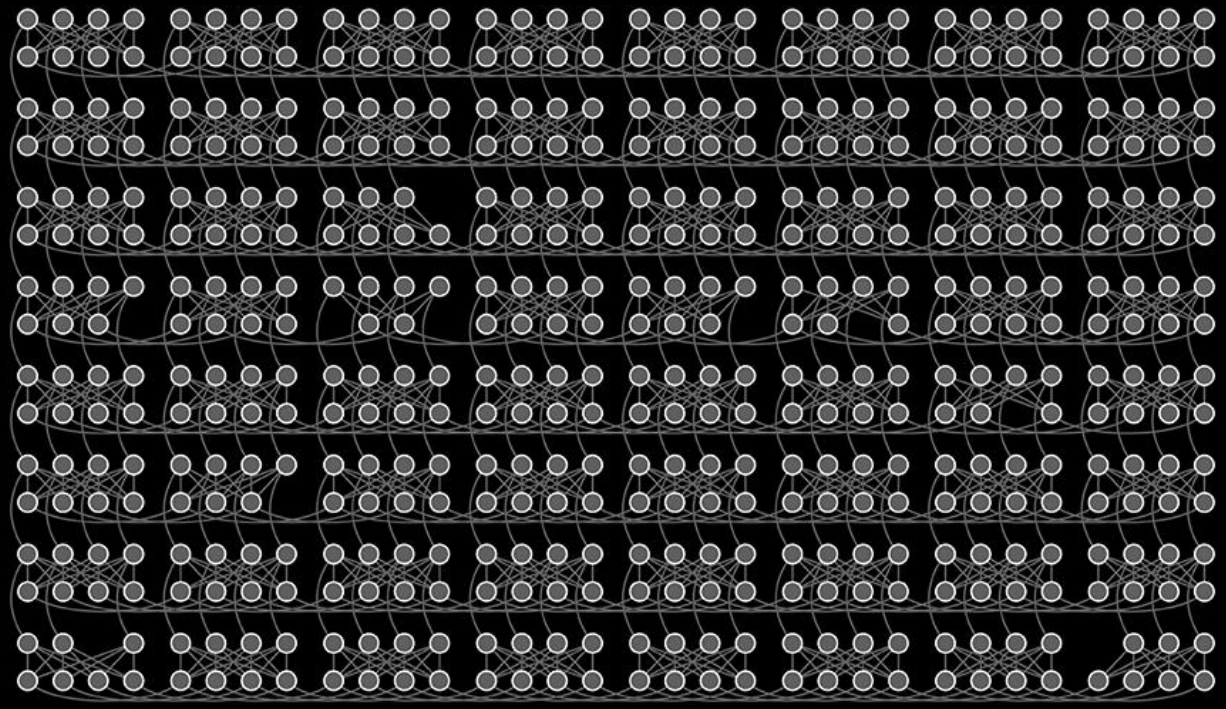
Farhi, Goldstone, Gutmann



optimalizácia na kvantovom ihrisku

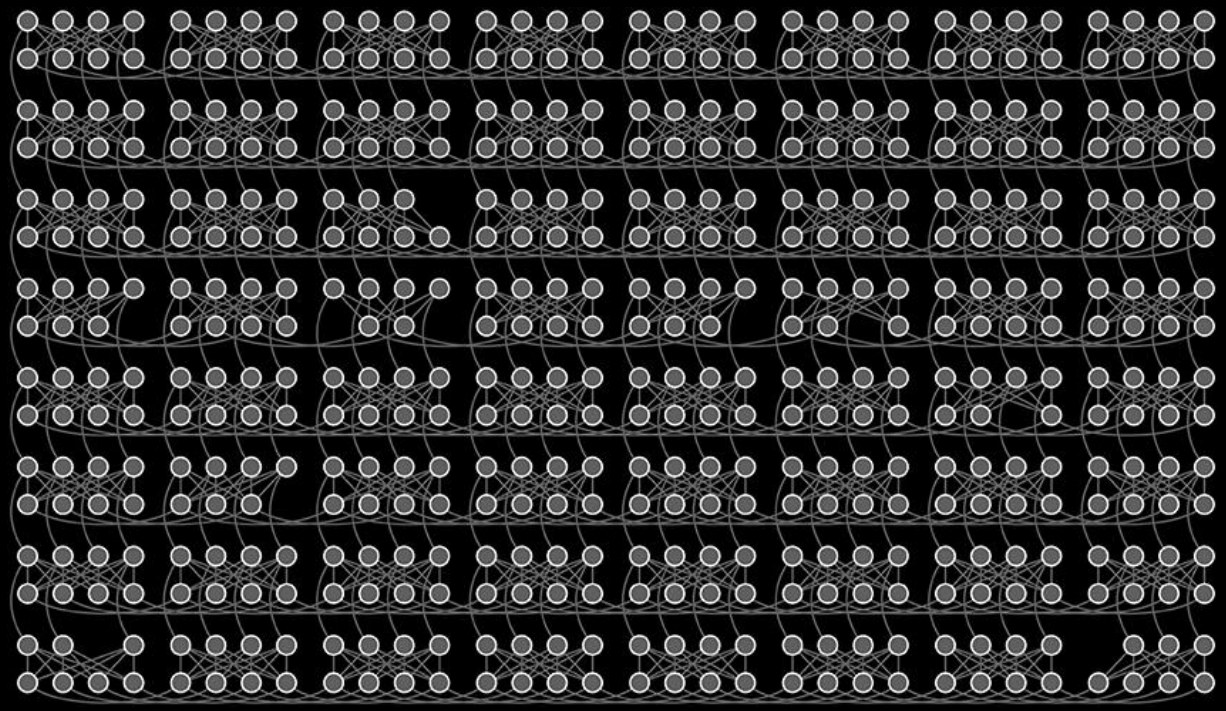
adiabatické počítanie

Farhi, Goldstone, Gutmann



optimalizácia na kvantovom ihrisku

adiabatické počítanie

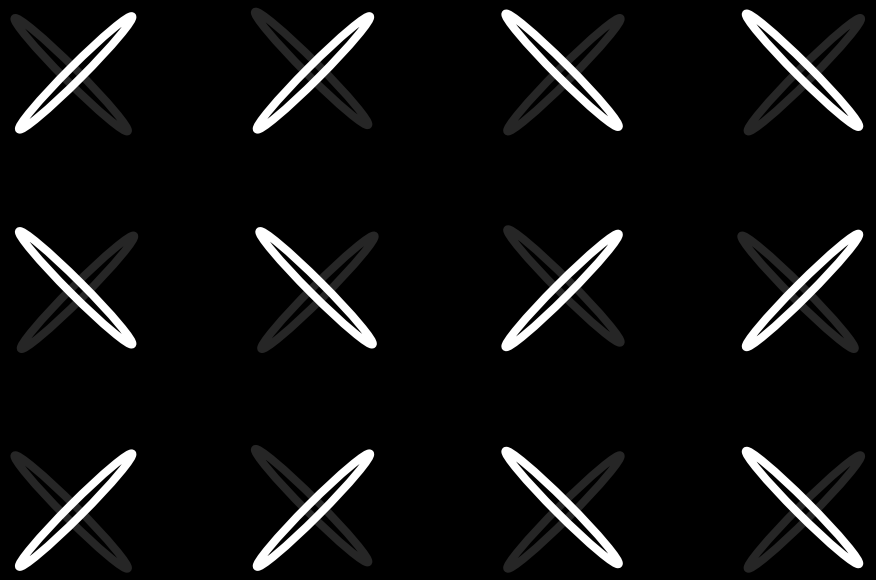


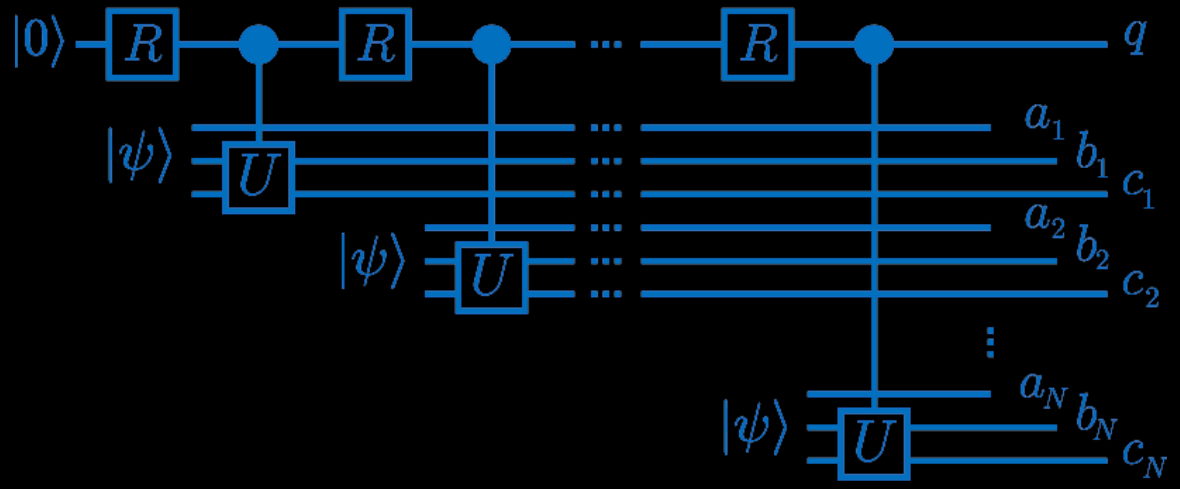
[chimera graph, D-Wave, 2014]

[D-Wave, 2017]

kvantové počítanie

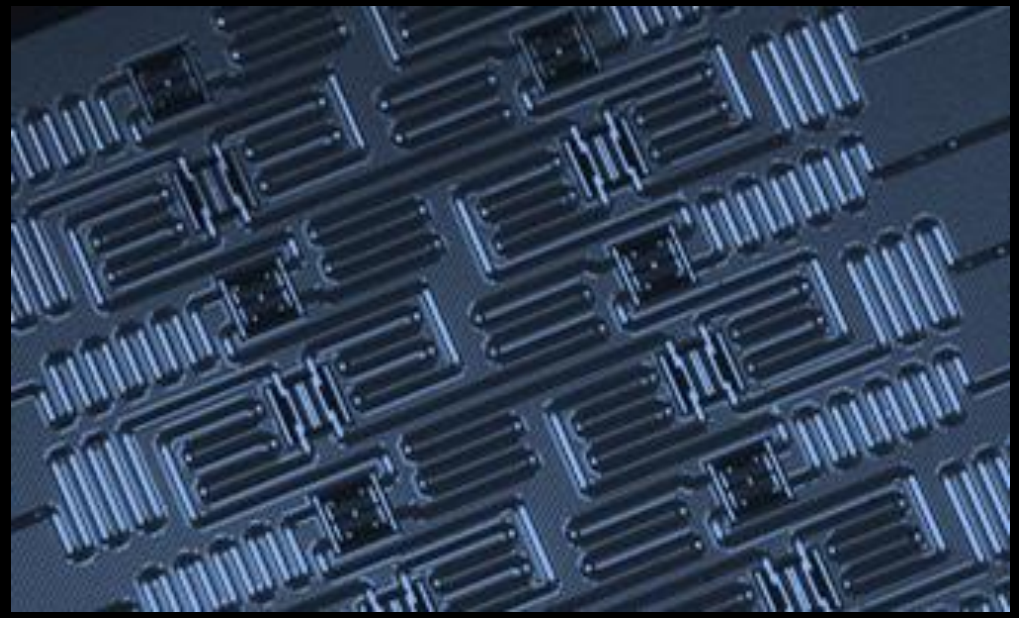
imagined by science





kvantové počítanie

made by science

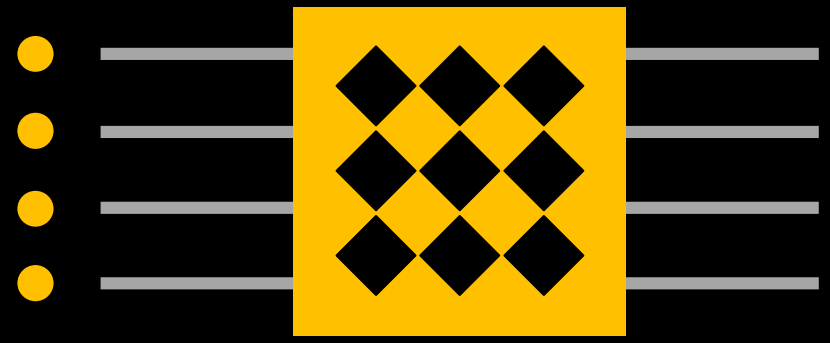


[IBM, 2017]

kvantová

SUPERIORITA

quantum supremacy



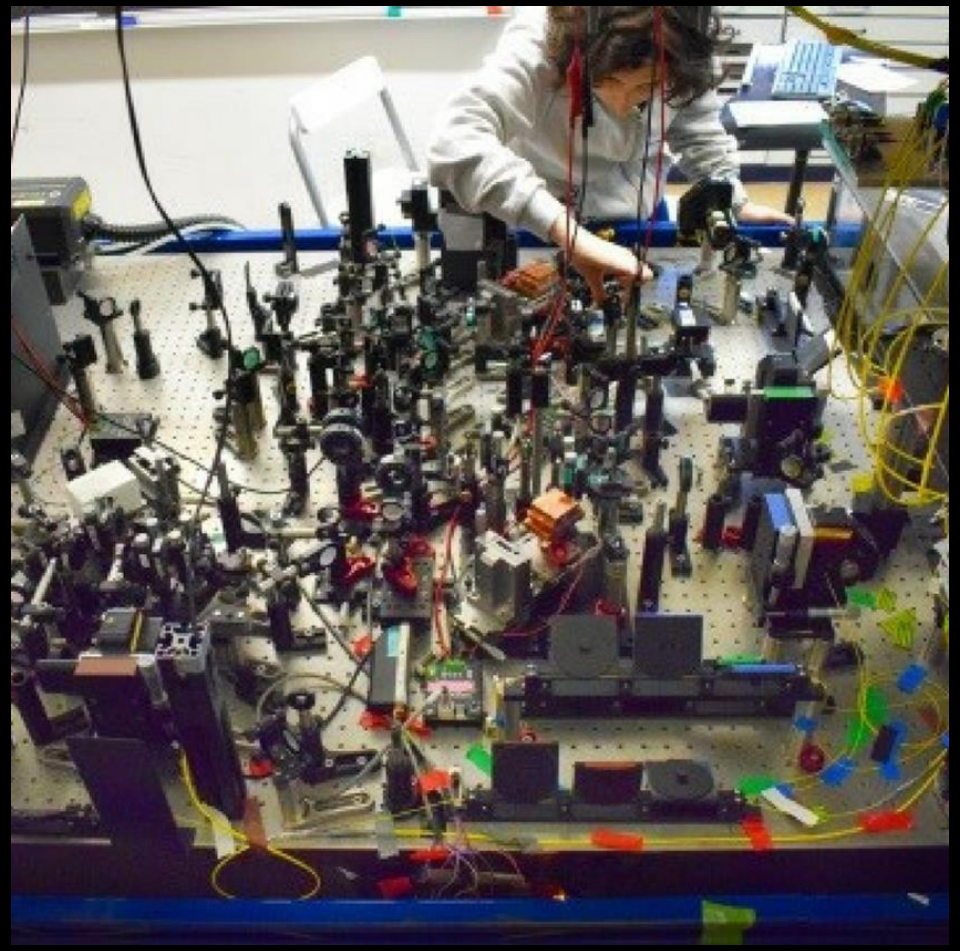
?

bozónové samplovanie

Aaronson, Arkhipov

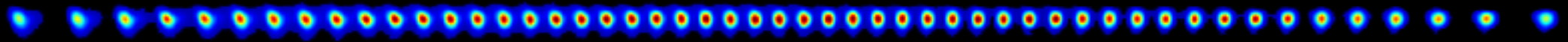
v podstate neužitočné
kvantovo dostupné
klasicky p p p o o o o m m m m a a l é

fotóny



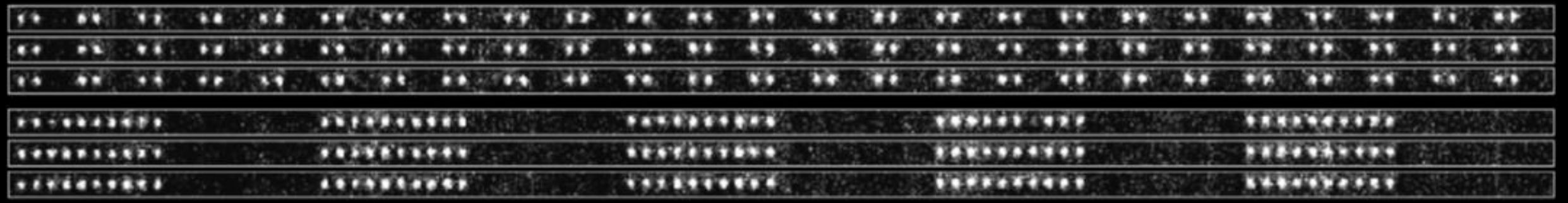
[Uni Wien, P. Walther]

lapené iónyl

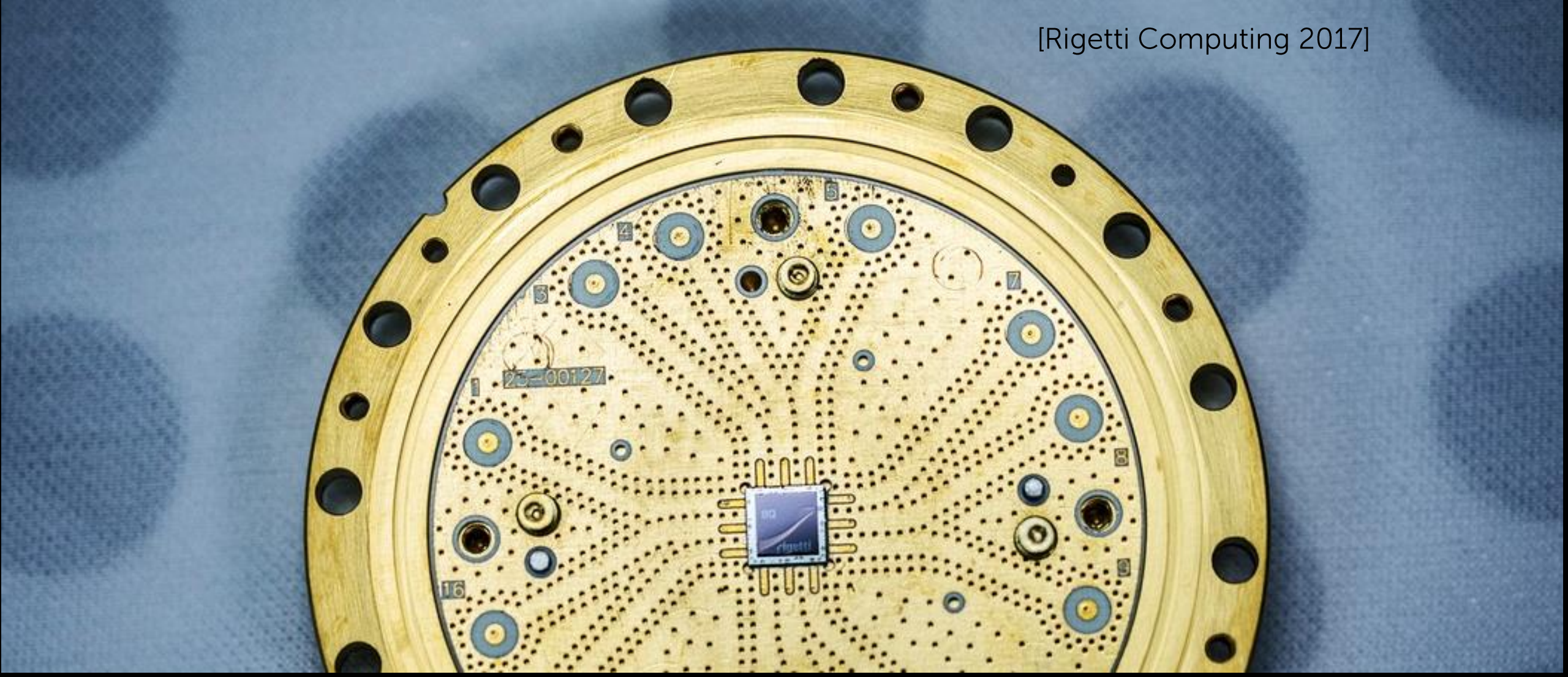


[Uni Innsbruck, R. Blatt]

studené atómy



[Endres et al., Science 354, 2016]

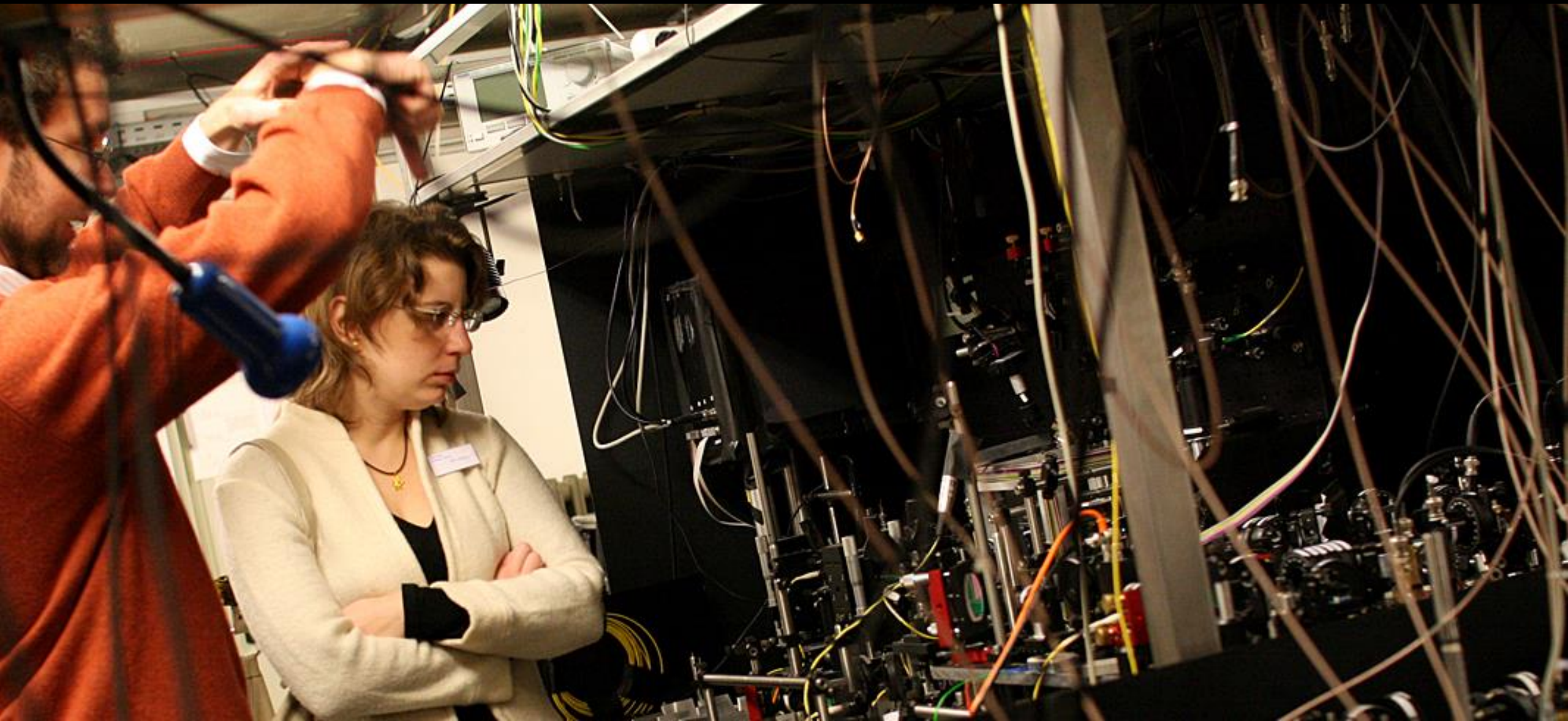


supravodivé obvody

oprava chýb

[Libor Caha]

škálovanie



Quantum Manifesto

A New Era of Technology

May 2016

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