Potential applications of negative radiation pressure?

e.g. 2WQC, medical, astro?

Jarek Duda, rec, arXiv:2409.15399 , 2WQC

Radiation pressure: $\vec{p} = \frac{\langle \vec{E}\times\vec{H}\rangle}{c} = \frac{I_e}{c}$ (Poynting) photon emission, **toward** surface: **positive/push**

Negative radiation pressure: **outward** surface, e.g. **reverse**: **T-symmetry**, $\vec{H} \to -\vec{H}$

nature.com/articles/s41598-022-10699-7 **positive**/**negative** in metamaterials,

gain medium, pulling kinks ... **EM pulling energy from resonators like atoms?**

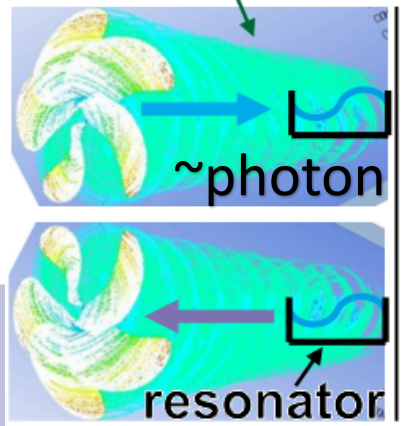
T-symmetry switches between **absorption** and **stimulated emission** equations

EM ~ hydro

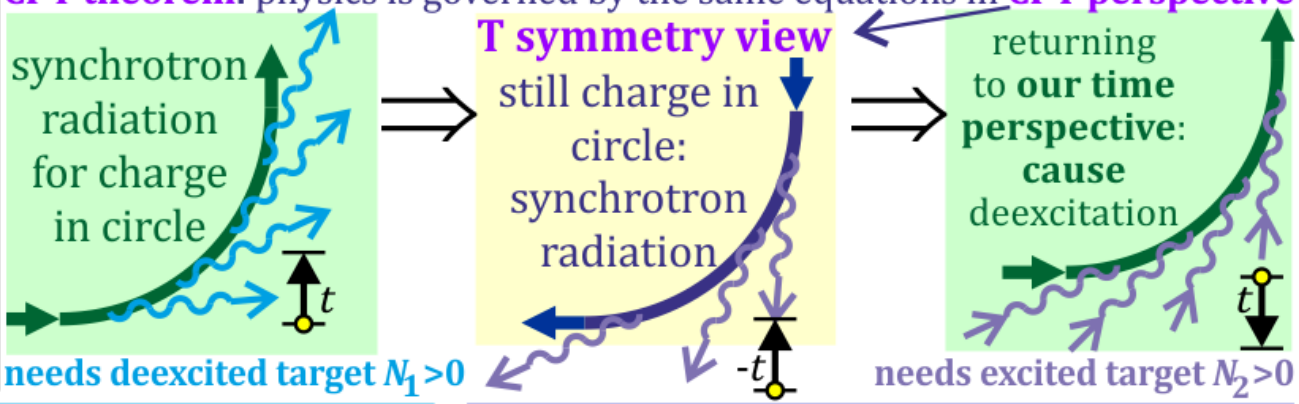
EM Barnett effect: uncharged magnetized by spinning $B \propto \omega$

$E, \vec{p}, \vec{L}$ like **photon**:

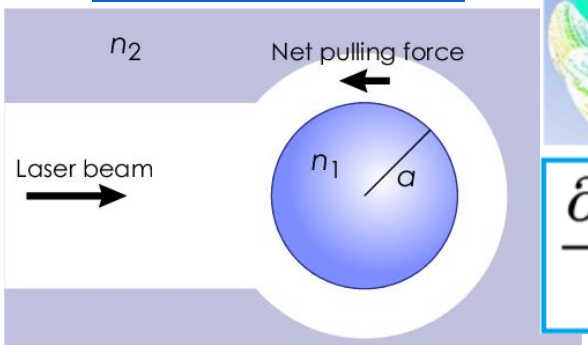
Theory	Gauge fields	Circulation	Gauge condition	Matter field
Electro-dynamics	φ , $\vec{A}$ four-potential	$\vec{B} = \vec{\nabla}\times\vec{A}$ magnetic f.	$\vec{\nabla}\cdot\vec{A} + \frac{1}{c^2}\frac{\partial\varphi}{\partial t} = 0$	$\vec{E}_e = -\frac{\partial\vec{A}}{\partial t} - \vec{\nabla}\varphi$
Hydro-dynamics	$\chi = v^2/2, \vec{v}$ flow velocity	$\vec{\omega} = \vec{\nabla}\times\vec{v}$ vorticity	$\vec{\nabla}\cdot\vec{v} + \frac{1}{c_s^2}\frac{\partial\chi}{\partial t} = 0$	$\vec{E}_h = -\frac{\partial\vec{v}}{\partial t} - \vec{\nabla}\chi$



CPT theorem: physics is governed by the same equations in **CPT perspective**



Optical pulling:



$$\frac{\partial N_2^{\text{excited}}}{\partial t} = -\frac{\partial N_1^{\text{ground}}}{\partial t} = B_{12}\,\rho(\nu)\,N_1 \quad \text{absorption} \quad \text{usually } \sim N$$

T

$$\frac{\partial N_2^{\text{excited}}}{\partial t} = -\frac{\partial N_1^{\text{ground}}}{\partial t} = -B_{21}\,\rho(\nu)\,N_2 \quad \text{stimulated emission} \quad \text{usually } \sim 0$$

Laser causes **absorption** $\overset{\text{CPT}}{\longleftrightarrow}$ **stimulated emission** e.g. in Rabi cycle – let's use the latter

Stimulated emission applications with negative radiation pressure

Like Rabi cycle, STED microscope

apply/test macro CPT symmetry

CT scan of emission coefficient

as CPT analog of absorption CT,

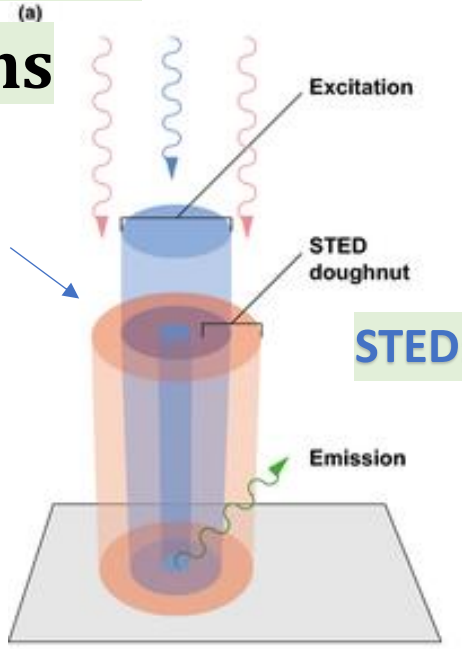
radiotherapy to starve tumor,

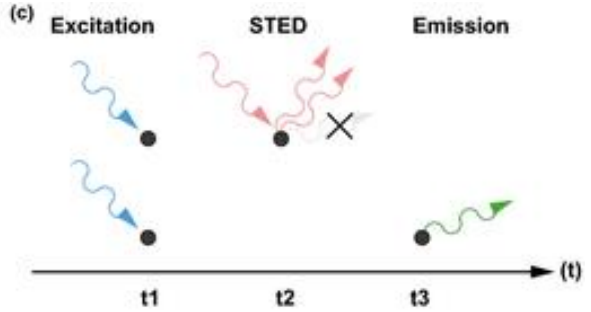
astro: **CPT(black hole) only emits**?

surprising neg. radiation objects?

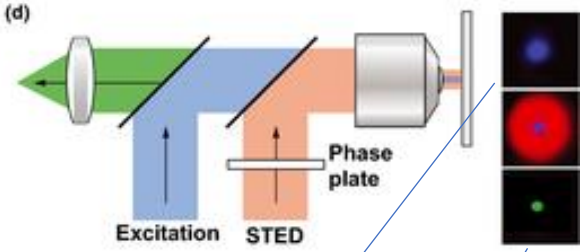
2WQC: two-way quantum computers

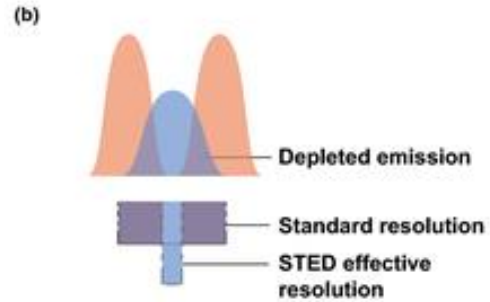
S-matrix: $\langle\psi_f|U|\psi_i\rangle \overset{\text{CPT}}{\longleftrightarrow} \langle\psi_i|U^\dagger|\psi_f\rangle$

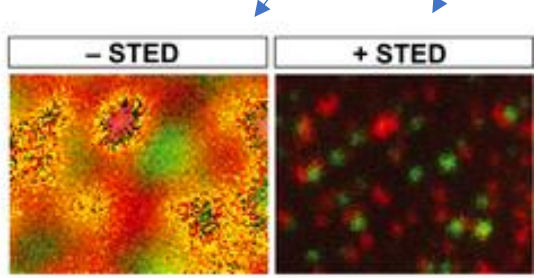




STED: STimulated Emission Depletion

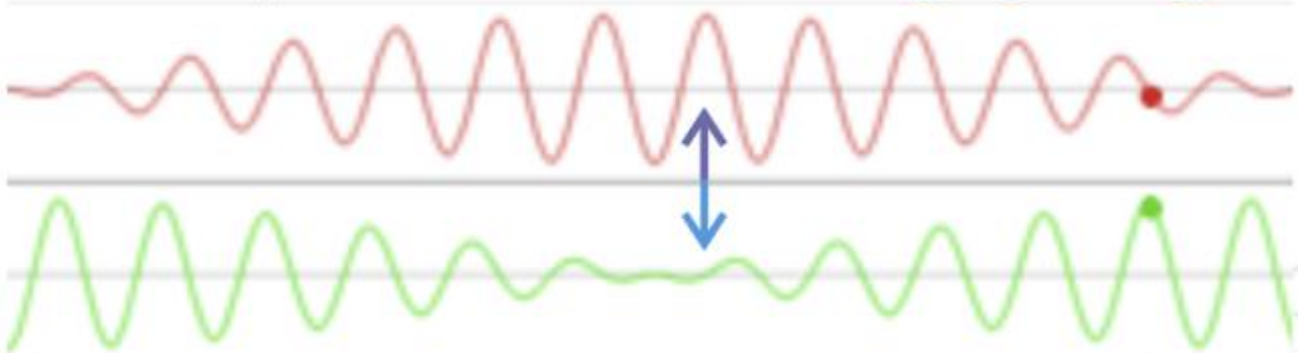


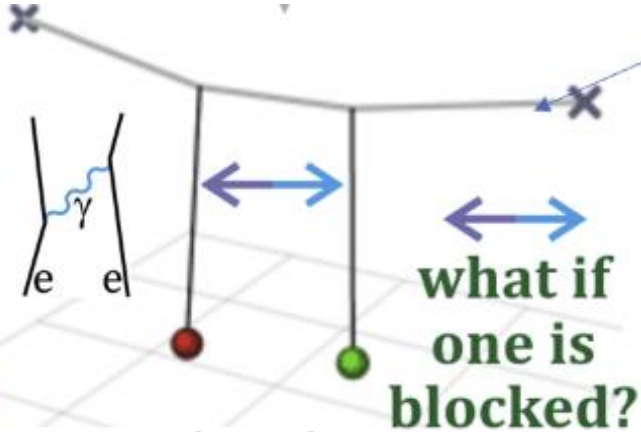




Purcell effect: couple to deexcite (antenna)

Rabi: coupled resonators exchanging energy





also **FRET**: Förster resonance energy transfer requiring absorber

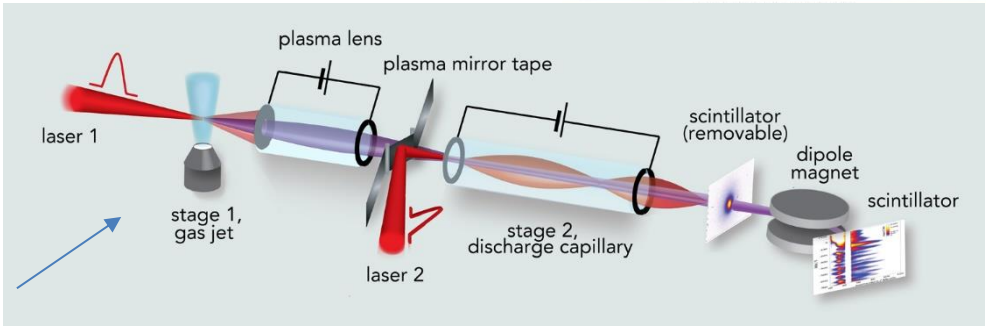
"**CPT theorem**: CPT holds for all physical phenomena"

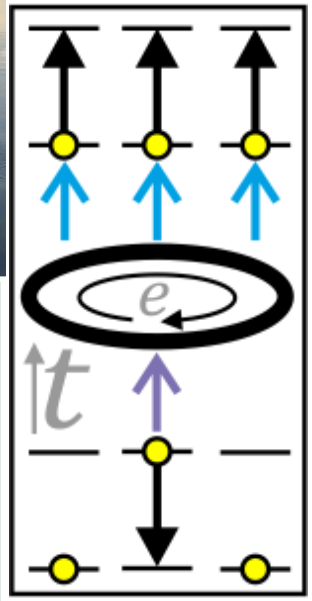
Symmetry of **equations** can be violated in **solution**

e.g. by **rock thrown** into **(symmetric) lake**

Big Bang: 2nd law of therm.: **entropy growth**,

also **asymmetry of radiation**: circulat. electron loses energy - more emitters than absorbers, unless e.g. tabletop accelerator





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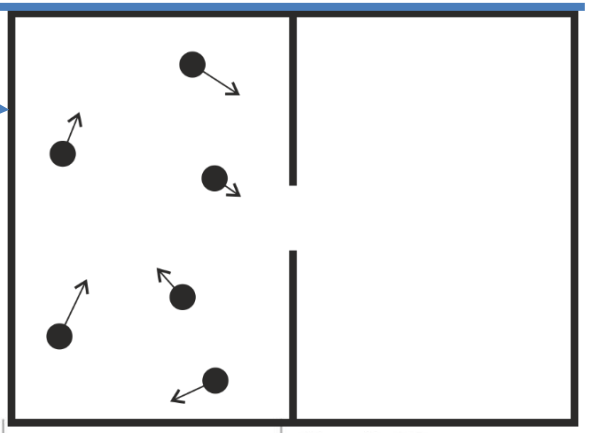
e.g. **connected gas containers**



Classical evolution: symmetric, deterministic, 0 entropy

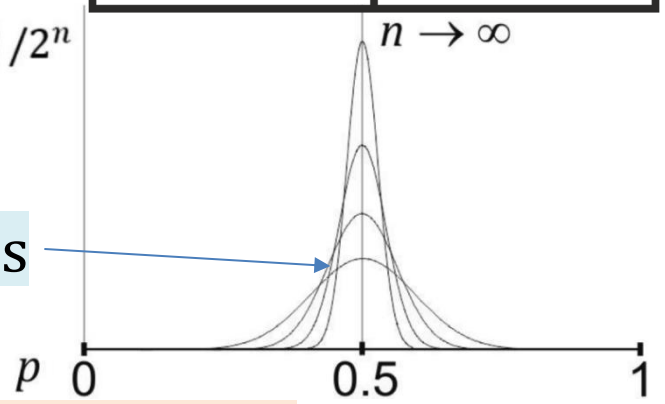
⇓ **approximate** (~mean field, stosszahlansatz) with ⇓

***p* – percentage of particles on the left** (smoothening)

effective description – of our knowledge,

leading to (Jaynes) maximizing entropy $p = 1/2$

as ½ corresponds to the largest number of possibilities



symmetry first? nature.com/s41598-025-87323-x:

"system is dissipative and decohering in both temporal directions"

opg.optica.org/ oe-20-9-9501 two → three tested 2024

Superradiance using negative radiation pressure

forward bias diode (LED): tendency to emit + T-symm.:

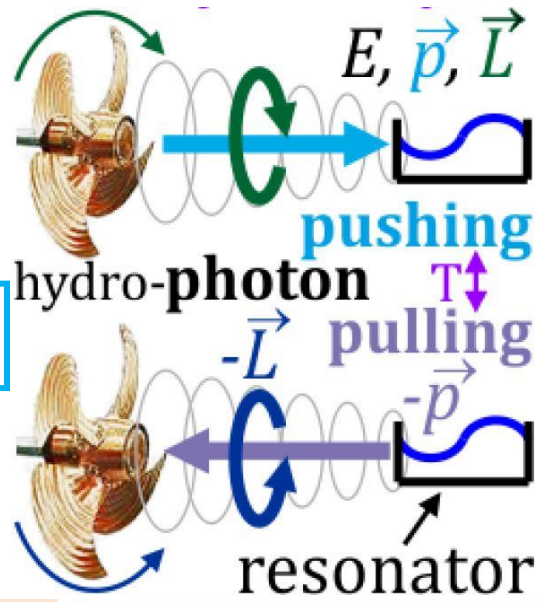
reverse bias diode: tendency to absorb e.g. in detectors

S-matrix $\langle\psi_f|U|\psi_i\rangle$: both control photon exchange

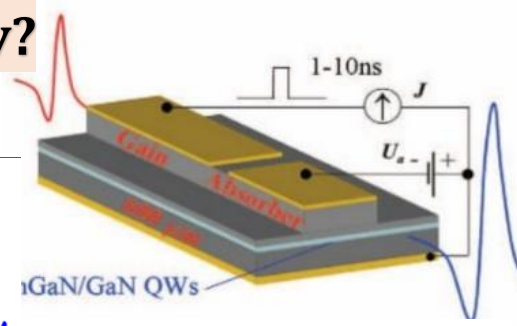
Causing absorption/stimulated emission on target

Reverse biased actively helped with emission:

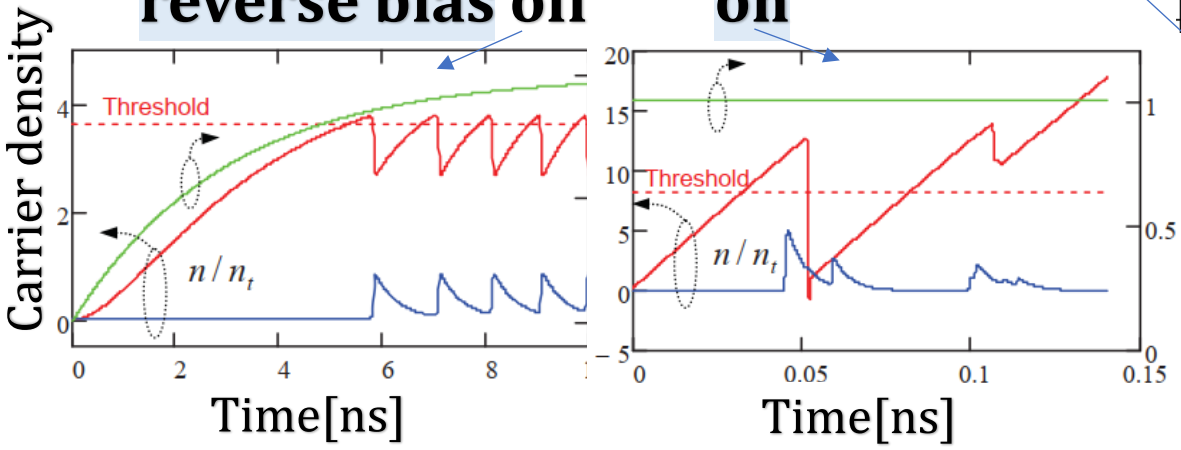
more than just absorber, getting superradiance

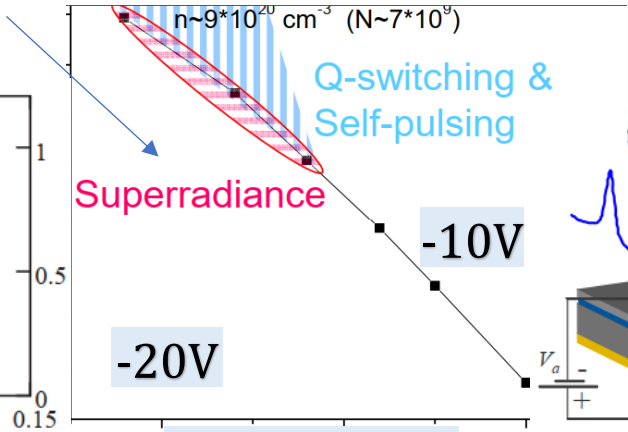


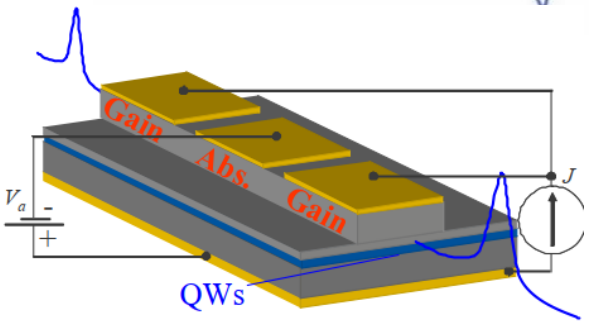
delay?

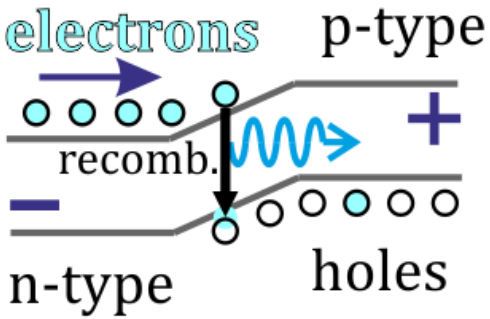


reverse bias off **on**

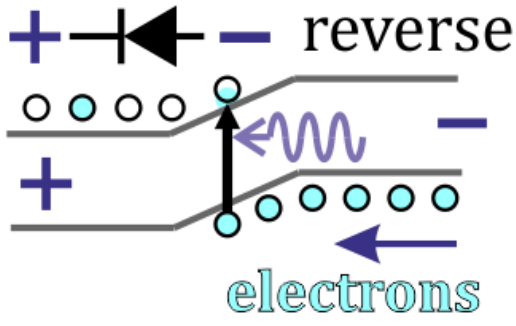


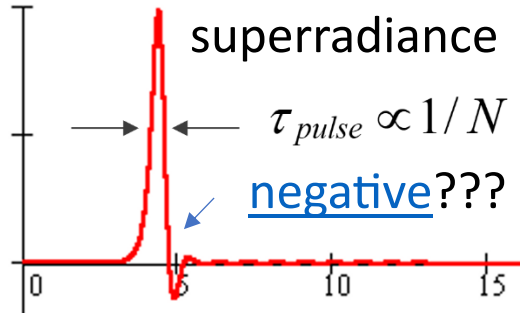






light diode gets
tendency to absorb
for **reverse bias**:
electron gradient

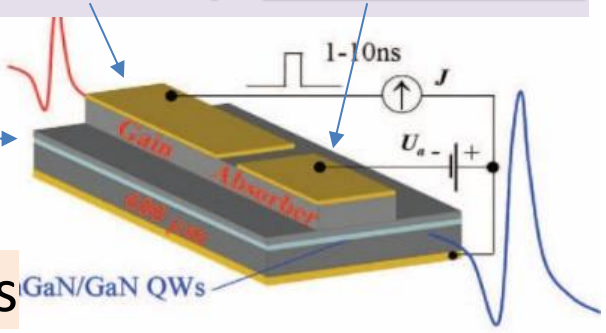




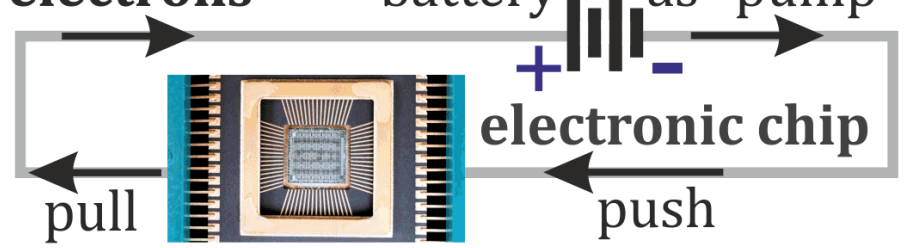
S − matrix: $\langle\psi_f|U|\psi_i\rangle$ − based computers

Two-way control: from past (push) and future (pull) e.g. between coupled resonators (Purcell), opposite V diodes:
Trivial for classical computers, for quantum (2WQC)
would allow to attack postBQP ∋ NP, e.g. break most ciphers

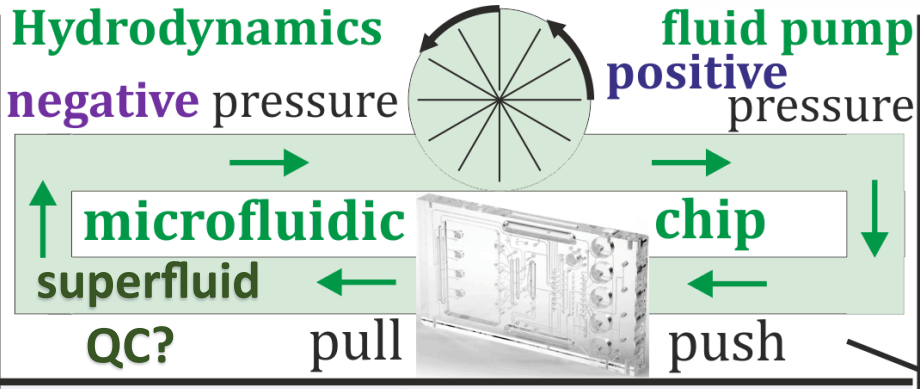
forward-chip-reverse bias



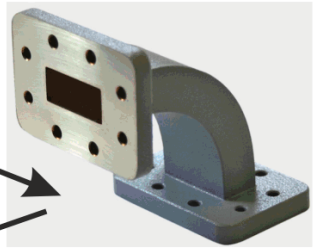
Push&pull for better flow control

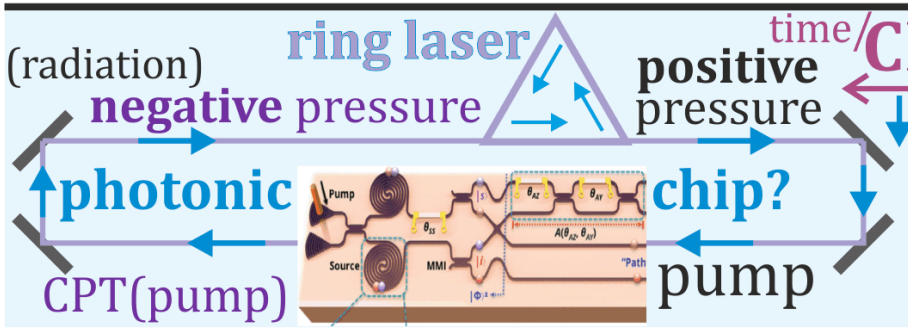


Hydrodynamics

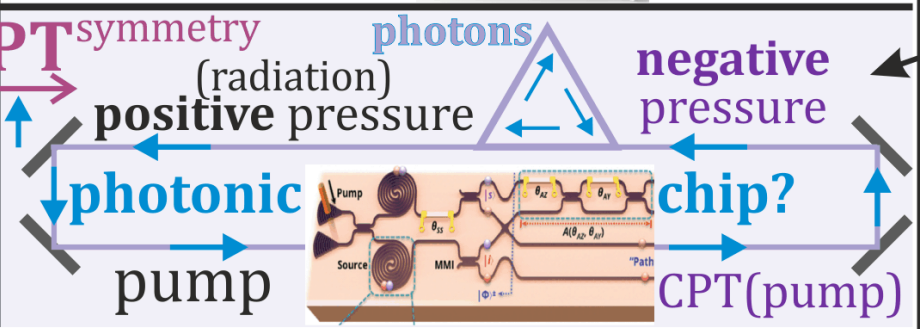


microwave waveguide quant. chip?





time/CPT symmetry



EM field (photons?) nearly the same equations as **superfluid** (mechanical vibrational qubits?)

CPT(process used for state preparation) to influence the final state

setting	Gauge fields	Circulation	Gauge condition	Matter field
Electro-dynamics	φ , $\vec{A}$ four-potential	$\vec{B}=\vec{\nabla}\times\vec{A}$ magnetic f.	$\vec{\nabla}\cdot\vec{A}+\frac{1}{c^2}\frac{\partial\varphi}{\partial t}=0$	$\vec{E}_e=-\frac{\partial\vec{A}}{\partial t}-\vec{\nabla}\varphi$
Hydro-dynamics	$\chi=v^2/2,\vec{v}$ flow velocity	$\vec{\omega}=\vec{\nabla}\times\vec{v}$ vorticity	$\vec{\nabla}\cdot\vec{v}+\frac{1}{c_s^2}\frac{\partial\chi}{\partial t}=0$	$\vec{E}_h=-\frac{\partial\vec{v}}{\partial t}-\vec{\nabla}\chi$

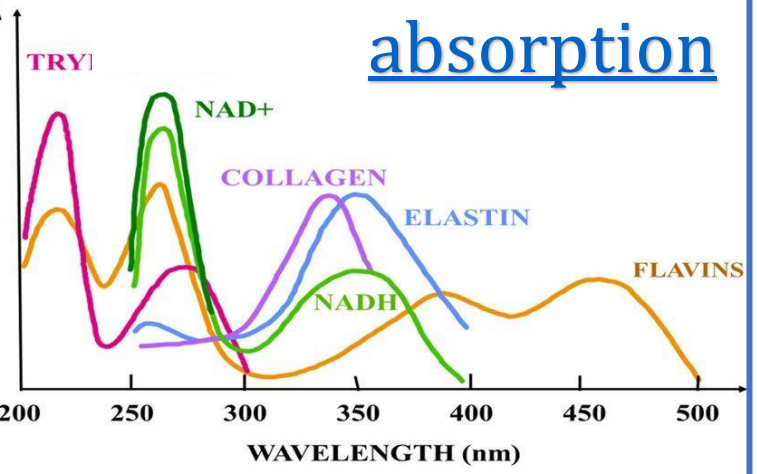
Medical applications?

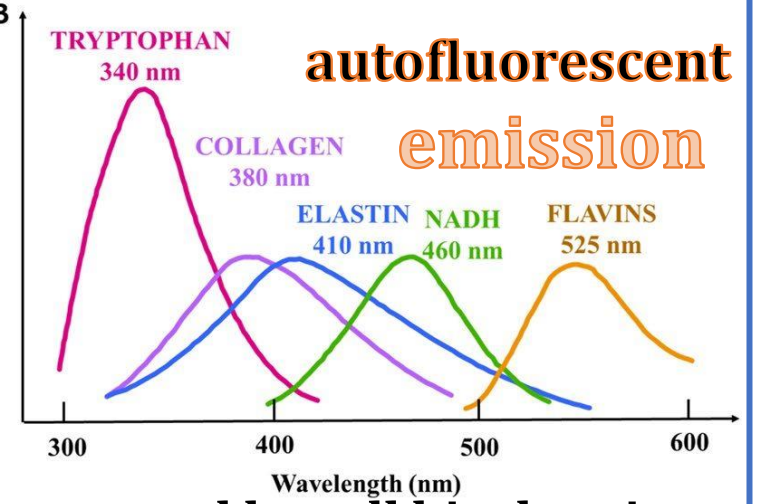
arXiv:2409.15399

e.g. mapping emission coefficient?

e.g. in human body

mobile if on diodes





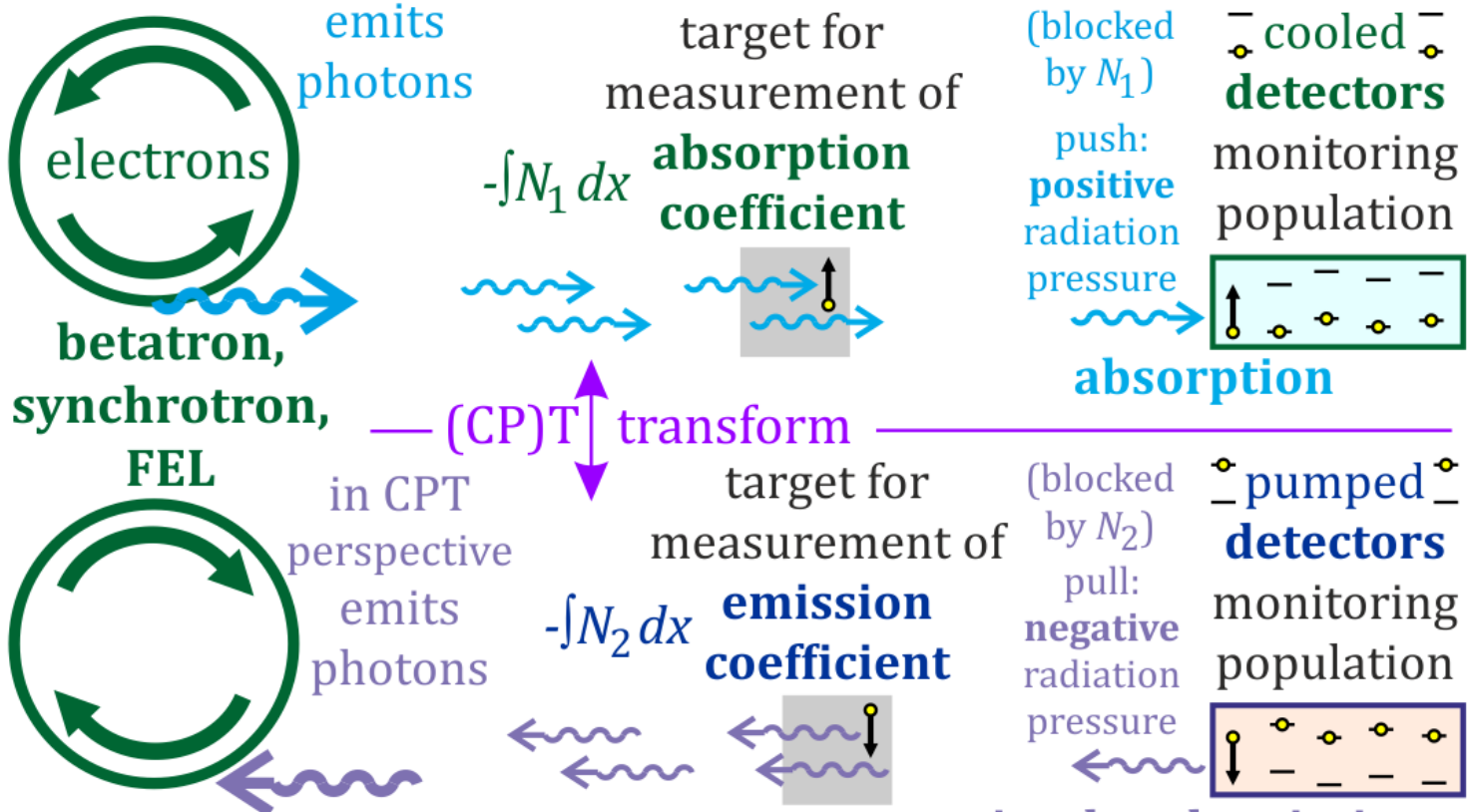
powered by cell biochemistry

Harmless (non-ionizing) color RTG/CT? (video?)

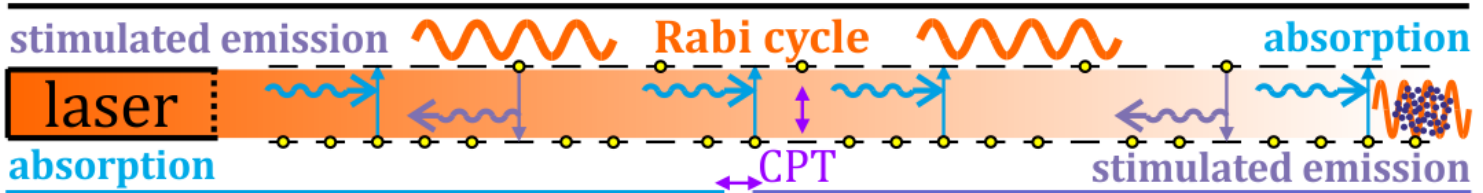
CT scan of emission coeffcient for 3D map of e.g.

tryptophan ~340nm, NADH ~460nm, flavins ~525nm emission

should have **much better transparency** as usually $N_2 << N_1$



$\vec{p} = \langle \vec{E} \times \vec{H} \rangle / c$ **radiation pressure** - **positive** (toward surface) or **negative** (outward)



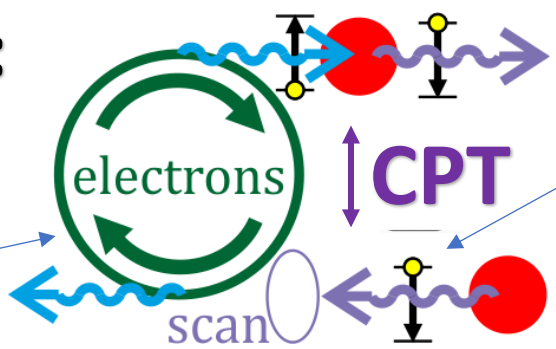
$$\frac{\partial N_2}{\partial t}^{\text{excited}} = -\frac{\partial N_1}{\partial t}^{\text{ground}} = B_{12}\,\rho(\nu)\,N_1 \quad \text{usually } \sim N \quad \text{absorption}$$

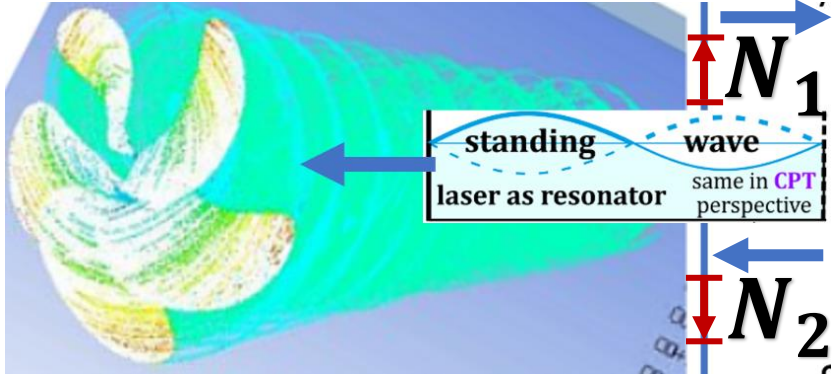
$$\frac{\partial N_2}{\partial t}^{\text{excited}} = -\frac{\partial N_1}{\partial t}^{\text{ground}} = -B_{21}\,\rho(\nu)\,N_2 \quad \text{usually } \sim 0 \quad \text{stimulated emission}$$

Just cause deexcitation:

STED microscopy …

without photobleaching?





separation(positive/negative pressure)

transparency: blocked by N_2 not N_1

2WQC, reversed photolithography, chemistry, nuclear, neuro, medicine?

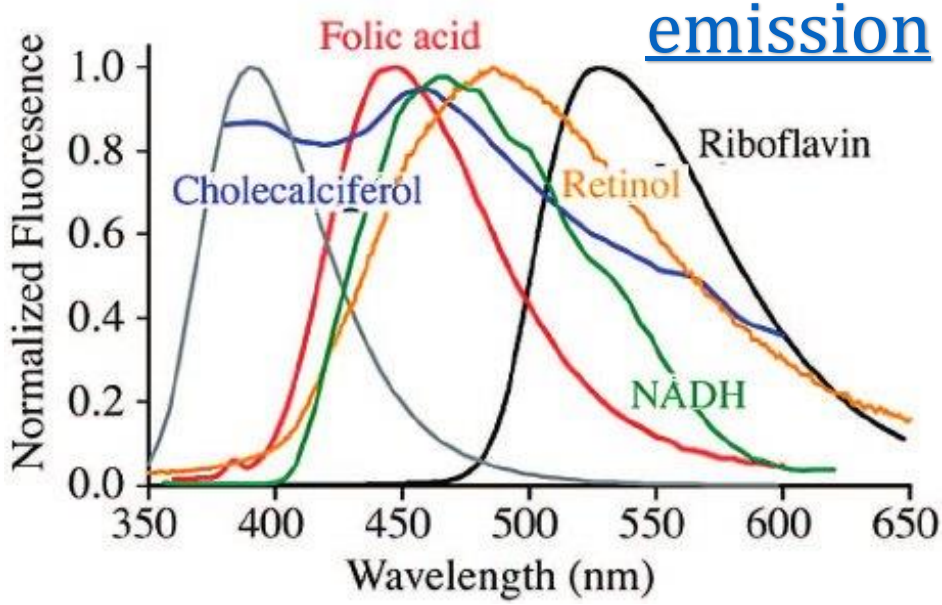
e.g. degrade NADH to starve cancer?

precise, non-ionizing

neutral for intermediate tissues

Metabolic issues? (toxic) singlet oxygen ~1280nm IR emission? …

[emission]



Backward ASE radiotheraphy?

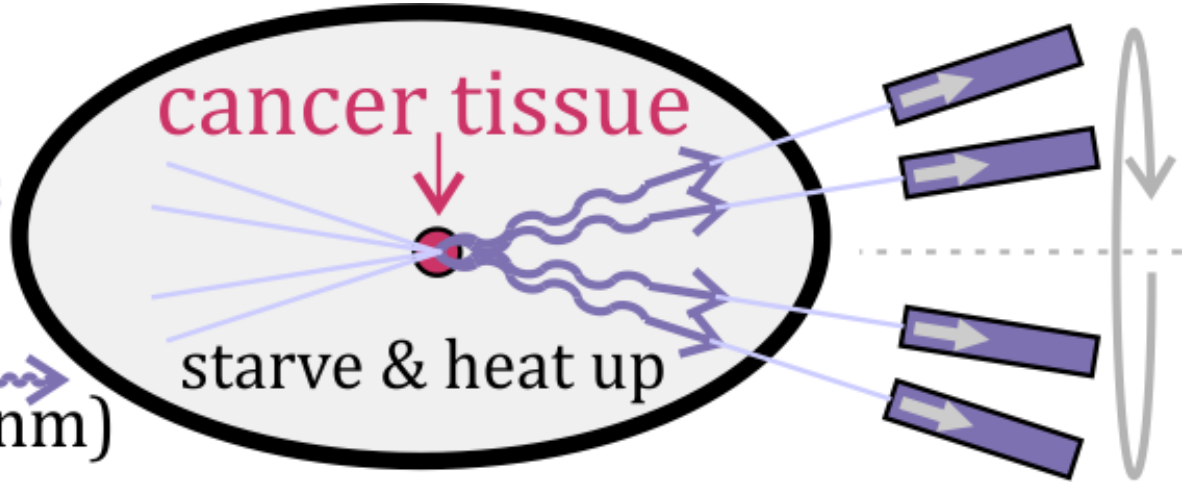
amplify chosen photon emission

by intersecting **backward beams**

e.g. stimulate NADH degradation

to starve, release energy heating

$NADH \rightarrow NAD^+ + H^+ + 2e^- + \gamma$ (~460nm)



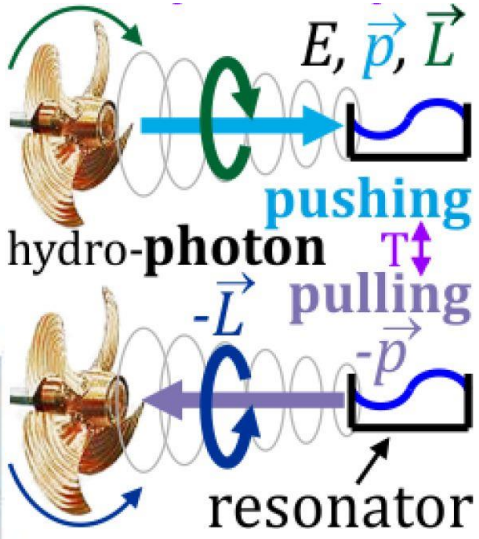
Are there **cosmic sources** of **negative radiation pressure**?

Astronomy: now focused on absorption - of positive radiation pressure

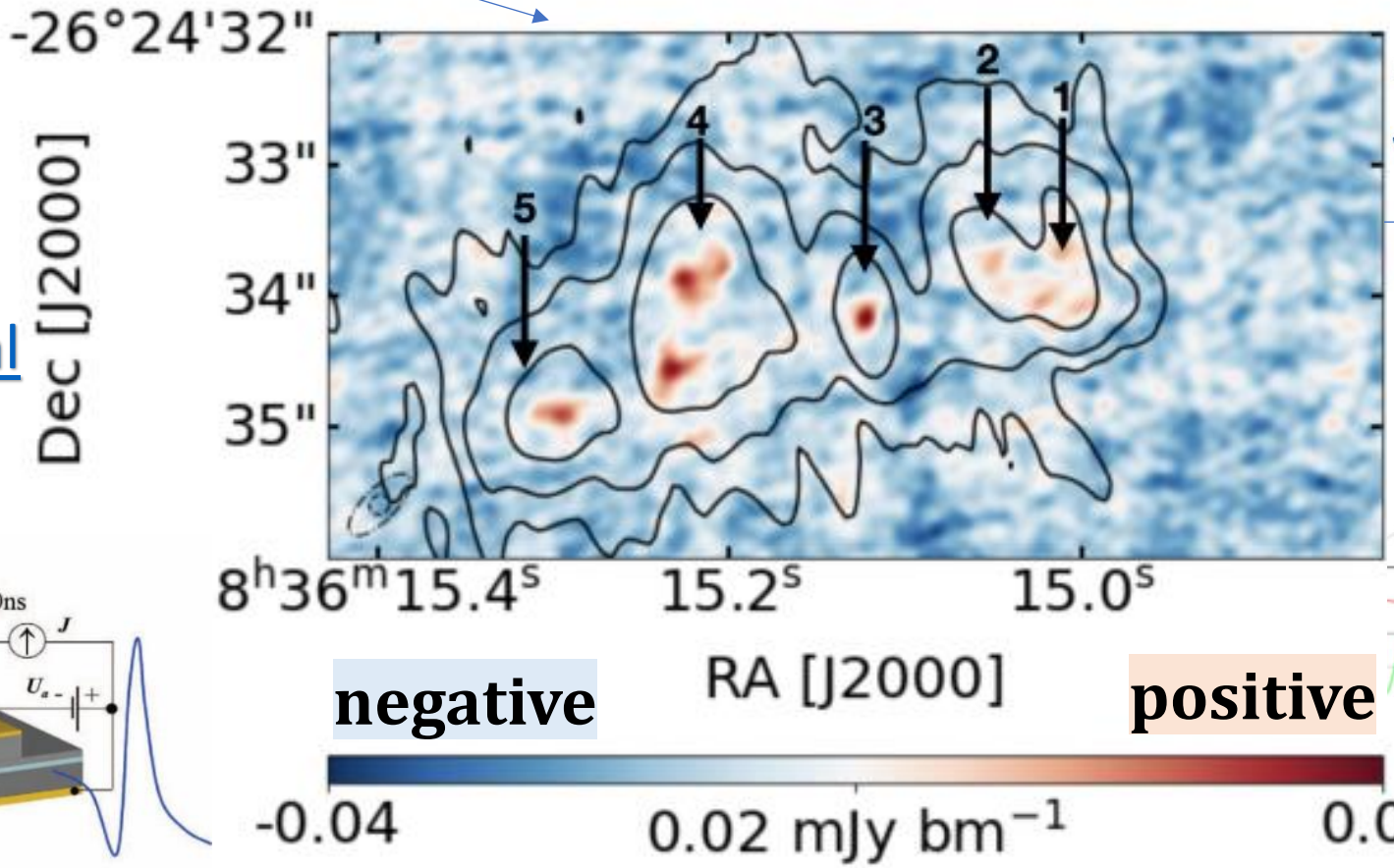
Negative: telescope emits more than absorbs?

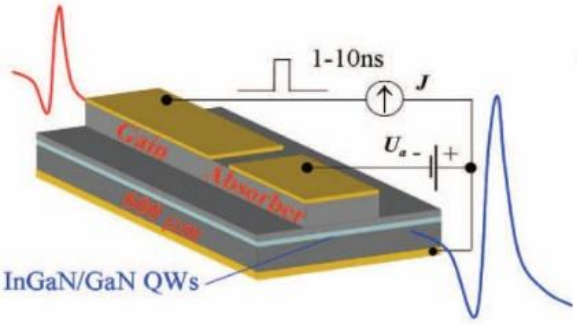
Reverse-bias-diode-like sources? Pulsar? Black hole?

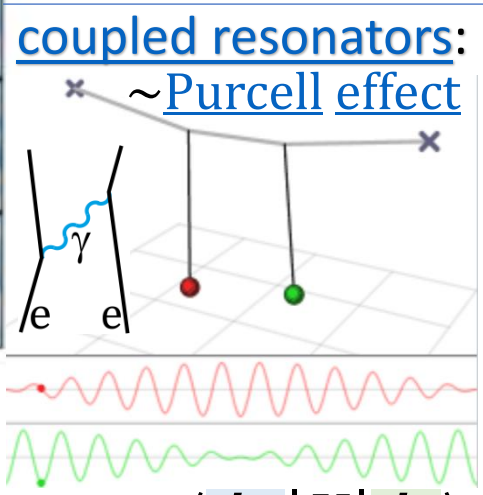
Observed e.g. in radio flux maps – really artifacts?



[arXiv:2107.02695 Astrophysical Journal]







$\langle \psi_f | U | \psi_i \rangle$

needs both

Figure 1. 33 GHz continuum map of Henize 2-10. The contours are the 5 GHz map from VLA/AJ314 to show radio knots as originally classified by Kobulnicky & Johnson (1999). The 5 GHz contours are at 5, 10, and 22σ. The beams are shown in the lower left.

$\langle\psi_f|U|\psi_i\rangle$: **white hole** perfect emiter $|\psi_i\rangle \overset{\text{CPT}}{\longleftrightarrow}$ **black hole** perfect absorber $\langle\psi_f|$

From CPT perspective, our black hole is white hole: very active

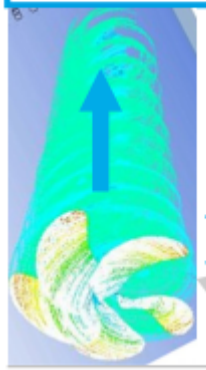
CPT(white hole heating around) = black hole cooling (like Purcell)?

Black hole information paradox: destroyed in BH evaporation???

Solution: white hole exchanges information by positive radiation pressure, hence (CPT) symmetrically black hole by negative radiation pressure

$$\frac{\partial N_2}{\partial t}_{\text{excited}} = -\frac{\partial N_1}{\partial t}_{\text{ground}} = B_{12}\,\rho(\nu)\,N_1 \quad \text{usually } \sim N \text{ (absorption)}$$

$$\frac{\partial N_2}{\partial t}_{\text{excited}} = -\frac{\partial N_1}{\partial t}_{\text{ground}} = -B_{21}\,\rho(\nu)\,N_2 \quad \text{usually } \sim 0 \text{ (stimulated emission)}$$



push, **emit**, **heat**, acting with **absorption** equation, positive radiation pressure, forms **jets going out**

pull, **absorb**, **cool**, acting with **stimuated emission**, negative radiation pressure forms **jets going in**

push blow

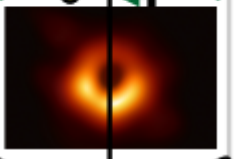
horizon

time

radiation pressure

$$\vec{p} = \langle \vec{E} \times \vec{H} \rangle / c = I/c$$

pull suck



lightcones

white hole **T/CPT symmetry** **black hole**

arXiv:2509.10615 : “SMBHs are **expected** to be surrounded by progressively hotter gas (…) **Surprisingly** (…) Sagittarius A* (…) **seems to have no currently active jet or wind**.”

?: Intermediate mass BH $10^2 - 10^5\ M_\odot$: very low luminosity

$\frac{\partial E}{\partial t}$ **CPT(WH) = BH**

CPT(heating) = cooling

$\propto N_1 \gg \propto N_2$

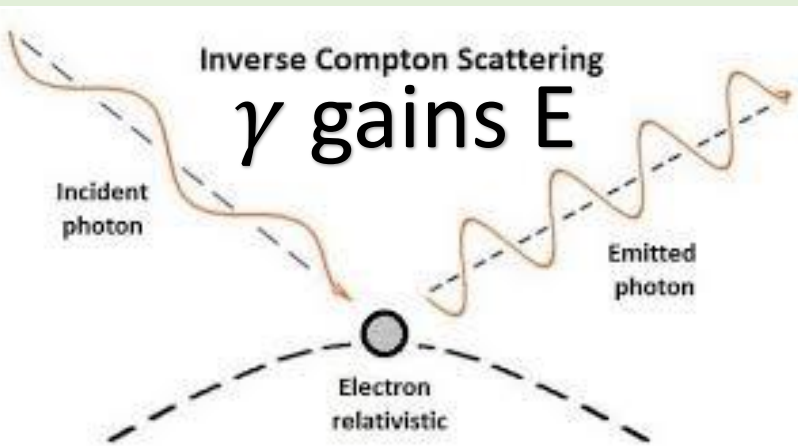
“surprising”, “dust”?

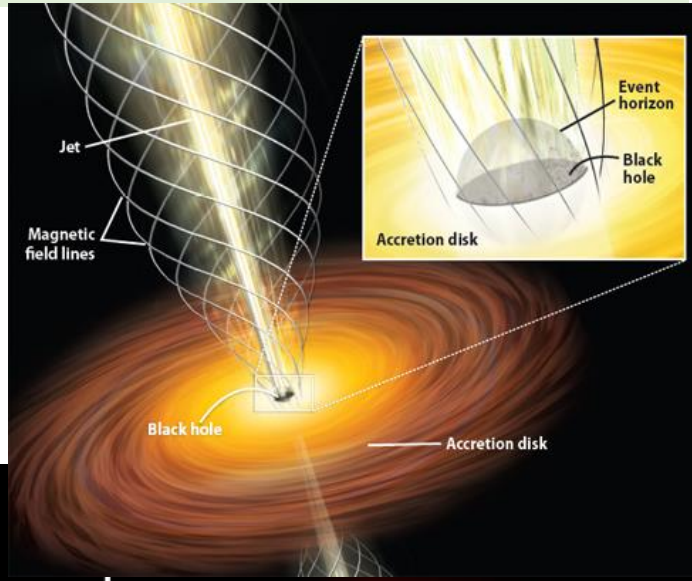
BH is WH in CPT view

CPT violation otherwise?

BH simulations: **electron temperature << of ions! E.g. 160x**

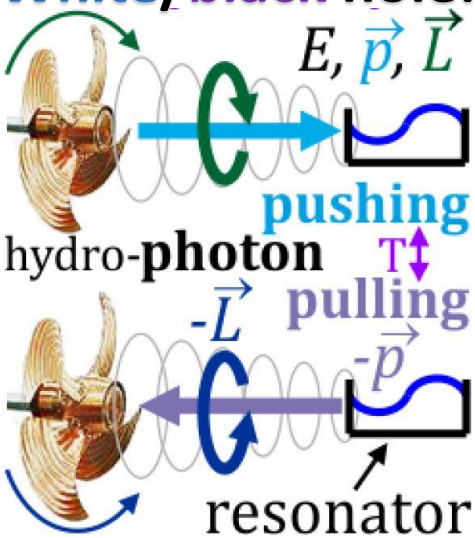
MAD, **SANE model**: "Near $R_{high} \approx 160$, the emitting region shifts significantly toward **higher latitudes** and **jet-disk boundary**” **cooling**: **inverse Compton** + **pull/stimulated emis.**?



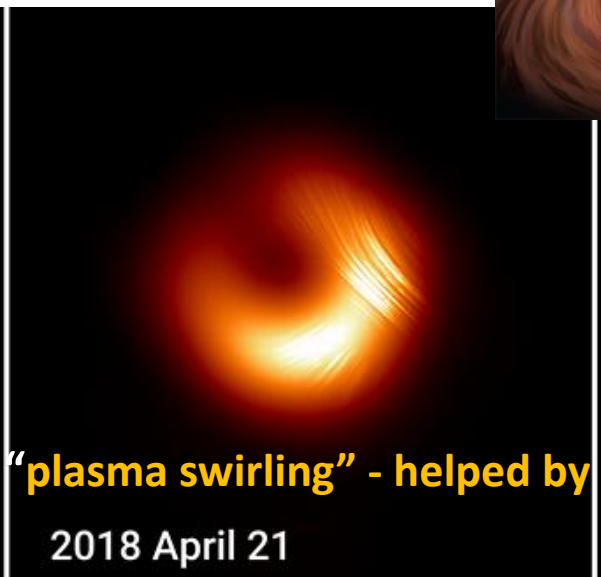


“Tremendous growth black hole”? by **pulling gravit. + EM**? Hawking?

White/black hole:



Event Horizon Telescope: 2017 April 11



“plasma swirling” - helped by negative radiation pressure?

2018 April 21

2021 April 18

Negative-temperature pressure in black holes, Norte, EPL 2024

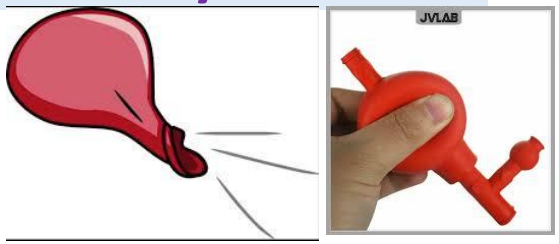
BH negative temperature? [1,2,3,4,5]

"negative T yield negative pressures"

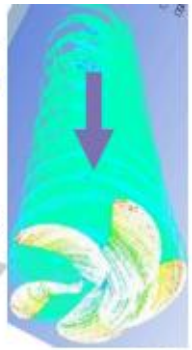
$T > 0$ matter: tendency to emit radiating **positive** radiation pressure.

$T < 0$ matter: tendency to absorb by **negative pressure**

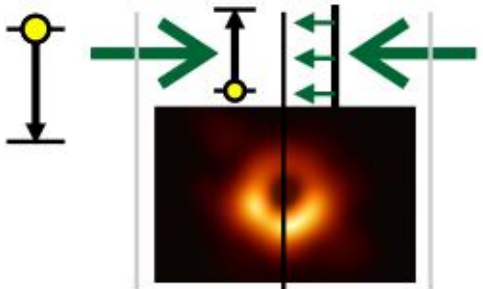
$t \leftrightarrow -t$ time



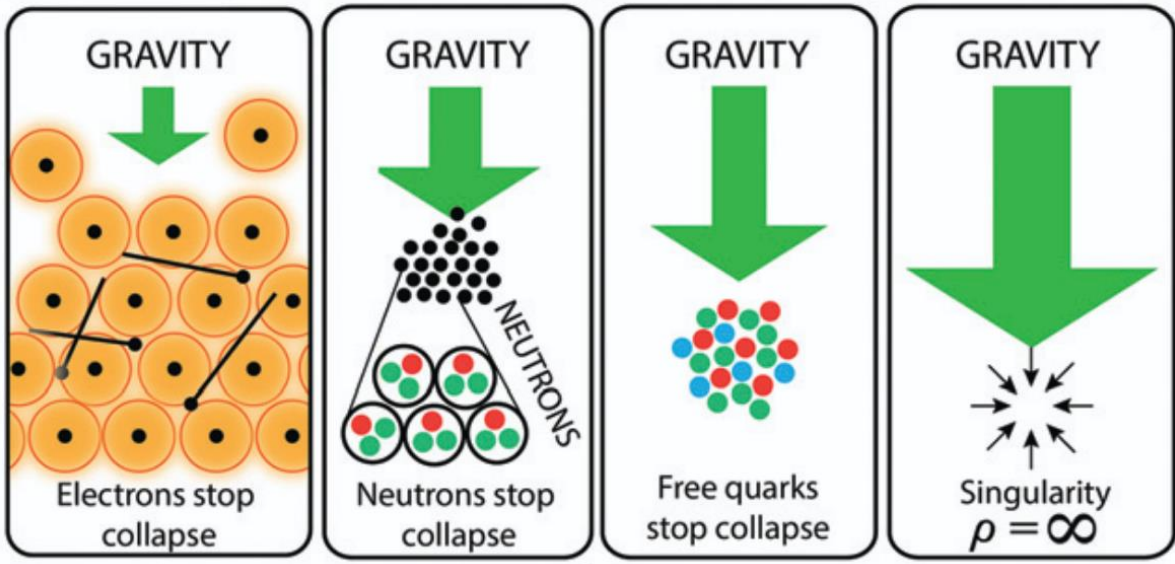
pull, absorb, cool, acting with **stimuated emission**, negative radiation pressure forms **jets going in**

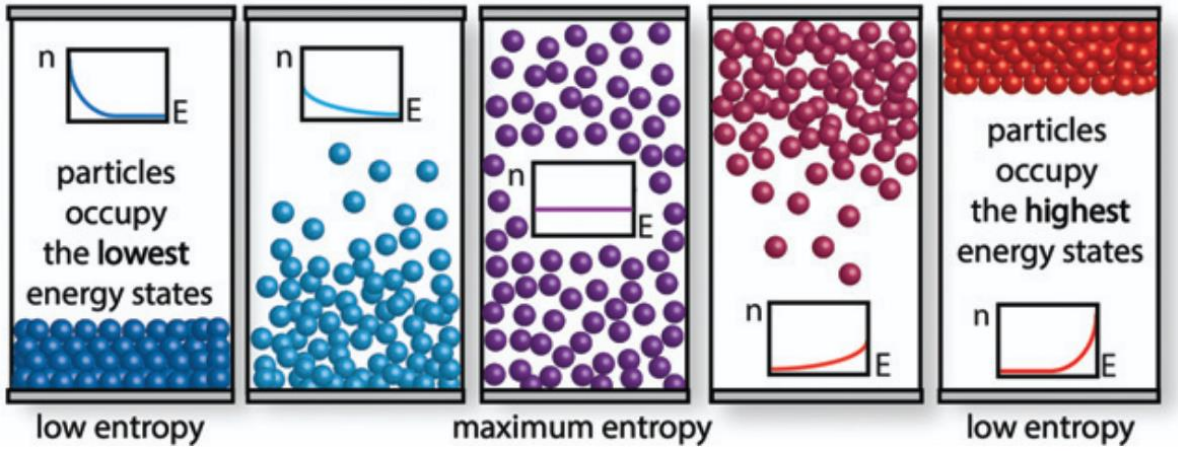


deex-cite



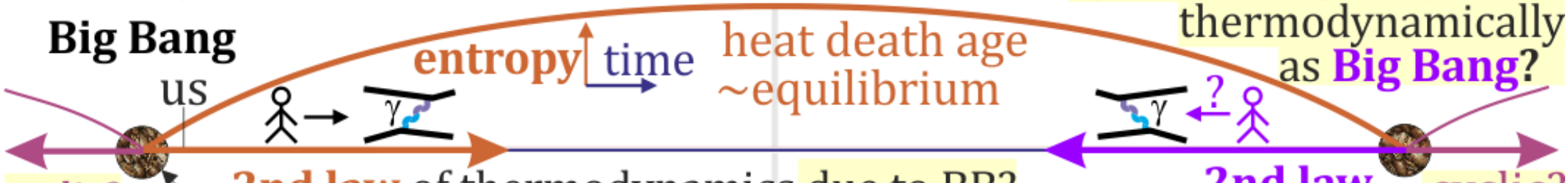
pull suck





Universe no longer accelerating? DESI: dark energy weakens?, revisit, Sabine: younger dimmer?

History of (4D block) Universe? (CPT) symmetry? Cyclic?

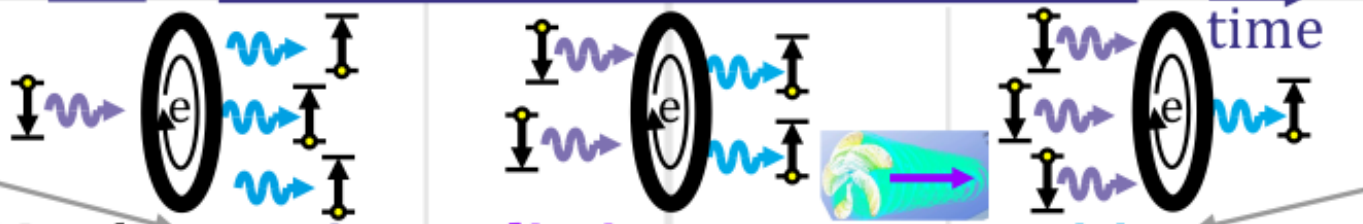


Differences between **evolutions**: **forward Big Bang** vs **backward Big Crunch**?

spontaneous emission  **coupled** by photon practically **random** two electrons in **4D Feynman diagram**  **spontaneous** absorption?

Asymmetry because of more **absorbers** in the **future** than **emitters** in the **past**?

stimulated: synchrotron mainly **emit/ lose energy**



Mainly **negative** **radiation pressure** **positive** acting

synchrotron for us mainly **absorb/ gain energy?**

black hole (forward) 

?

switched from T/CPT perspective

?

white hole??? (backward)

As white holes would **actively emit/push**, **shouldn't black holes absorb/pull**?

What **spectrum** should we expect from (lone) **white holes**? Black body radiation?

"push through earth" … maybe "pull by negative radiation pressure"?

ANITA-I, III, IV, Fluorescence Detector of the Pierre Auger Observatory

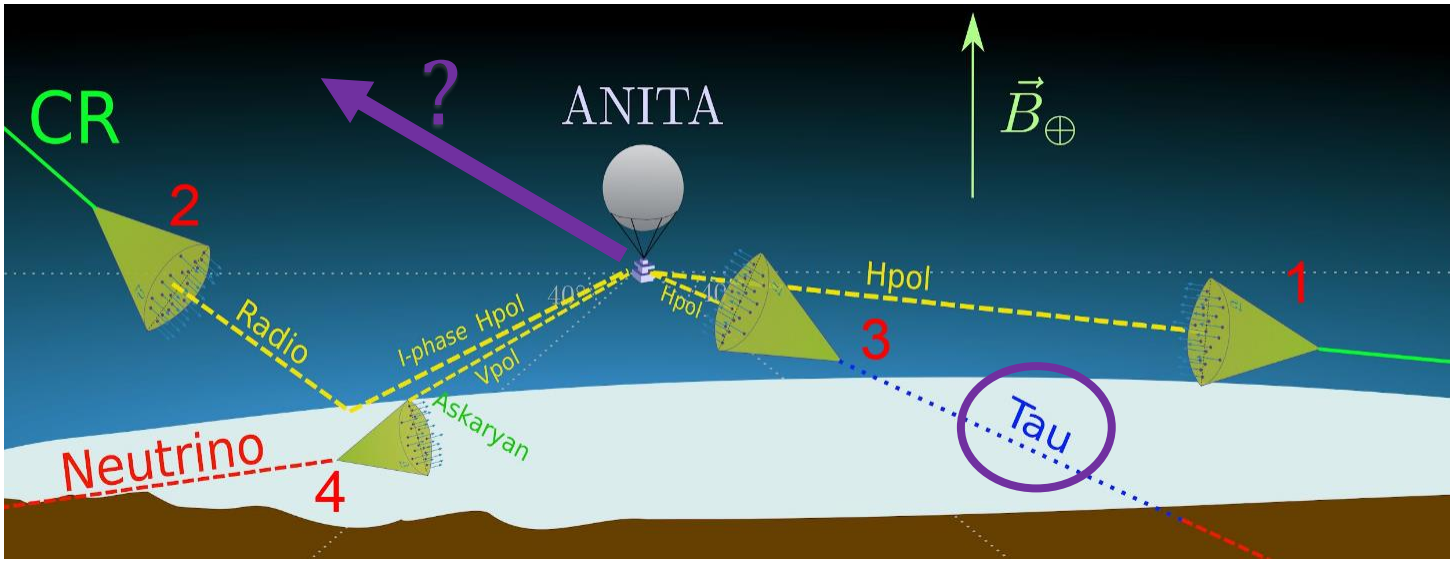
SM, ν_τ ($> 10^{18}$eV)

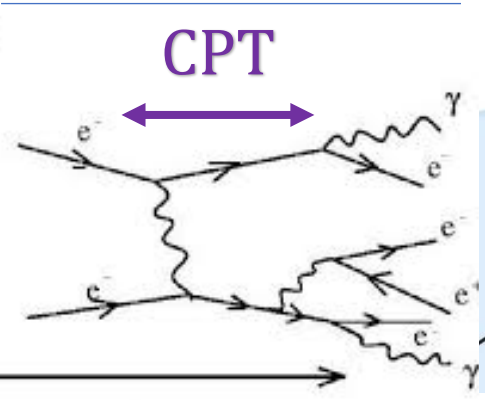
excluded

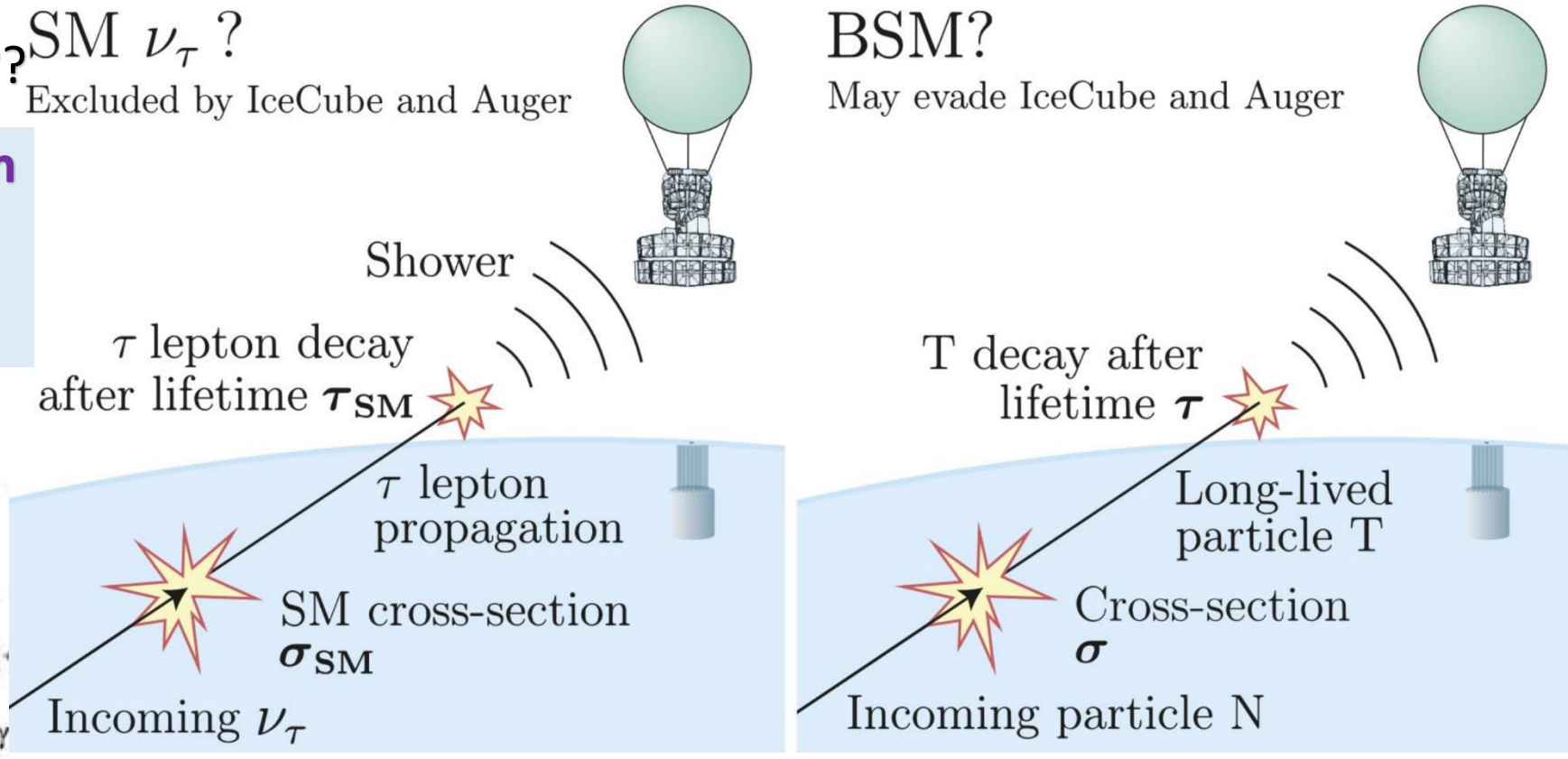
(IceCube, Auger)

Needs long-lived after interaction???

Maybe some push scenario in CPT perspective?





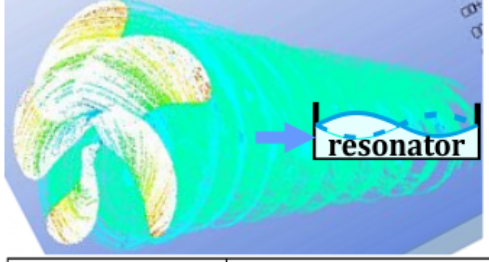


Realizations?

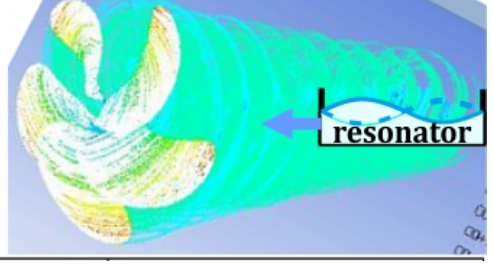
Marine propeller-like antenna?

causing excitation

T ↔ deexcitation



photon carries **energy**, **± momentum/pressure**, **± angular momentum** like **swirl-like wave** behind marine propeller



Theory	Gaug
Electro-dynamics	φ four-p
Hydro-dynamics	$\chi =$ flow

T sym: reverse (radiation)

pressure: $\vec{p} = \langle \vec{E} \times \vec{H} \rangle / c$

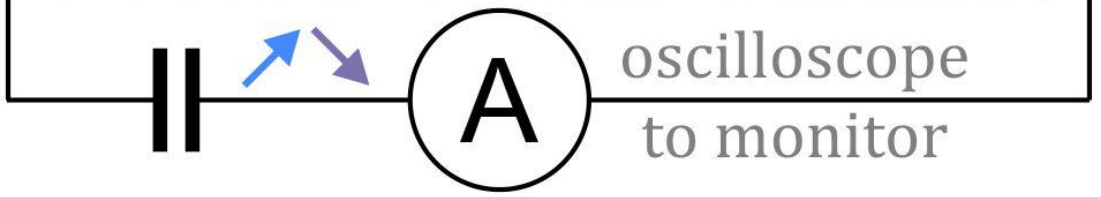
First impulse to excite, like wireless then **T-symmetric**: reversed voltage **impulse** to get **faster relaxation**?

radio telescope with excited LC?

Reverse coupling?

transmitter: to **excite** with impulse → **receiver**: antenna + LC oscillator

T symmetry: reverse electron trajectory also radiation pressure: $\vec{p} = \langle \vec{E} \times \vec{H} \rangle / c$ shouldn't **cause deexcitation** if excited?



Rabi cycle: coupled resonators, e.g. atoms

stimulated emission

Rabi cycle

absorption

laser

absorption

CPT

stimulated emission

CPT sym.

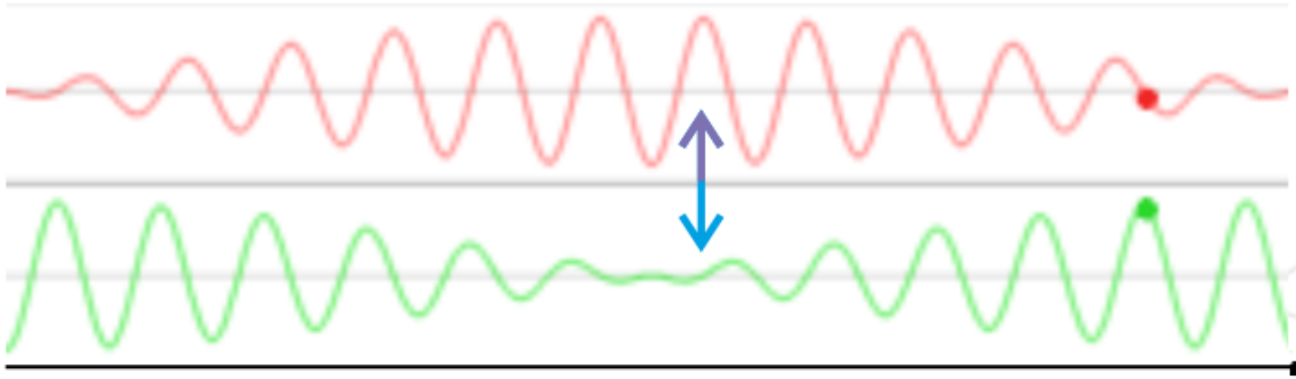
$$\frac{\partial N_2}{\partial t}^{\text{excited}} = -\frac{\partial N_1}{\partial t}^{\text{ground}} = B_{12}\,\rho(\nu)\,N_1 \quad \text{usually } \sim N \quad \text{absorption}$$

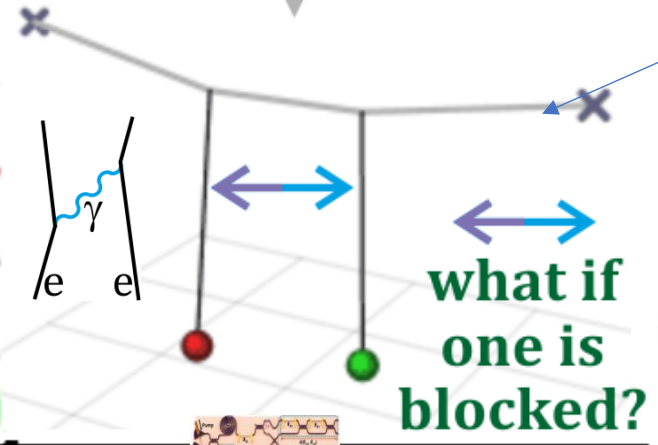
$$\frac{\partial N_2}{\partial t}^{\text{excited}} = -\frac{\partial N_1}{\partial t}^{\text{ground}} = -B_{21}\,\rho(\nu)\,N_2 \quad \text{usually } \sim 0 \quad \text{stimulated emission}$$

$$|\psi(t)\rangle \propto e^{-\frac{iE_+t}{\hbar}}|E_+\rangle + e^{-\frac{iE_-t}{\hbar}}|E_-\rangle$$

$$\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = \mathrm{Re}\left(c_1 \begin{pmatrix} 1 \\ 1 \end{pmatrix} e^{i\omega_1 t} + c_2 \begin{pmatrix} 1 \\ -1 \end{pmatrix} e^{i\omega_2 t}\right)$$

Rabi: coupled resonators exchanging energy





(de)excite with fan? "as laser"

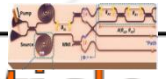
Directional?

hydrodynamical Rabi cycle

standing wave

laser as resonator

same in **CPT** perspective



particle

momentum transfer by **positive**/**negative** pressure

$\vec{p} = \langle \vec{E} \times \vec{H} \rangle / c$ **radiation pressure** - **positive** (toward surface) or **negative** (outward)

Electrons in atoms…

Free electrons:

Synchrotron radiation:

statistical

~spontaneous

emission: $P \propto N_e$

Coupled electrons

~superradiance:

SASE in FEL, $P \propto N_e^2$

laser: **absorption↔**

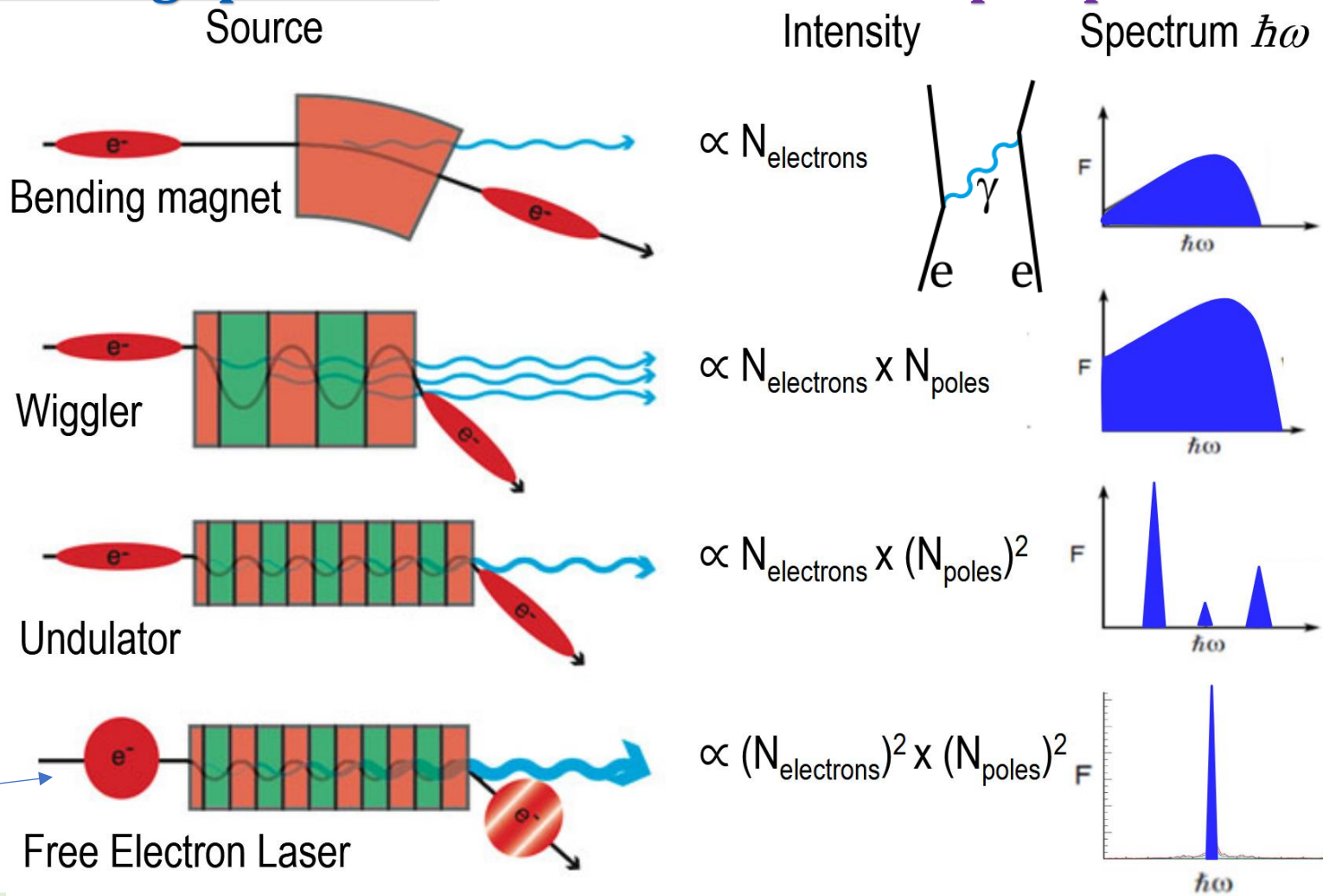
stimulated emission

switched in T/CPT

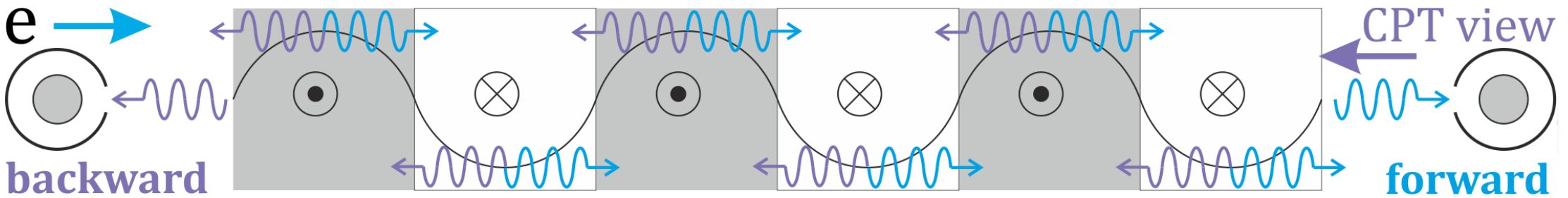
just **EM: T symmetric**

Narrowing spectrum, coherence

CPT perspective?



SASE: self-amplified spontaneous emission



wiggler/undulator/synchrotron: in CPT reversing electron & photon trajectory

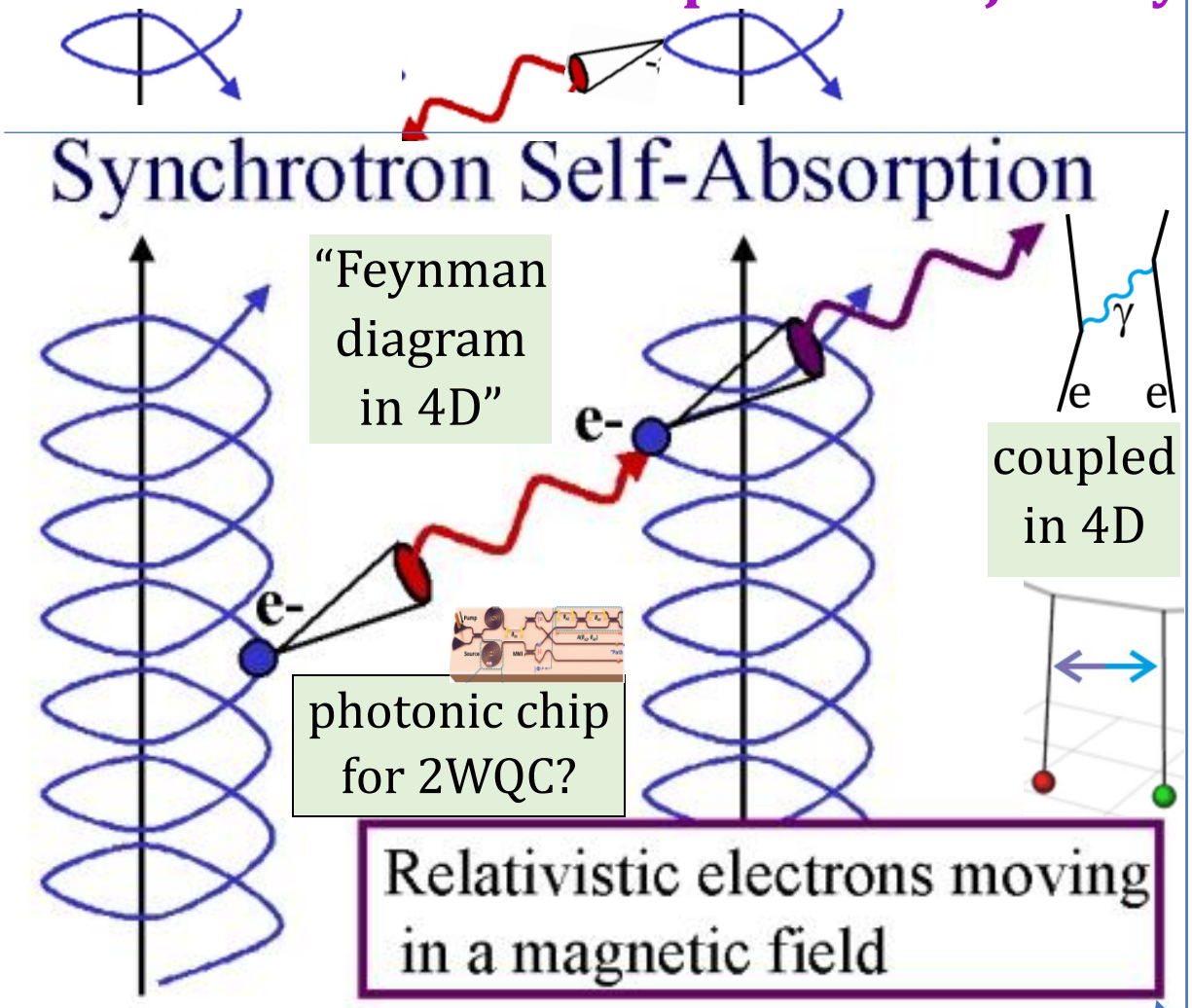
Synchrotron radiation by accelerating charge, also needed

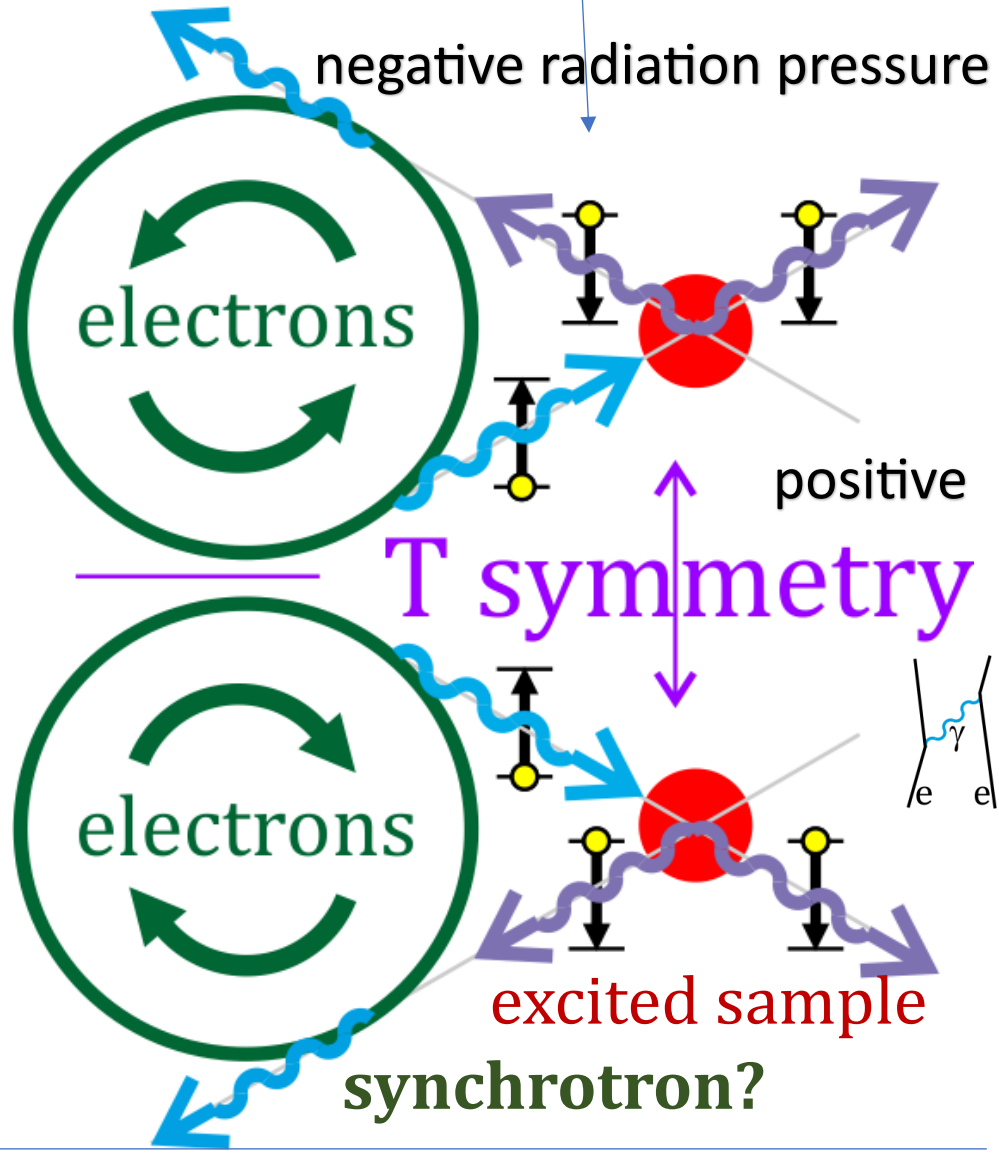
CPT symmetric synchrotron self-absorption, self-amplified SE

What about **causality**? In **EM** should be **the same in T perspective**

Is there really spontaneous emission? Or coupled with e.g. electron?

T: reversed electron+photon trajectory





astrophysics [1, 2, 3, 4, 5, 6, 7], **SASE** in FEL

https://www.mssl.ucl.ac.uk/www_astro/lecturenotes/hea/radprocess/sld028.htm

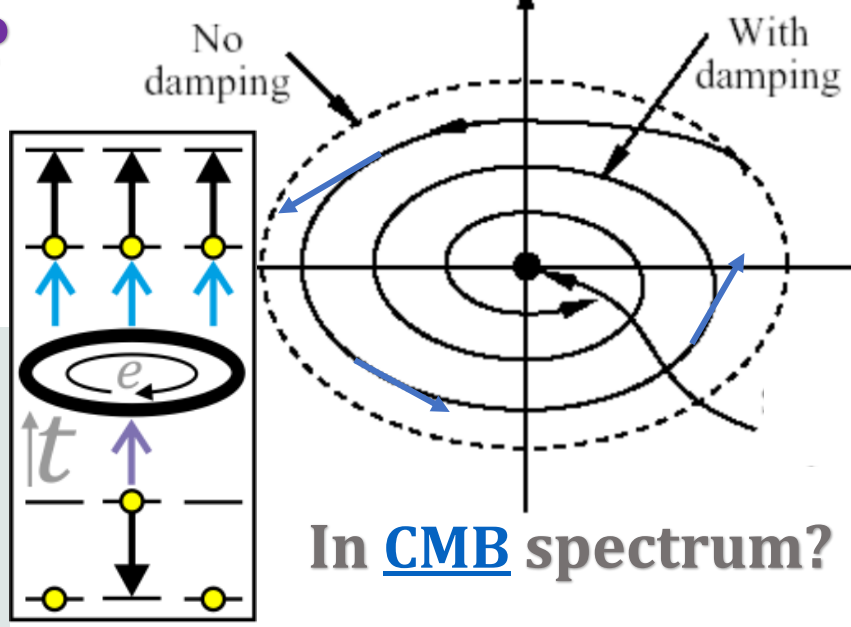
Emission asymmetry

CPT symmetry?

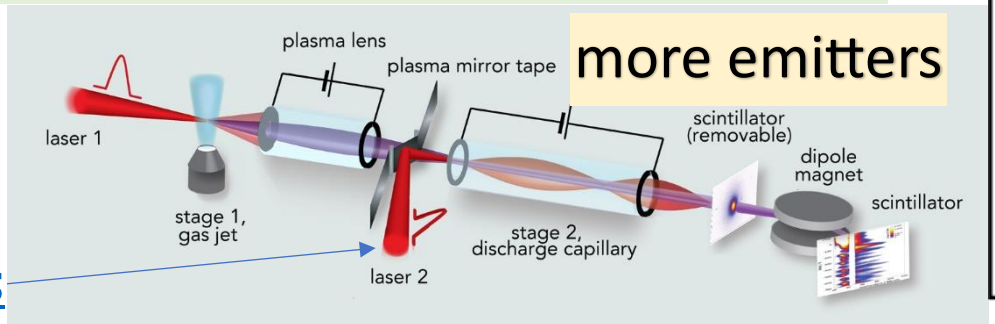
Circulating electron **loses energy** (damping)

in **CPT** also circulating but **gains energy** instead.

Because of **more absorbers** than **emitters**?



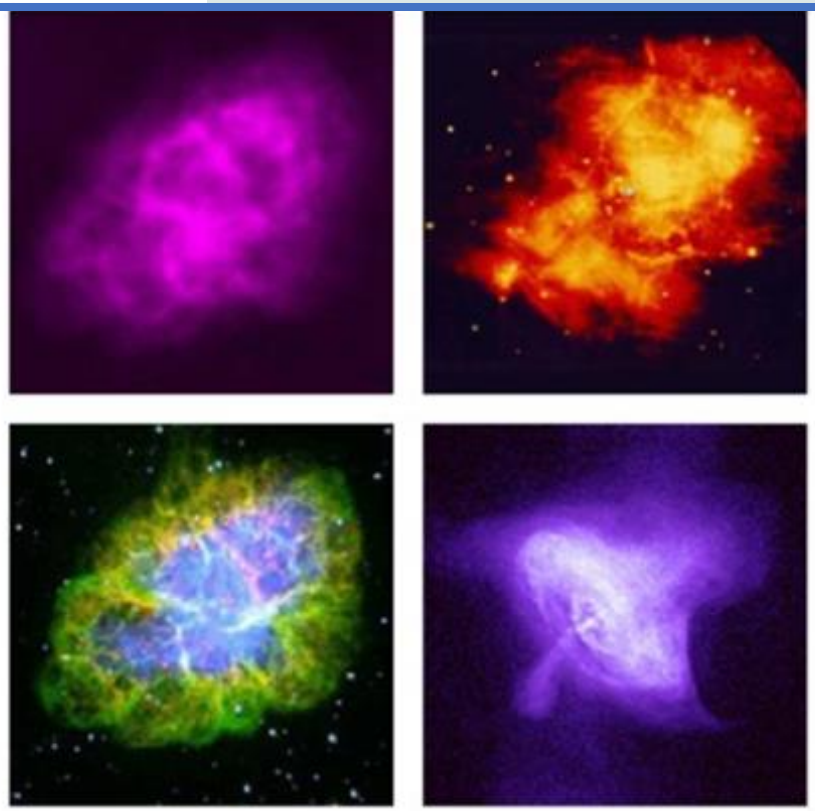
Reversed: gain energy in tabletop accelerators

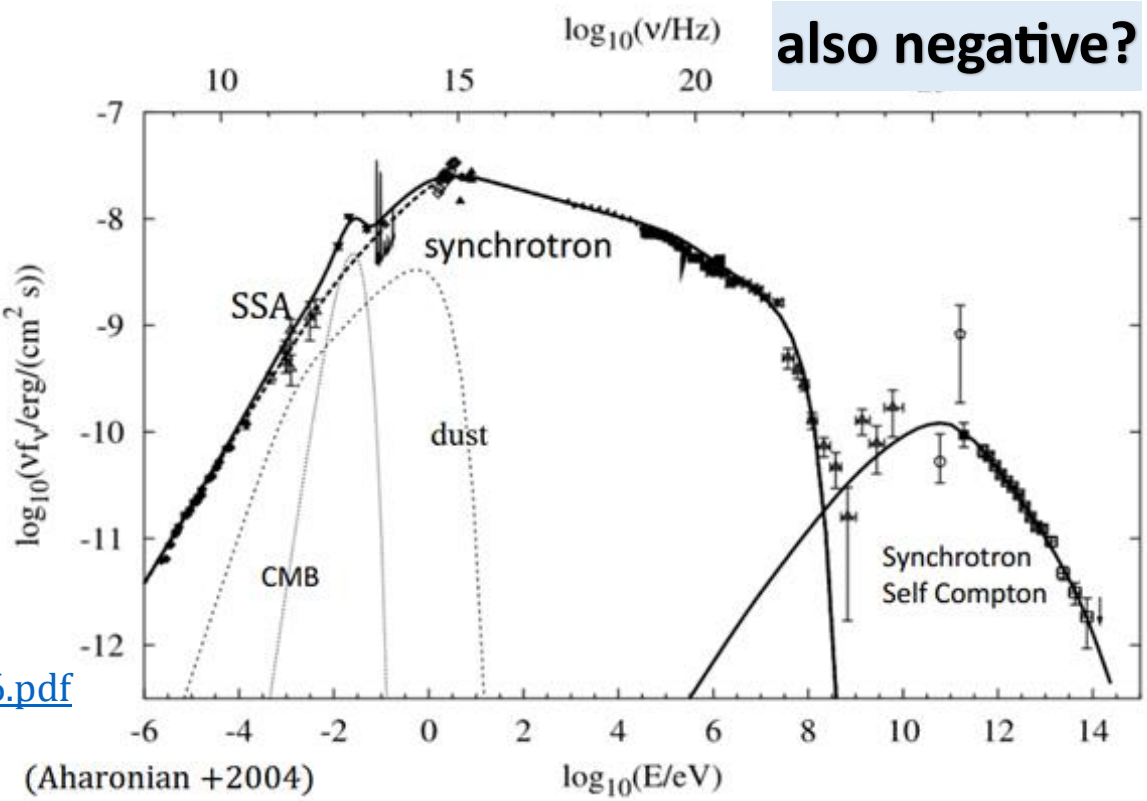


more emitters

In CMB spectrum?

resonators? atoms, nuclei, synchrotron?





also negative?

https://people.sissa.it/~perrotta/lezioni_2023_2024/chapter6.pdf

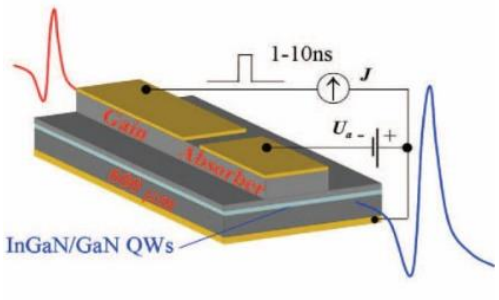
Images of the Crab in radio, infrared, optical and X-ray.
see http://chandra.harvard.edu/photo/0052/what.html.

ASE – amplified spontaneous emission (**SASE**: self-)

backward ASE prevented by forward optical isolator: photons '→'

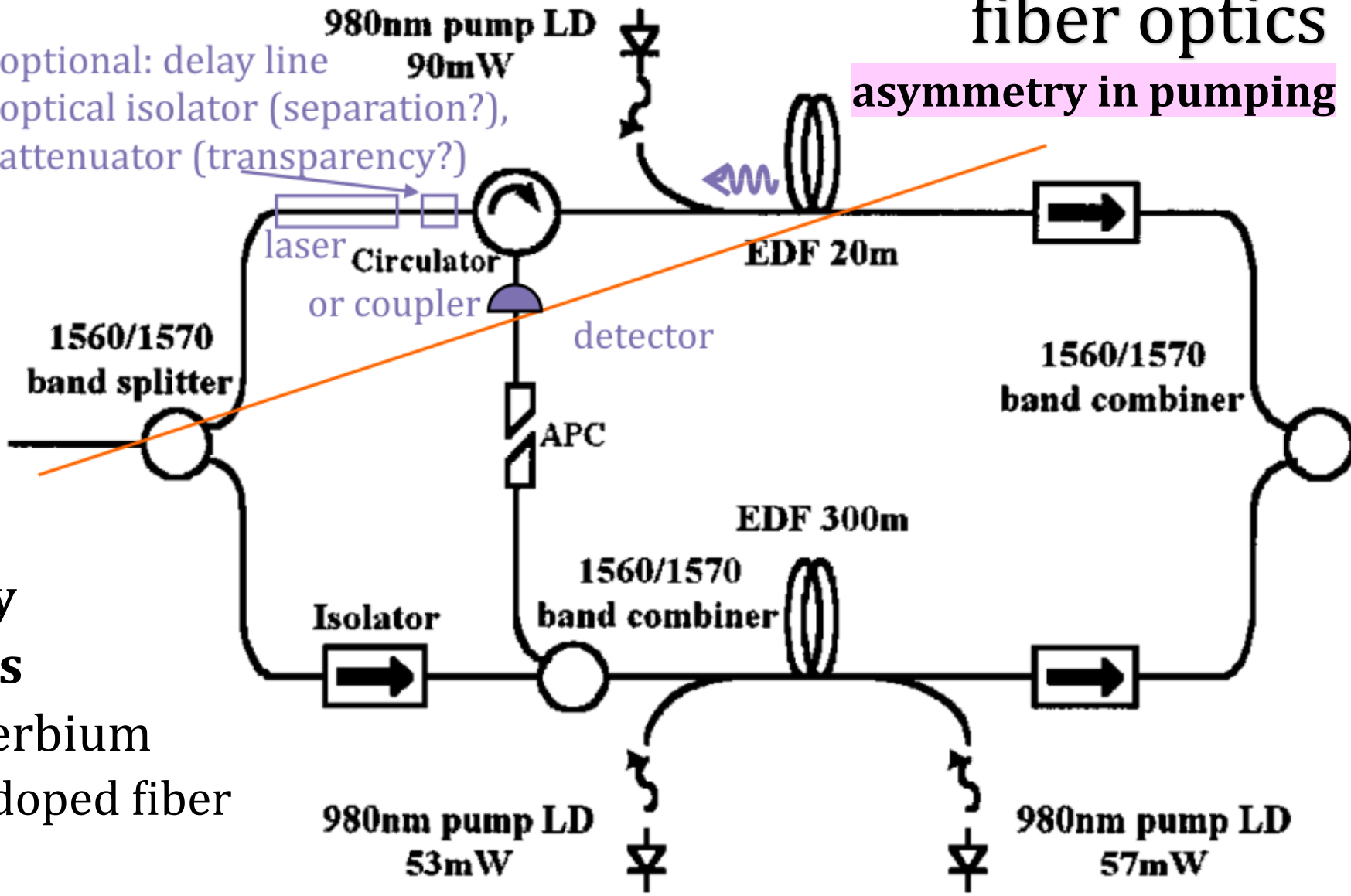
CPT? **forward ASE prevented by backward optical isolator? '←' ?**

forward/backward ASE ~ positive/negative radiation pressure



fiber optics

asymmetry in pumping



Black from IEEE:841259

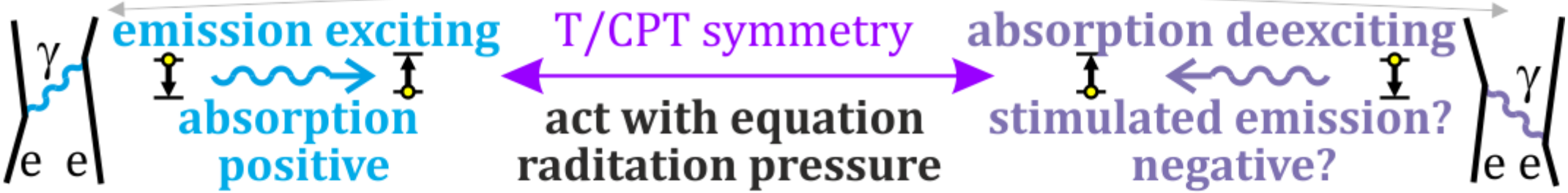
laser literally pulls photons from excited erbium

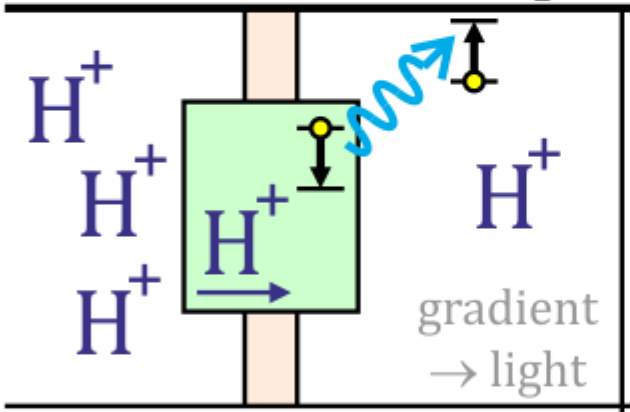
EDF – erbium doped fiber

Various potential approaches for tendency to emit/absorb

S-matrix: $\langle \psi_f | U | \psi_i \rangle$ - e.g. emission/absorption **need both conditions**

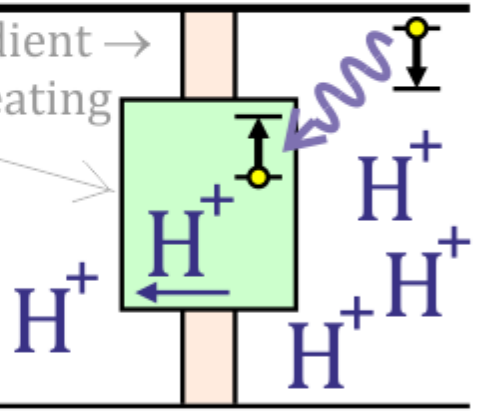
Spontaneous increasing Feynman diagram amplitude/probability

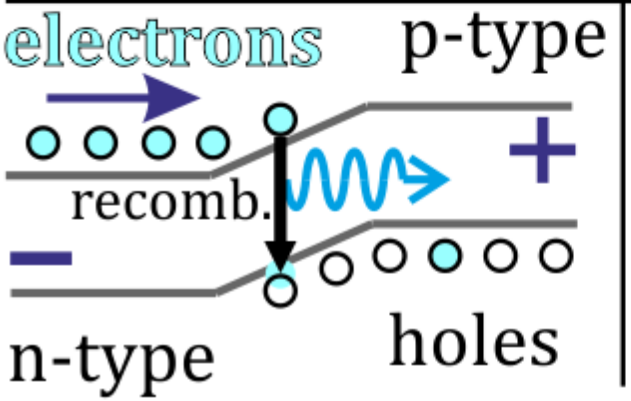




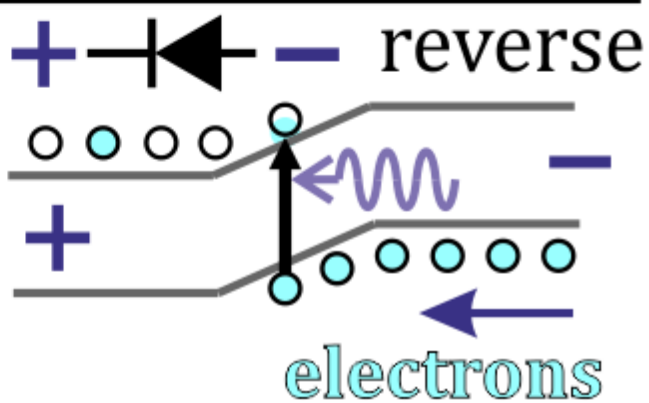
e.g. membrane GFP as light-driven proton pump:

tendency to absorb for reversed proton gradient





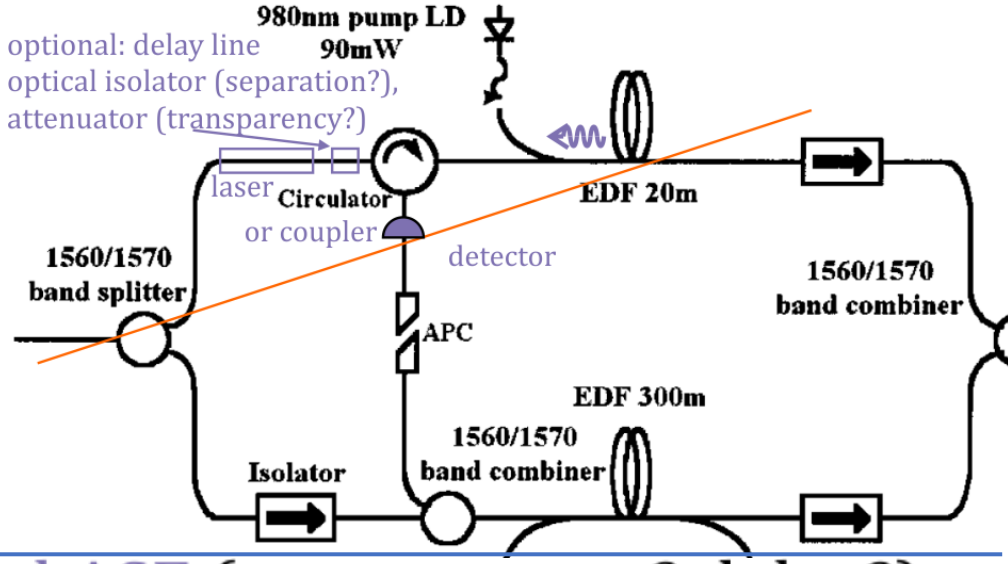
light diode gets **tendency to absorb** for **reverse bias**: electron gradient



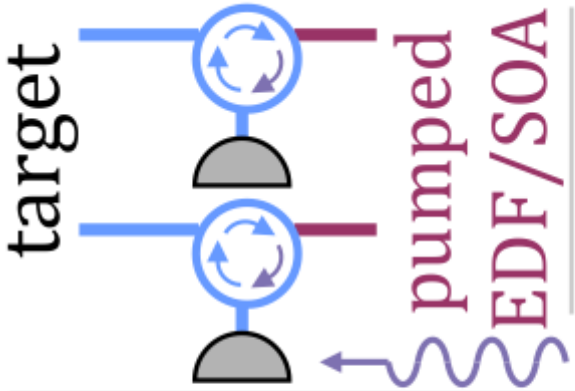
Detecting negative radiation pressure?

Backward camera? e.g. for emission CT, astronomy e.g. pulsar synchrotron radiation?

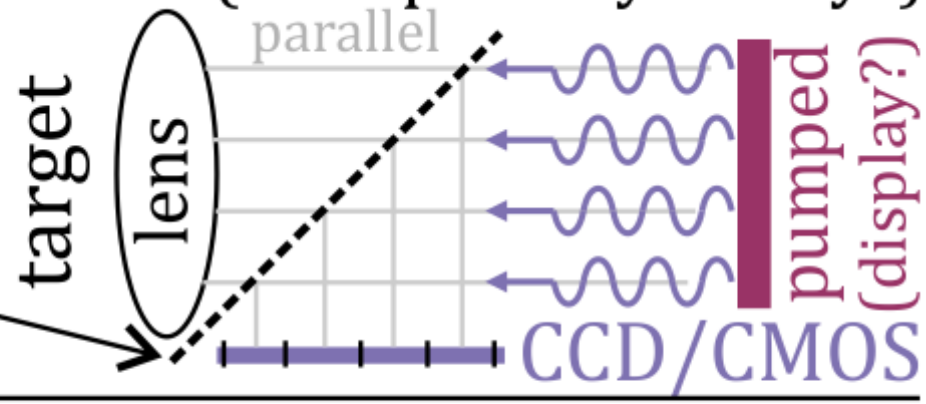
Backward lighted camera? amplify target deexcitation e.g. thermal, nuclear, attacks on e.g. BB84 "pulling more photons"



Backward camera: of target's backward ASE (transparency? delay?)



e.g. multimode optical fiber or semi-transparent mirror (coupler)



synchrotron?

(backward) **transmission scanning**: of (N_2)N_1 atoms/molecules:

(map of) target **emission spectrum** (CP)T target **absorption spectrum**

Backward lighted camera: causing backward ASE of target (BB84?)

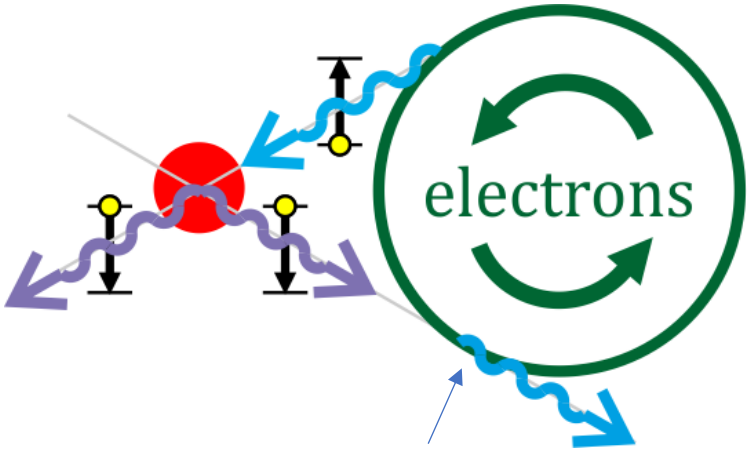
Amplifies target's directional emission

e.g. of BB84 transmission laser (+CNOT)

Is absorption/ stimulated emission in agreement with CPT symmetry?

If not: **can we show macro CPT violation?**

Many **micro** CPT tests

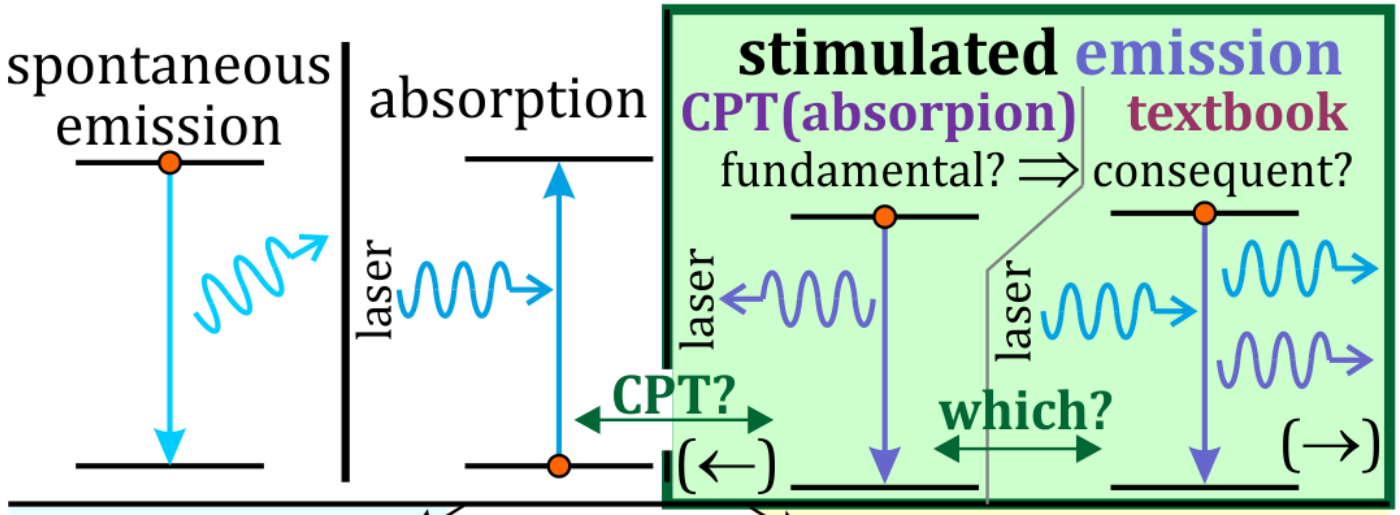


positive/negative radiation pressure:

tendency to emit photons →/←

(carried by photons?)

CT scanner modifications



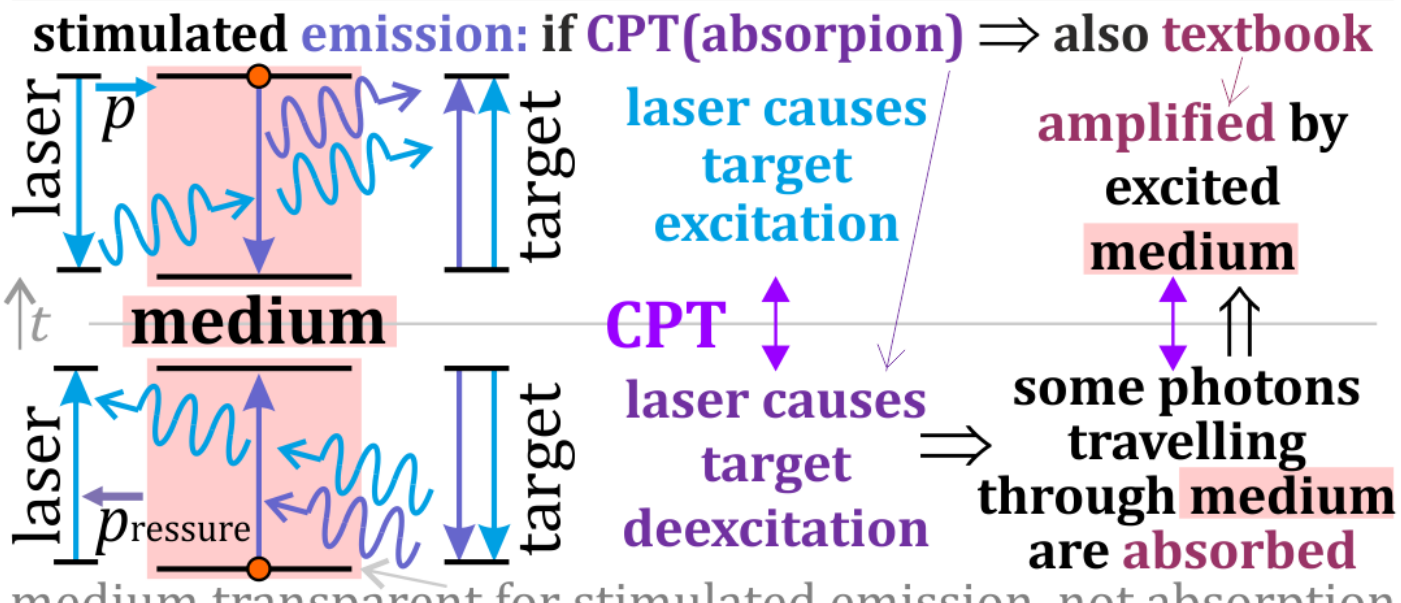
laser causes — **CPT transform** — CPT(**laser**) causes

target excitation — Einstein: $B_{12} = B_{21}$ — CPT(**target**) deexcitation

$$\frac{\partial N_2}{\partial t}^{\text{excited}} = -\frac{\partial N_1}{\partial t}^{\text{ground}} = B_{12}\,\rho(\nu)\,N_1 \quad \text{(absorption, usually } \sim N\text{)}$$

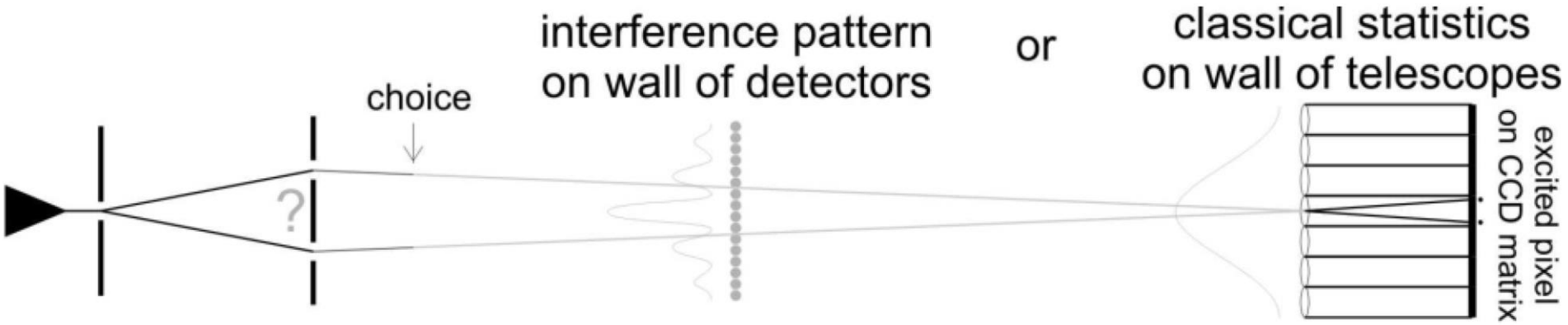
$$\frac{\partial N_2}{\partial t}^{\text{excited}} = -\frac{\partial N_1}{\partial t}^{\text{ground}} = -B_{21}\,\rho(\nu)\,N_2 \quad \text{(stimulated emission, usually } \sim 0\text{)}$$

transparent **if** $N_1 = 0$ $\neq!$ $N_2 = 0$ (no target)

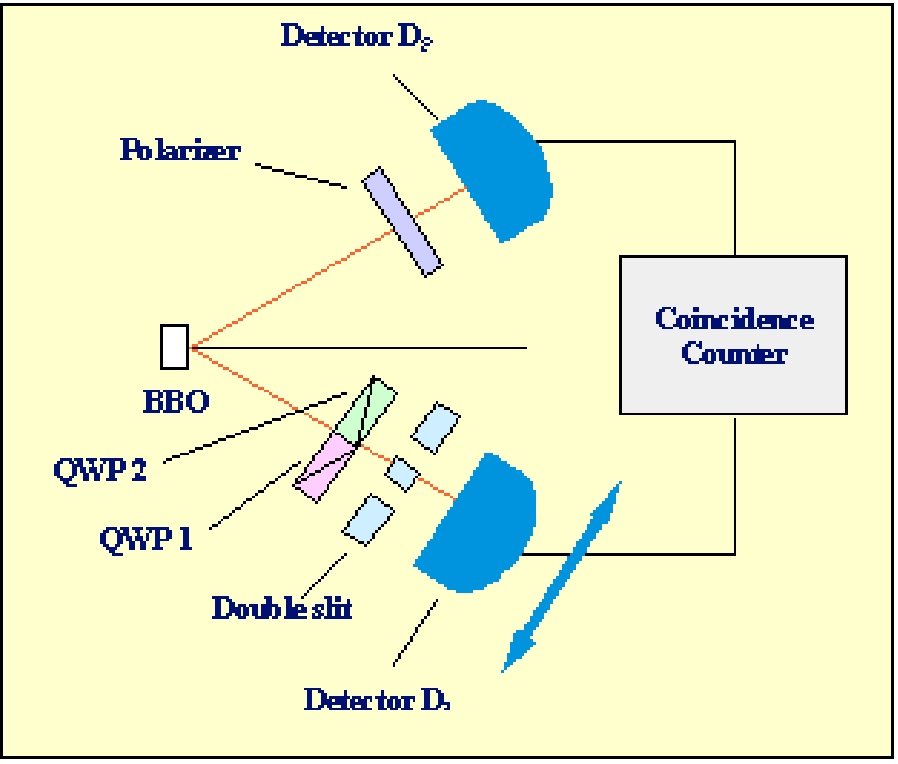


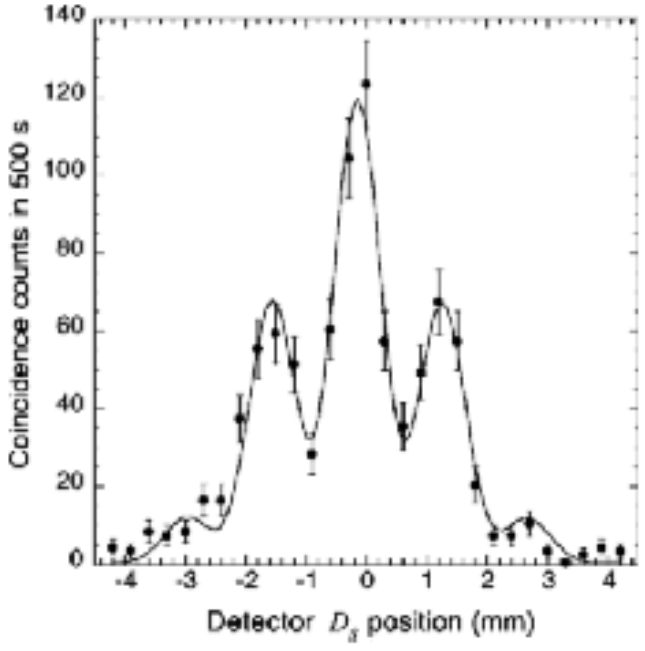
Time symmetry at heart of quantum ... classical mechanics

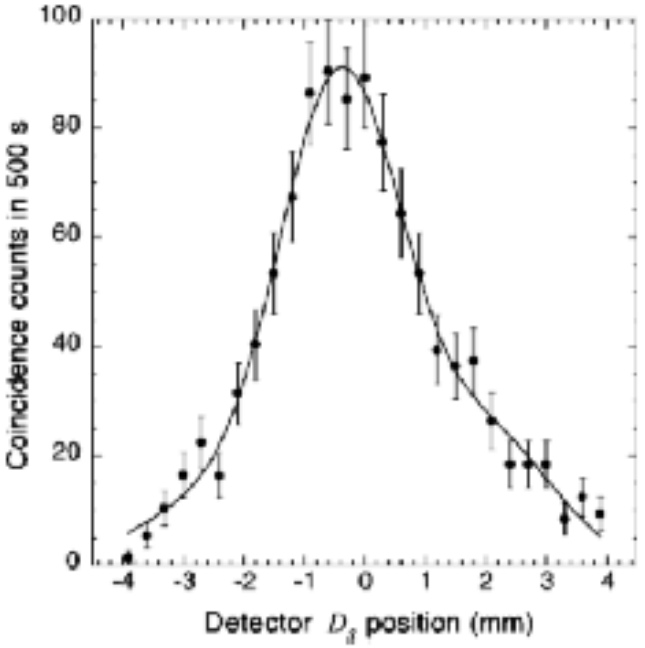
Wheeler experiment (Aspect's real.)– delayed choice classical/quantum



Double-slit quantum eraser (Walborn), explanation - **Rotating polarizer in one arm** we can erase which-path information, **changing second arm statistics**







Why **Born rule** in QM???
where its **square** comes from?

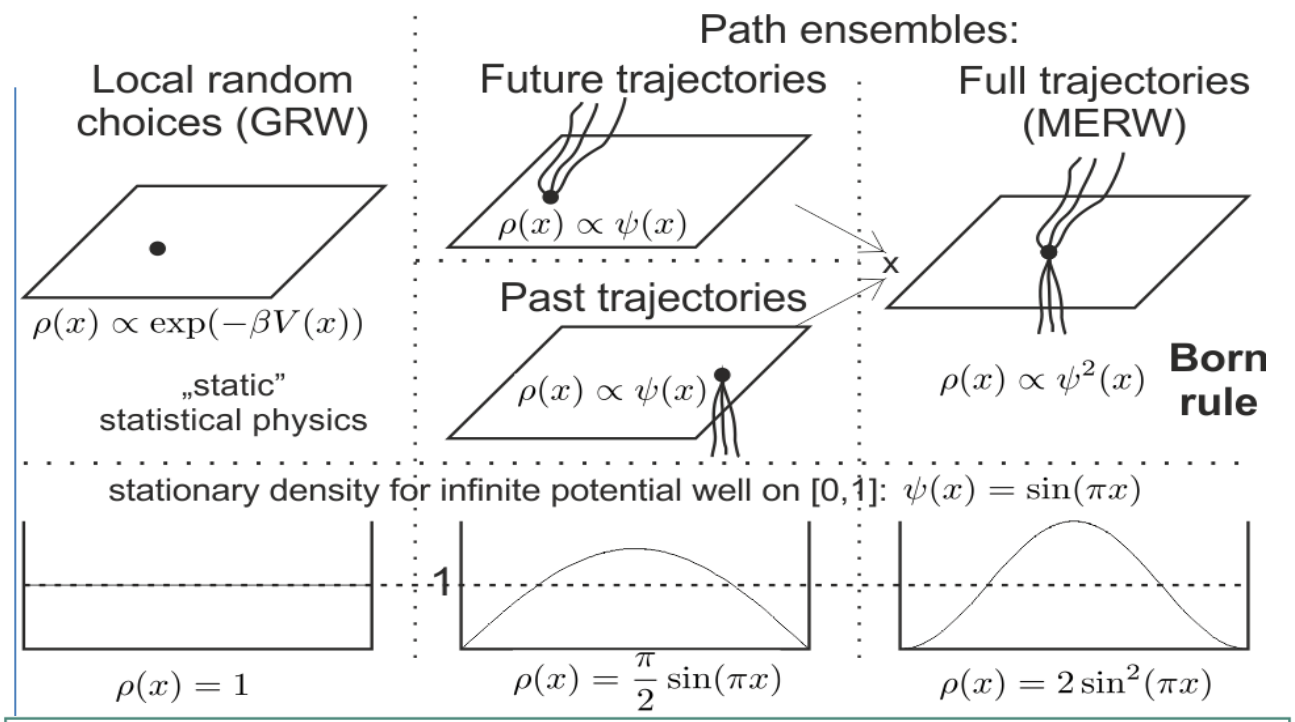
Scattering-matrix:

$$S_{\mathrm{fi}} = \lim_{t_2 \to +\infty} \lim_{t_1 \to -\infty} \langle \Phi_{\mathrm{f}} | \, U(t_2, t_1) \, | \Phi_{\mathrm{i}} \rangle$$

Two-state vector formalism:
propagators from
two time directions

Stationary distribution
in [0,1]? $\rho = 1$? $\rho \propto \sin^2$?
$\rho \propto \psi$ at the ends of Ising
(maximal entropy random walk)

Born allows violation of
Bell-like inequalities:
derived with Kolmogorov
3rd axiom instead



Mermin's inequality: „tossing 3 coins, at least 2 give the same"

$$\mathrm{P}(A=B) + \mathrm{P}(A=C) + \mathrm{P}(B=C) \geq 1$$

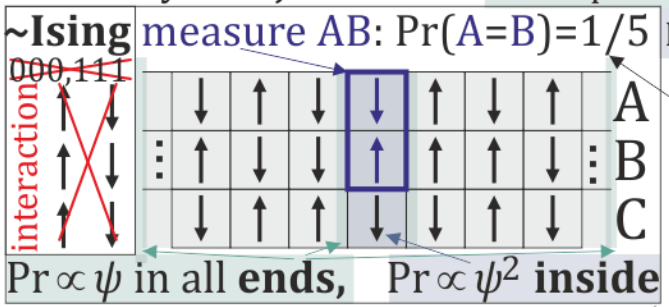
$A=0$	1		1		+	1	1			+	1			1	=	3	1	1	1
$A=1$		1		1				1	1		1			1		1	1	1	3
$B=$	0	1	0	1															
$C=$	0	0	1	1															

above: proof using **probabilities**

Kolmogorov 3rd axiom: $p_{AB?} = p_{AB0} + p_{AB1}$

Probability of disjoint events: sum of probabilitities vs ∝squared sum of amplitudes

Born rule: $p_{AB?} \propto (\psi_{AB0} + \psi_{AB1})^2$



MERW/Ising for **amplitudes:**

uniform path ensemble

$$\psi = \begin{array}{|c|c|c|c|}\hline \mathbf{0} & 1 & 1 & 1 \\ \hline 1 & 1 & 1 & \mathbf{0} \\ \hline \end{array}$$

$\psi_{000} = \psi_{111} = 0$

violation with Born rule: $\mathrm{P}(A=B) = \dfrac{(\psi_{000}+\psi_{001})^2 + (\psi_{110}+\psi_{111})^2}{\sum_{A,B\in\{0,1\}}(\psi_{AB0}+\psi_{AB1})^2} = \dfrac{2}{10}$

$\mathrm{P}(A=B) + \mathrm{P}(A=C) + \mathrm{P}(B=C) = 0.6$

Inequality derived with 3rd axiom, might be violated with Born rule

both: impulse lasers

Observed negative delays

Science 2003, Neg. PRL 26

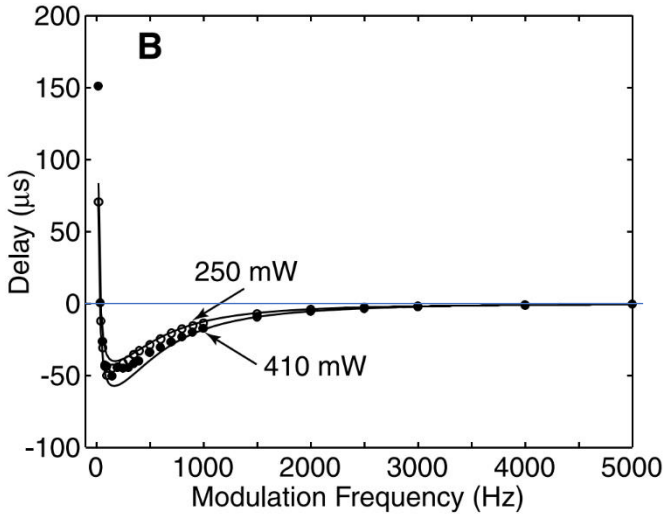
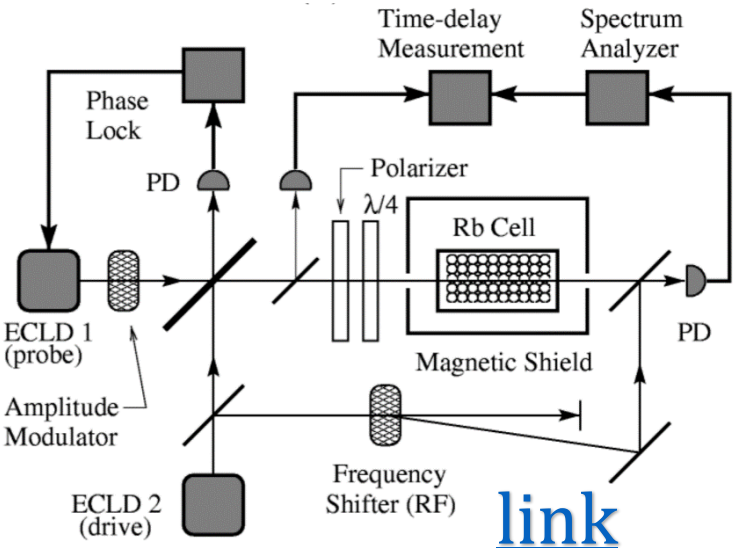


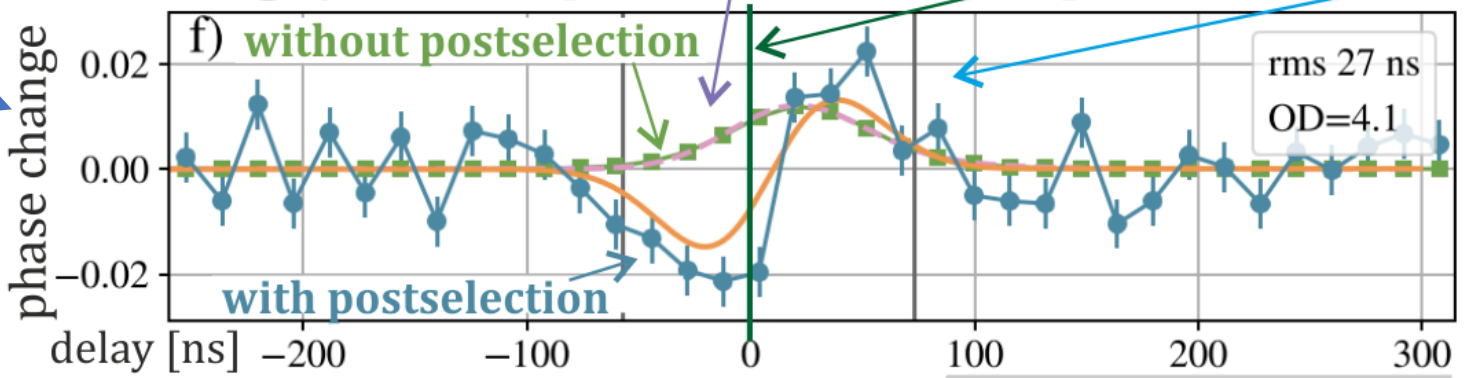
Fig. 2. (**A**) Relative modulation attenuation and (**B**) time delay measured for a 4-cm-long alexandrite crystal at a wavelength of 476 nm with pump powers of 250 and 410 mW. The observed negative time delay corresponds to superluminal propagation. The solid lines indicate the results of our theoretical model.

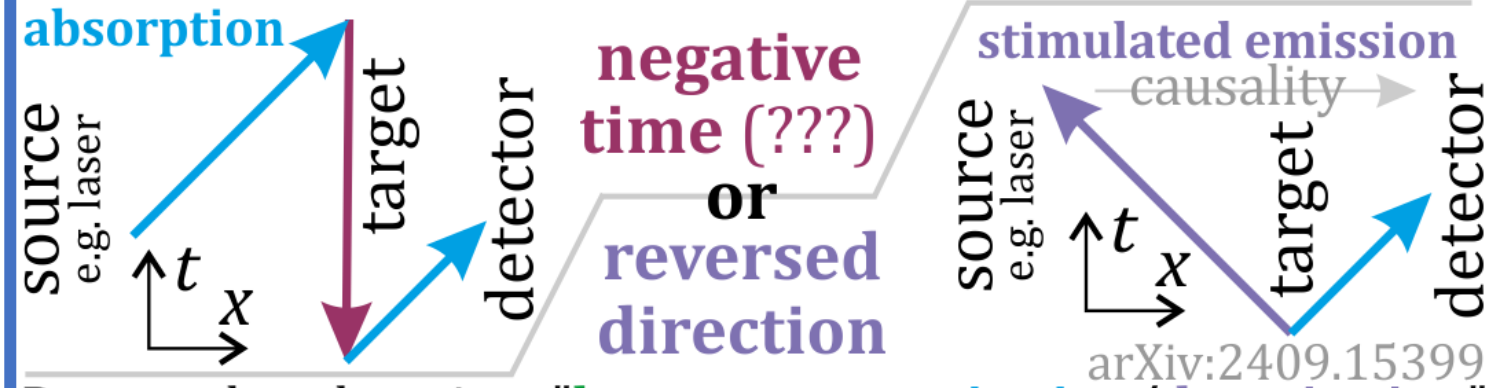


link

'Negative time evidence' Steinberg et al., arXiv:2409.03680

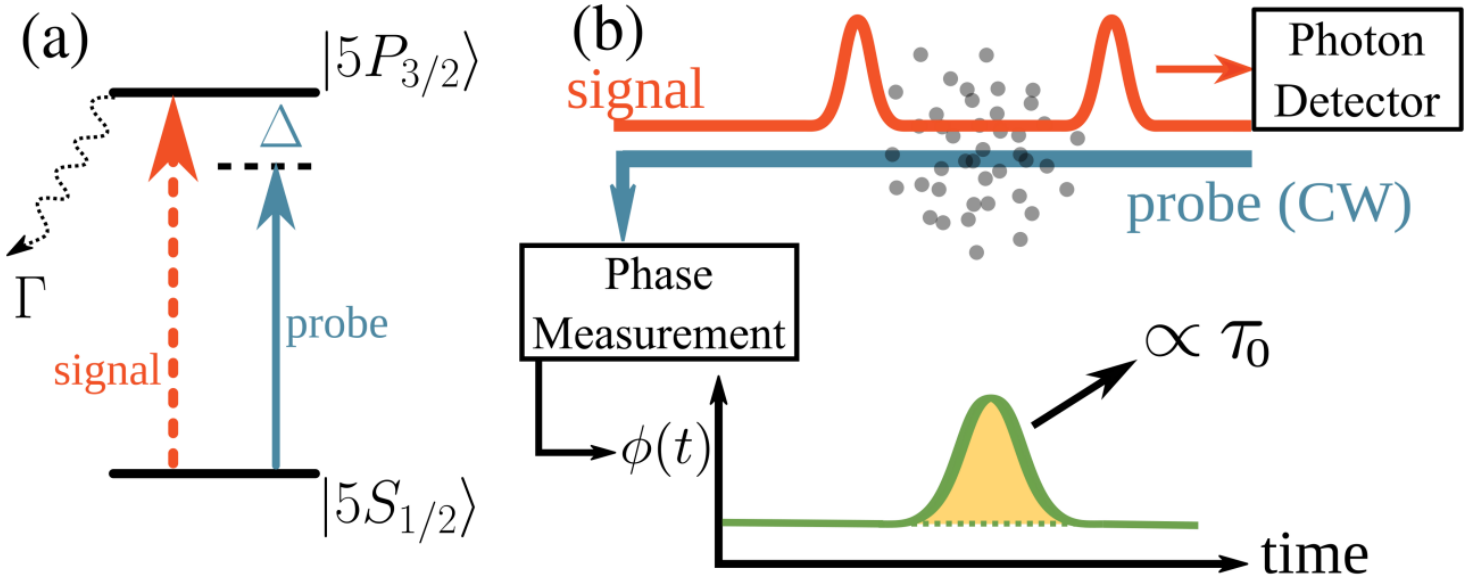
observing system response before the impulse and after





arXiv:2409.15399

Proposed explanation: "laser causes excitation/deexcitation" are CPT symmetry analogs: should have opposite delay sign

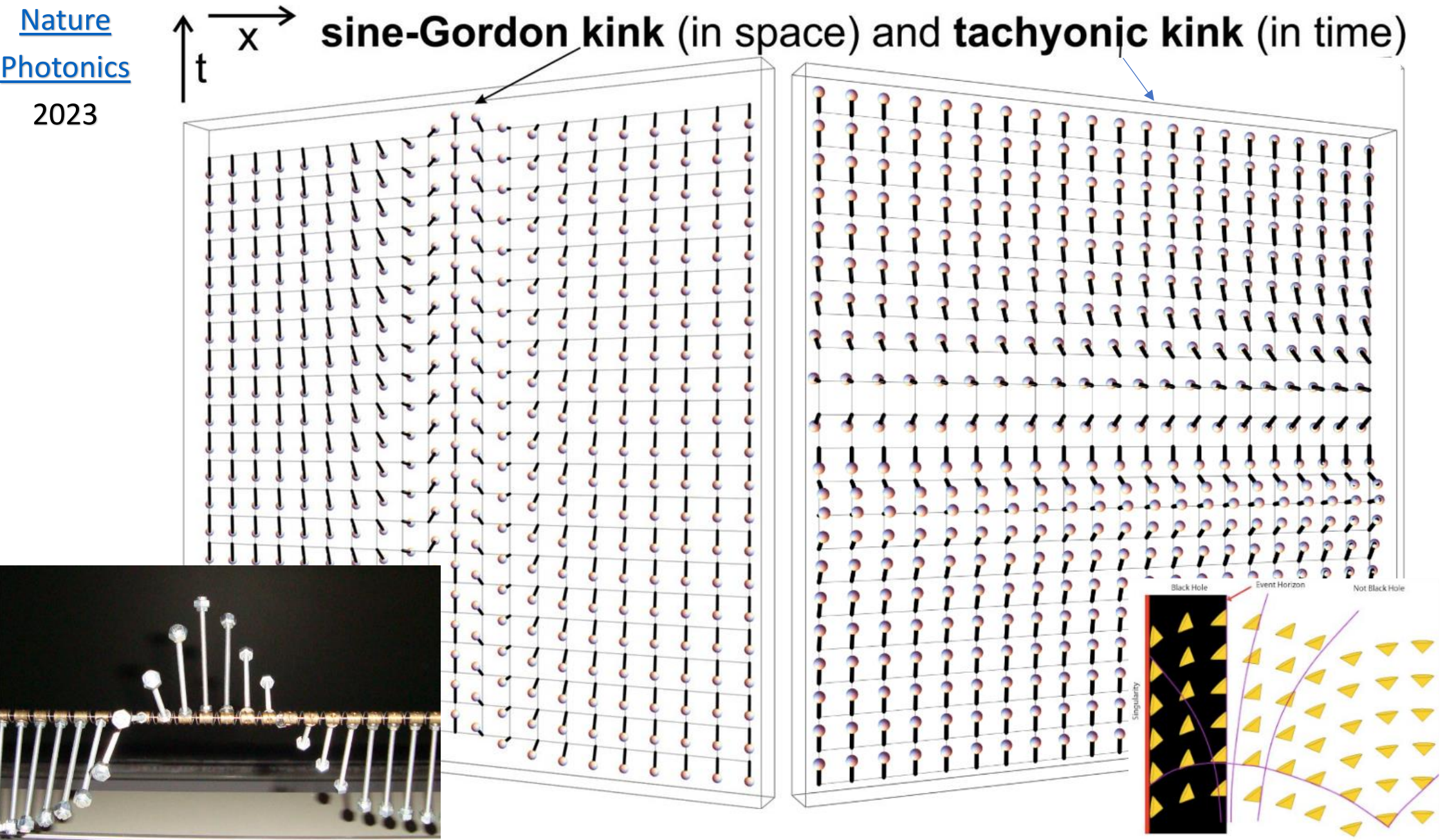


$\phi_{tt} - \phi_{xx} = \sin(\phi)$ kink solution in potential minimum $\xrightarrow[\text{BH?}]{x \leftrightarrow t}$ $\phi_{xx} - \phi_{tt} = -\sin(\phi)$ in maximum

Like **superradiance**: prepared excited medium, trigger: rapid burst quasiparticle … FTL?

FEL: "collective motion combined to create an electron Mexican wave that can **move faster than light**"

Nature Photonics 2023



(EPR) Rosen 1977: "Does gravitational radiation exist?"

retarded(-)/advanced(+) solutions, their **convex combinations**

Maxwell EM: $\Box A_\mu = 4\pi J_\mu \quad \Rightarrow \quad A^{\pm}_{\mu} = \int \frac{J_\mu(\boldsymbol{r}', t \pm |\boldsymbol{r}-\boldsymbol{r}'|)}{|\boldsymbol{r}-\boldsymbol{r}'|} d^3\boldsymbol{r}'$

GW: $\Box \tilde{h}_{\mu\nu} = -16\pi G T_{\mu\nu} \Rightarrow \tilde{h}^{\pm}_{\mu\nu} = 4G \int \frac{T_{\mu\nu}(\boldsymbol{r}', t \pm |\boldsymbol{r}-\boldsymbol{r}'|)}{|\boldsymbol{r}-\boldsymbol{r}'|} d^3\boldsymbol{r}'$

should depend on **boundary conditions**, like **emitters/absorbers**

Wheeler-Feynman assumed symmetric $\frac{1}{2}A^{-}_{\mu} + \frac{1}{2}A^{+}_{\mu}$, but instead

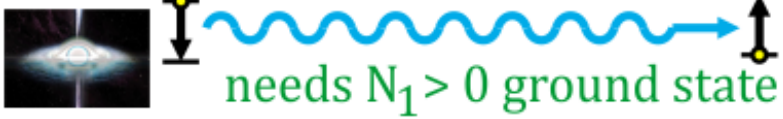
energy loss, inspiraling of orbiting show **Asymmetry of Radiation**

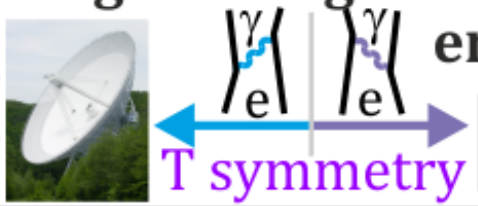
Current assumption: $1A^{-}_{\mu} + 0A^{+}_{\mu}$ only retarded - verification???

why not e.g. **$0.99A^{-}_{\mu} + 0.01A^{+}_{\mu}$?** GW can test (arXiv:2512.20692)

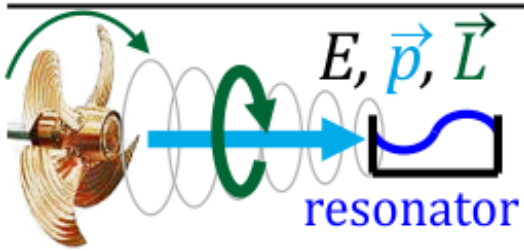
LIGO interferometer measures **length changes** - invariant to T/CPT symmetry, but **EM**:

absorption of **retarded** wave

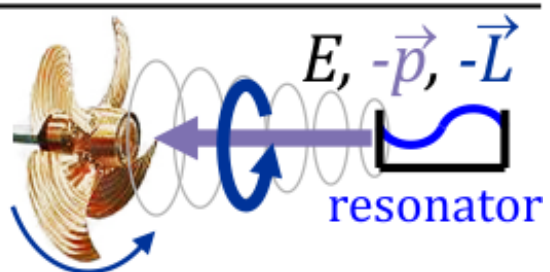




emission of **advanced** EM wave



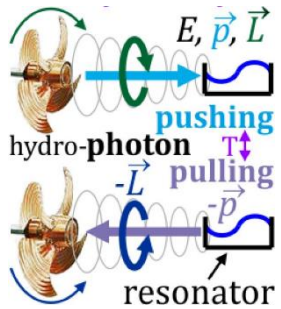
hydrodynamical analog: photon-like wave **pushing**/**pulling** energy from **resonator**, switched by T-symmetry: reversing rotation



LIGO interferometer measures **length changes** - invariant to T/CPT symmetry
should see **retarded** and **advanced waves** - **are there events for advanced?**

Euler-Lagrange / least action principle / Euler-Lagrange

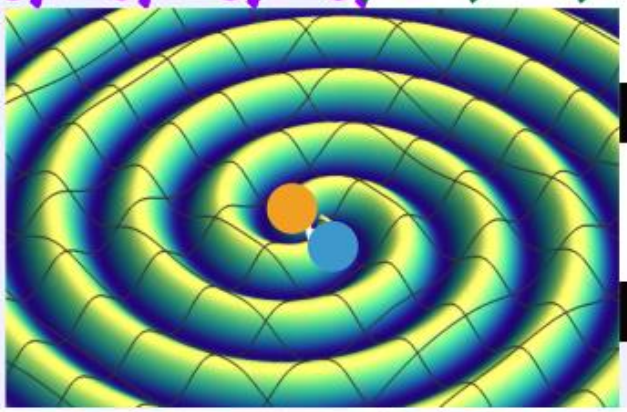
$t \to -t$ ← → **our time** →



advanced wave
α× weaker? (spiraling)
for us: gaining energy

retarded wave only?
for us: losing energy

waves mainly from orbiting - practically the same evolving in both time directions Wheeler-Feynman



black hole merger →

← **white hole splitter**

EM: $\Box A_\mu = 4\pi J_\mu \quad \Rightarrow \quad A_\mu^{\pm} = \int \frac{J_\mu(\mathbf{r}', t \pm |\mathbf{r}-\mathbf{r}'|)}{|\mathbf{r}-\mathbf{r}'|} d^3\mathbf{r}'$

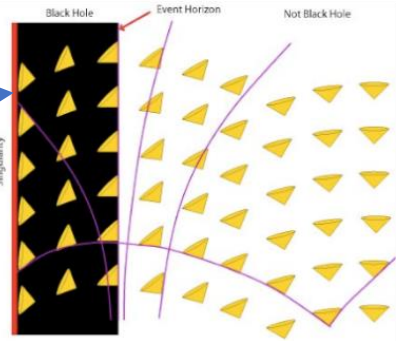
GW: $\Box \tilde{h}_{\mu\nu} = -16\pi G T_{\mu\nu} \Rightarrow \tilde{h}_{\mu\nu}^{\pm} = 4G \int \frac{T_{\mu\nu}(\mathbf{r}', t \pm |\mathbf{r}-\mathbf{r}'|)}{|\mathbf{r}-\mathbf{r}'|} d^3\mathbf{r}'$

retarded (-) / advanced (+) and **convex combinations**

If **certain missing EM counterpart**, only **1** per ~**400** seen so far, consider **advanced wave**
Or "**too early events**" like 50-120 black hole Mass Gap for GW190521: **66** + **85** → **142** $M_\odot$?
Pulsar Timing Array see vibrations of the Universe: **require more** supermassive black holes
Observed **luminosity distance ~27 Gly** twice the **age of the Universe** - maybe advanced?

arXiv: 2512.20692

https://en.wikipedia.org/wiki/**Non-orientable_wormhole**



General relativity in theory allows black hole horizon $t \leftrightarrow x$

Klein-bottle-like wormhole apply **T** symmetry to rocket

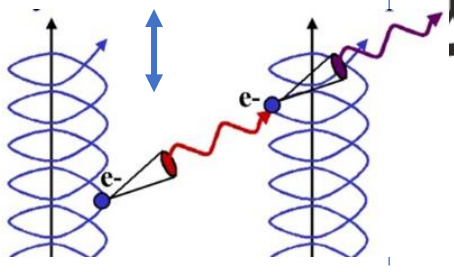
For external observer:

thought experiment

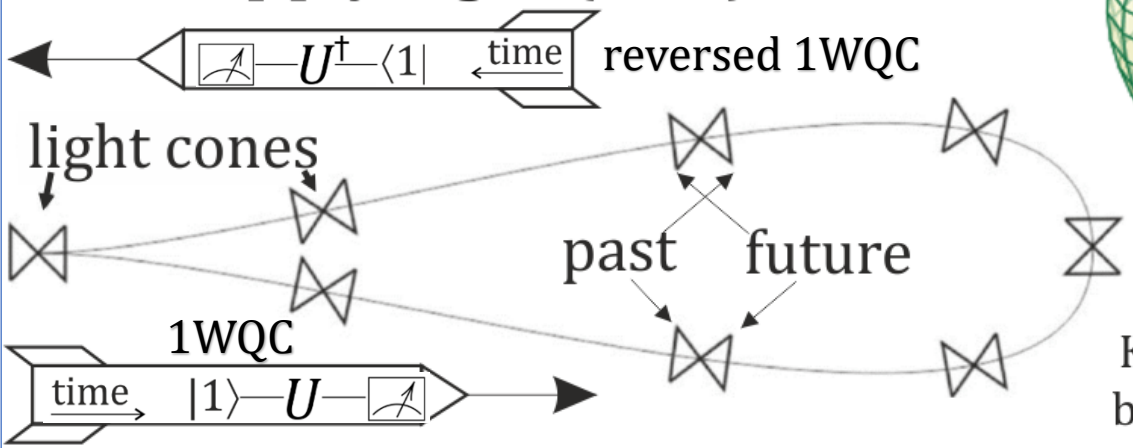
- **entropy decreases**, e.g. egg unscrambles,
- Reversed 1WQC,
- state $|0\rangle \leftrightarrow \langle 0|$,
- **pre-measurement**,
- **CT emission scan**,
- **retarded ↔advanced**
- **laser** causes deexcitation/**negative radiation pressure**,

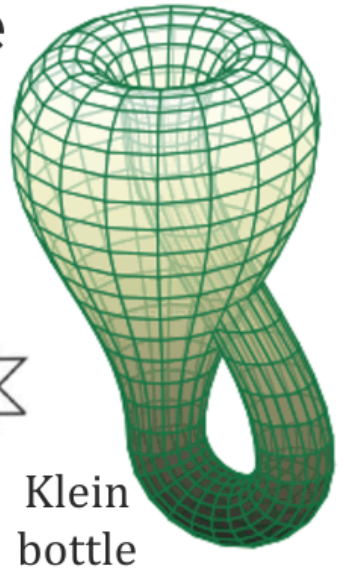
absorption↔emission stimulated?

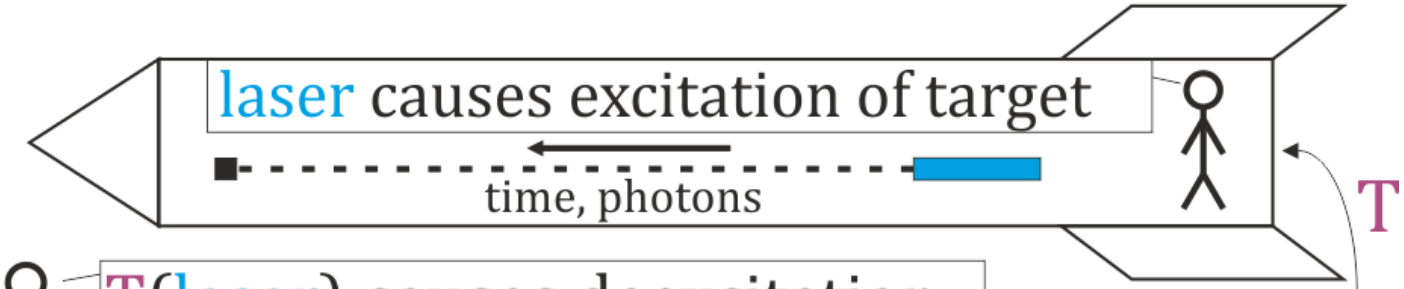
CPT
black ⟷ white hole

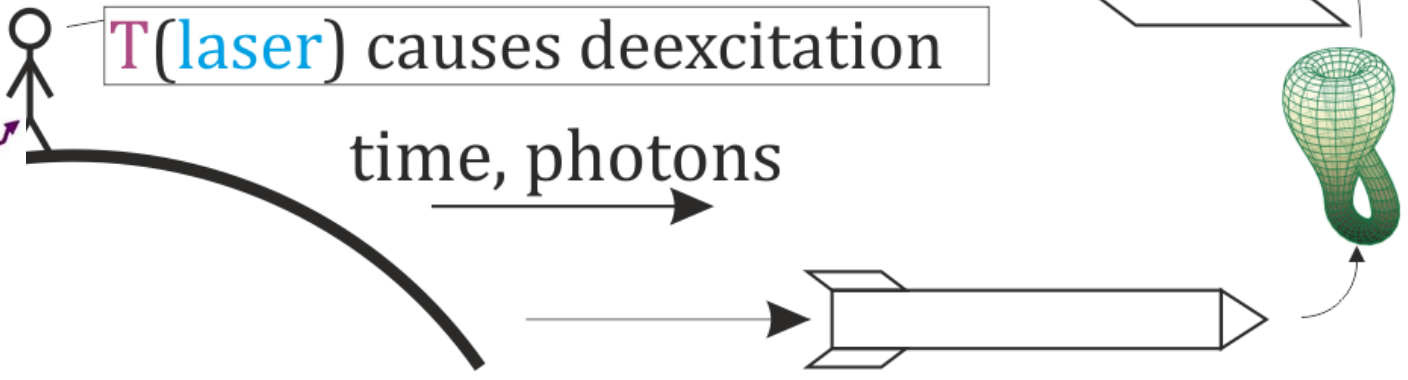


non-orientable wormhole
applying T (or P) transform







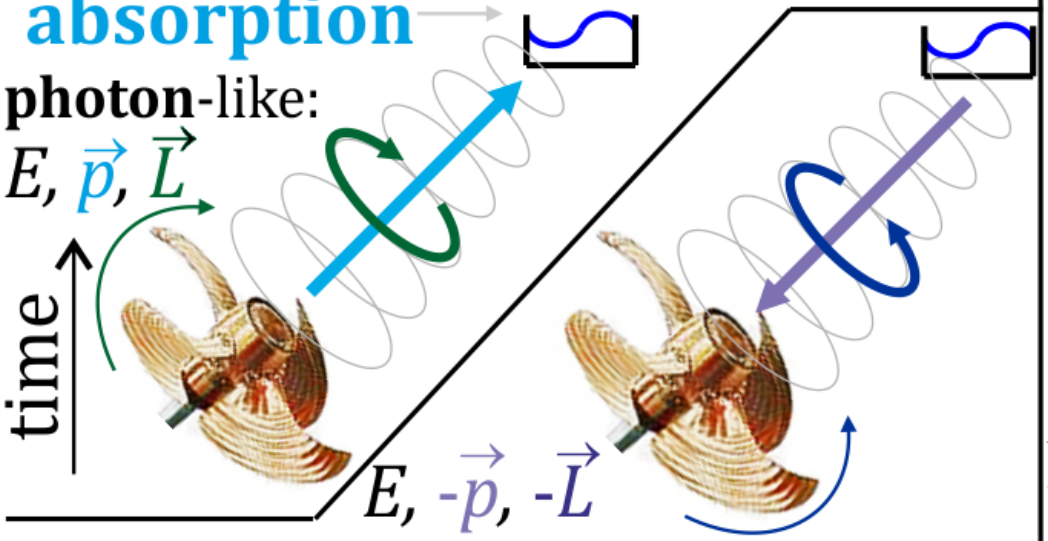


In theory 4 ways for hydrodynamics: what about EM?

Retarded wave: positive delay

positive radiation pressure

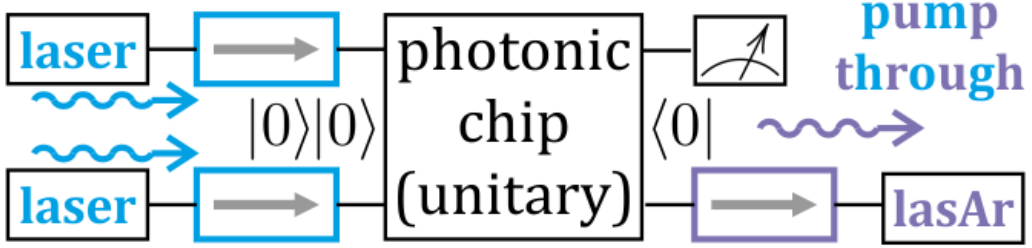
absorption



negative radiation pressure: stimulated emission - 2WQC

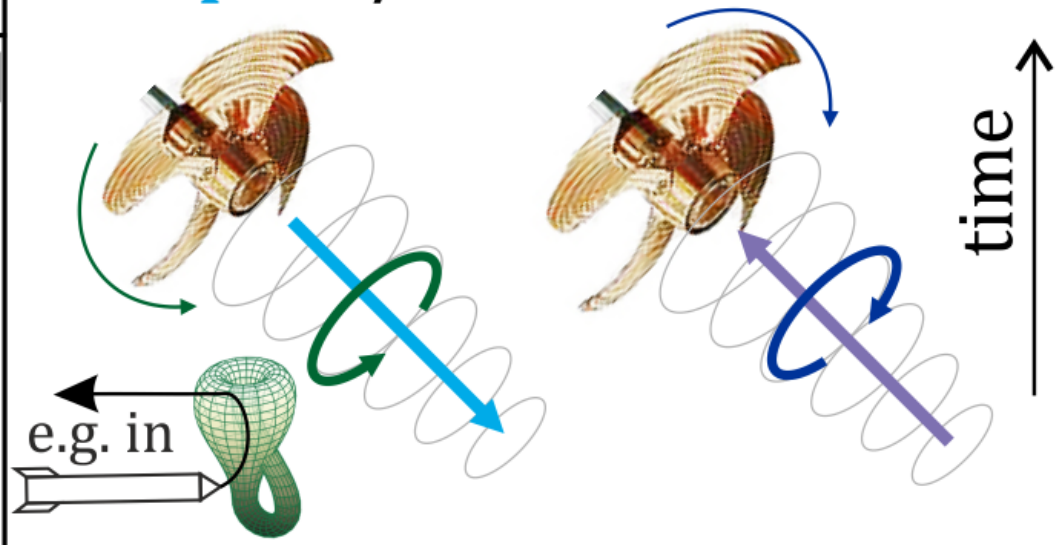
solve postBQP ∋ NP, needs quantum

two-way control: **preparation** + **postparation**

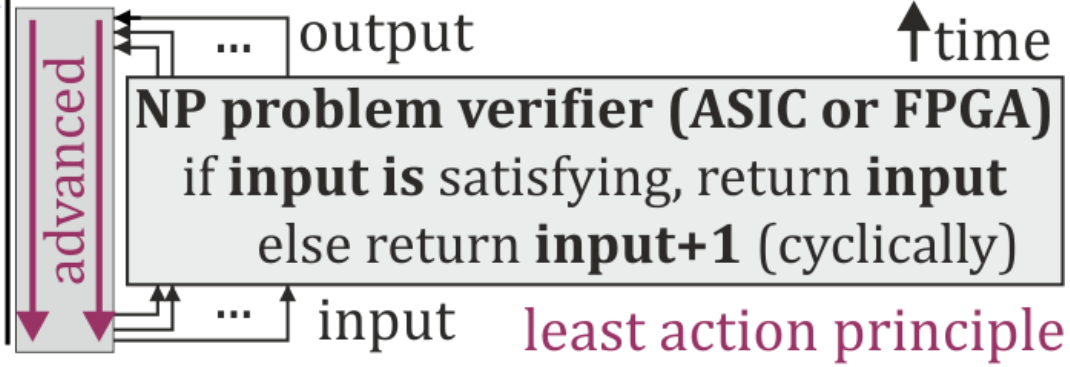


Advanced: negative delay

absorption/stimulated emission



Time-loop computers: **solving NP by augumenting classical computer, e.g. finding fixed point of a loop:**



Solve NP: negative rad. press. - quantum, advanced - classical

Let's speedup quantum supremacy! (e.g. solve NP, better error correction)

CPT symmetry: having $|0\rangle$, there is also $\langle 0|$

Jarek Duda, www.qaif.org/2wqc

2WQC: two-way quantum computers

adding $\langle 0|$ postparation:
CPT(state preparation)
Acts as **postselection**, but with **higher success rate**

In CPT symmetry perspective use state preparation process

e.g. **low temperature**: $|0\rangle \leftrightarrow \langle 0|$

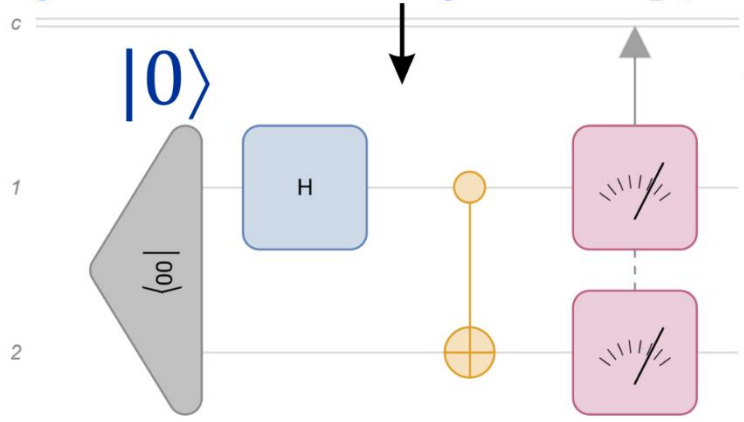
$$\langle\psi_f|U|\psi_i\rangle \overset{\text{CPT}}{\longleftrightarrow} \langle\psi_i|U^\dagger|\psi_f\rangle$$

Evolve forward $\leftrightarrow$ backward

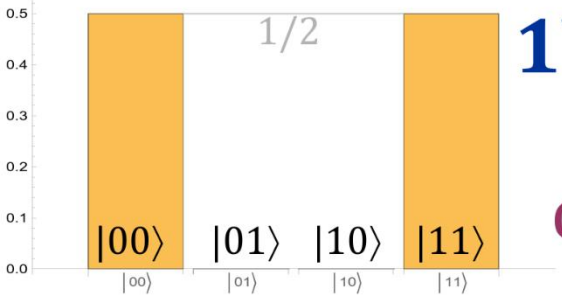
~~1~~2WQC


```
QuantumCircuitOperator[{"00", "H" → 1, "CNOT", {1, 2}}]
```

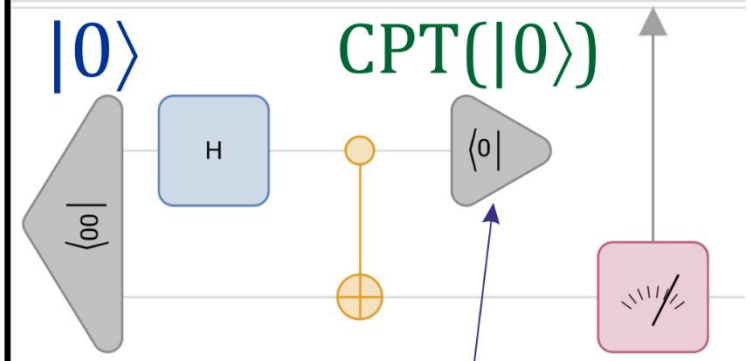
Wolfram Quantum Framework

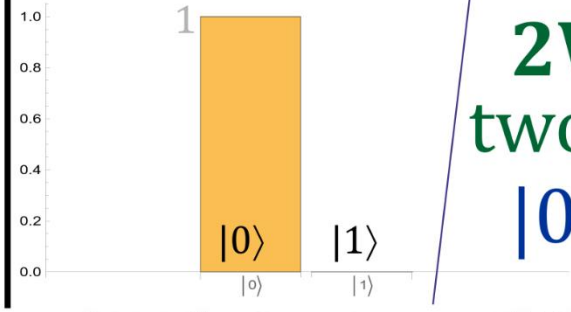



```
qc[]["ProbabilityPlot"]
```



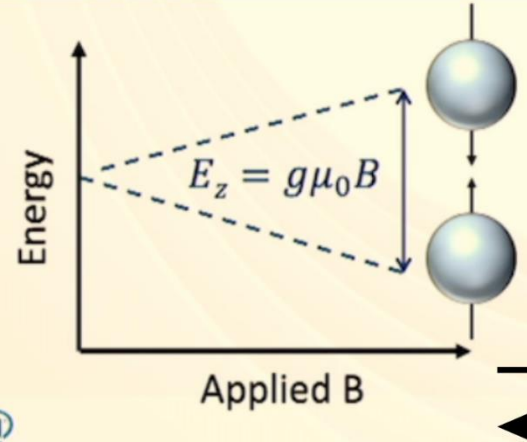
1WQC
$|0\rangle$
only



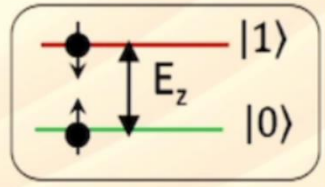


2WQC
two-way
$|0\rangle, \langle 0|$

```
QuantumCircuitOperator[{"00", "H" → 1, "CNOT", SuperDagger["0"], {2}}]
```



e.g. silicon quantum dots (Intel)



Apply Magnetic Field

strong B just before: preparation $|\uparrow\rangle$
strong B just after: postparation $\langle\uparrow|$
switched in CPT perspective

Pre: https://en.wikipedia.org/wiki/**Maximal entropy random walk**, *arXiv:0910.2724*

2023: *arXiv:2308.13522* "Two-way quantum computers adding CPT analog of state preparation"

2024: **2WQC XPRIZE team**, **~40 QInterns** ... **NP solver, better error correction**

G. Czelusta, **Grover's algorithm** on two-way quantum computer, *arXiv:2406.09450*

M. Noor, J. Duda, **No-cloning theorem** for 2WQC and postselection, *arXiv:2407.15623*

J. Duda, **3-SAT solver** for two-way quantum computers, *arXiv:2408.05812*

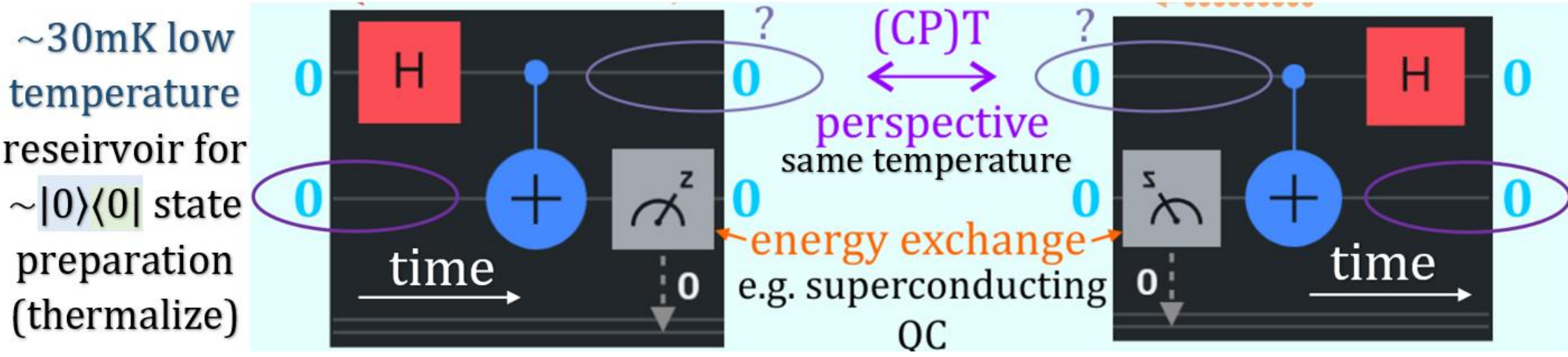
A. Linden, B. Gül, Optimization of **postselection** ... 2WQC approach, *arXiv:2409.03785*

Current talk: J. Duda, Testing stimulated emission photon direction, *arXiv:2409.15399*

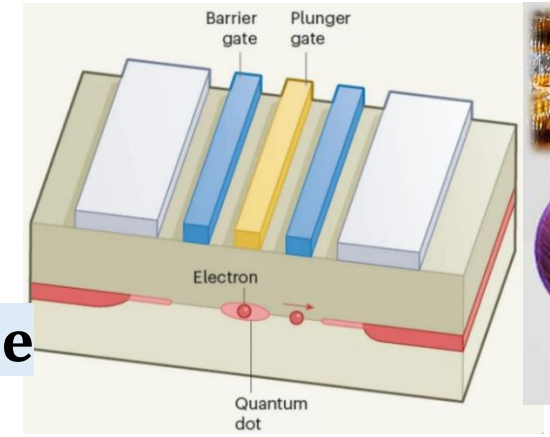
Many arguments, no counter? **search for help with experimental confirmation**

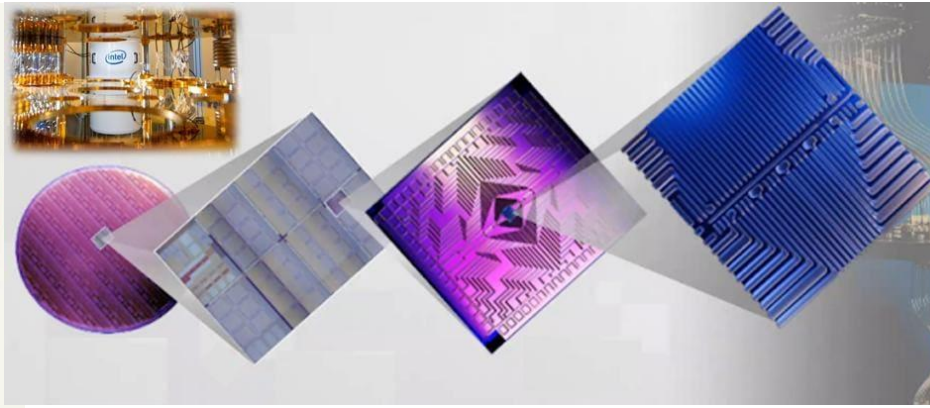
e.g. $|0\rangle$ by thermalization: nature.com/articles/s41598-025-87323-x

"the system is dissipative and decohering in both temporal directions"

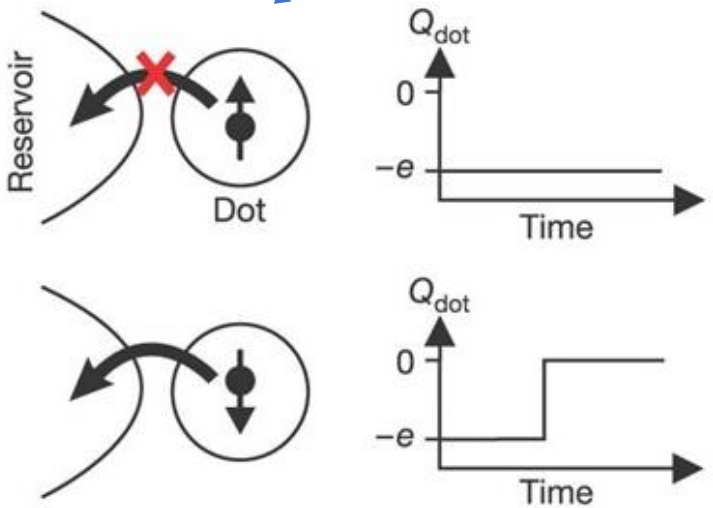


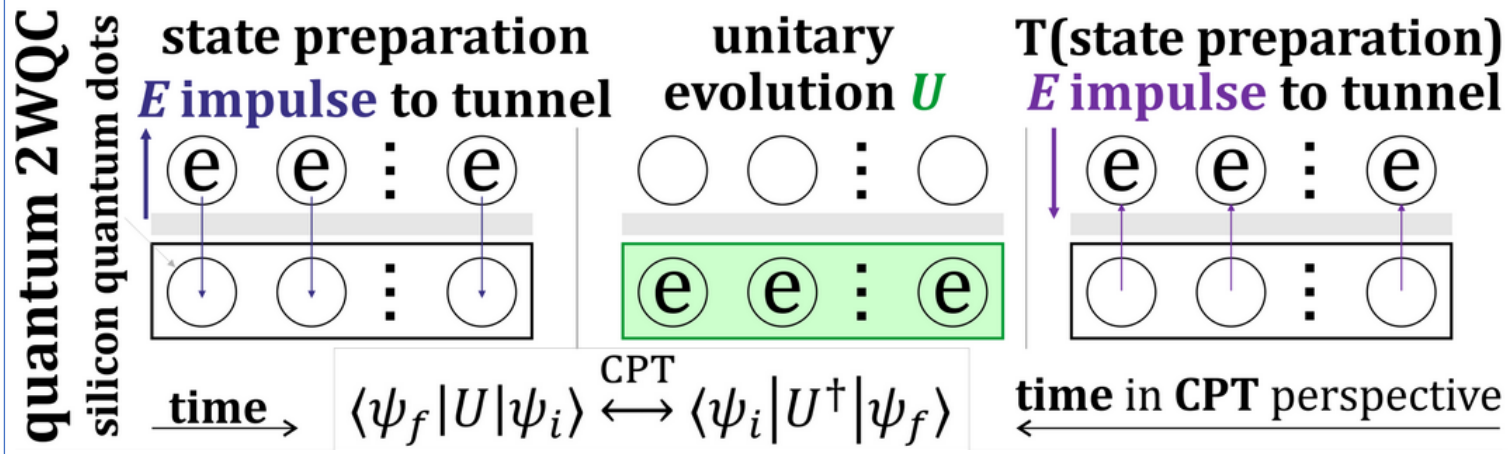
Silicon quantum dots
e.g. Intel 12 qubit





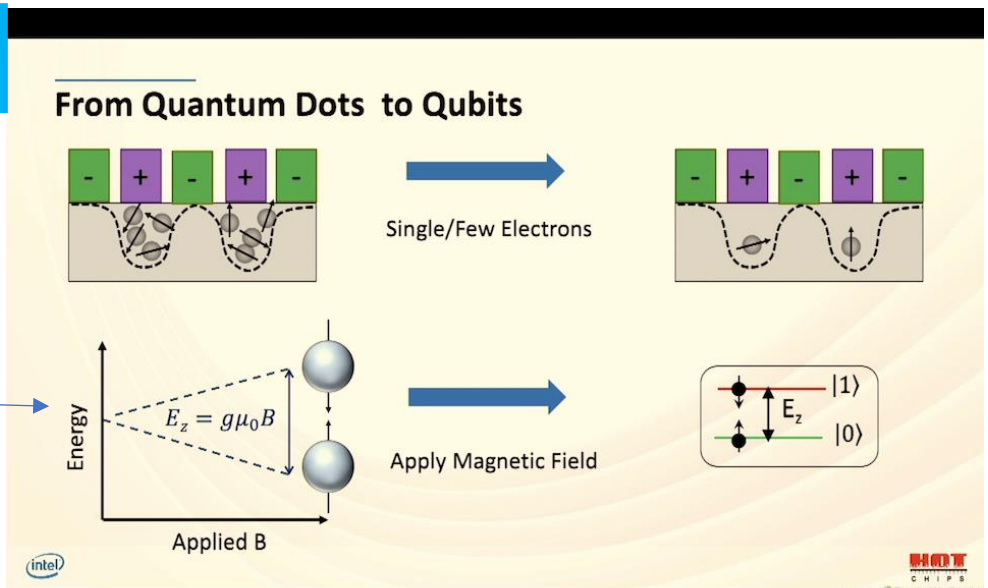
All operations with EM fields – easy to reverse spin or position qubits





reverse applied impulse: $V(t) \leftrightarrow V(-t)$

Elzerman readout: only ↓ spin can tunnel **in Intel 2024 article for state preparation**



Or use magnetic field to enforce spin direction **before for $|0\rangle$, opposite after for $\langle 0|$**

better stability thanks to 2WQC two-way flow control

arXiv:2406.09450 **Grover's algorithm** on two-way quantum computer

(G. Czelusta) in $O(1)$ time instead of $O(\sqrt{n})$, **more error resistant**

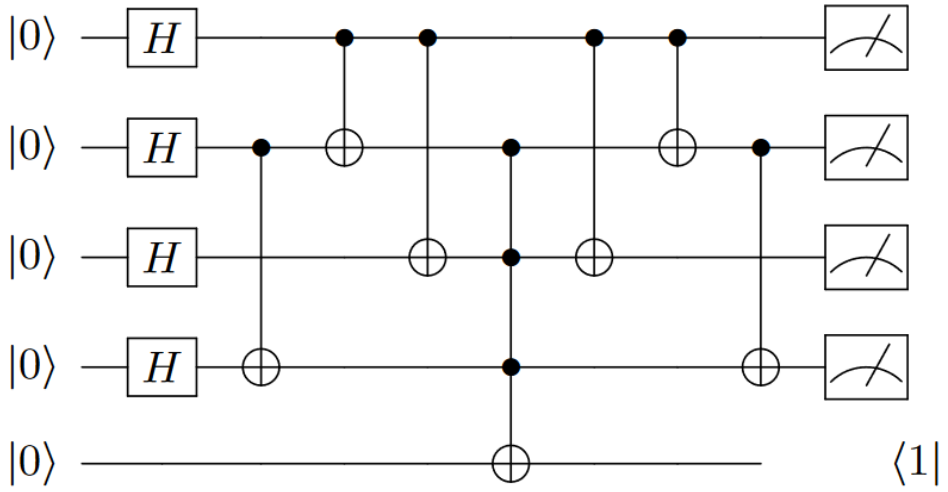
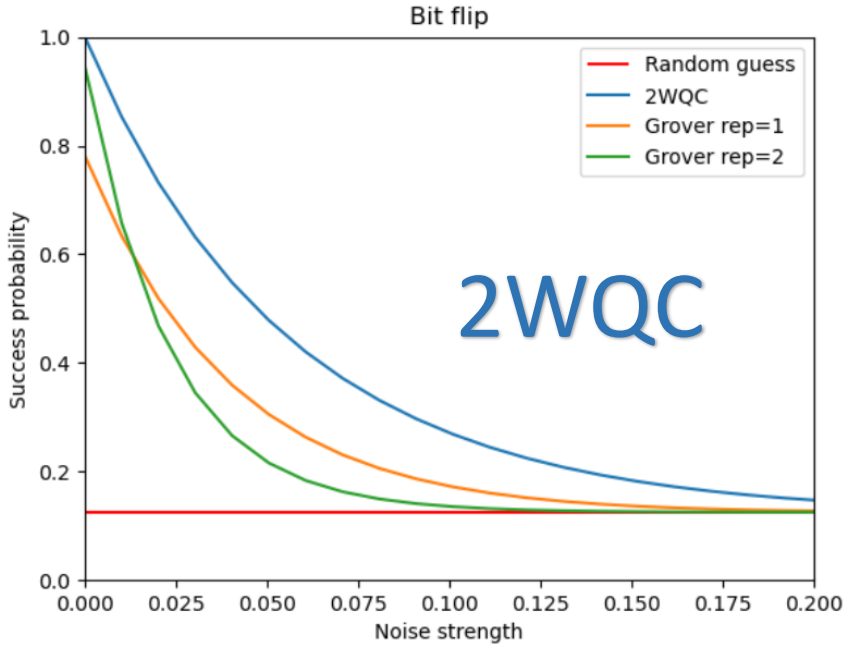
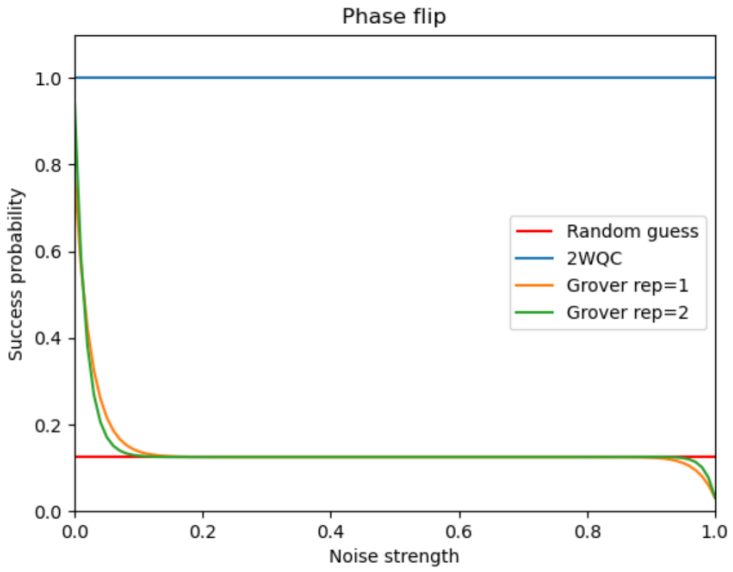
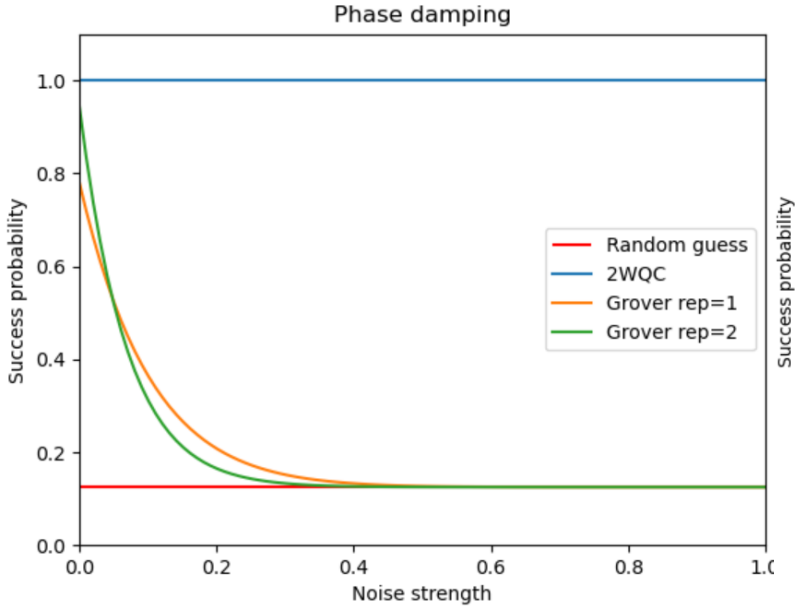
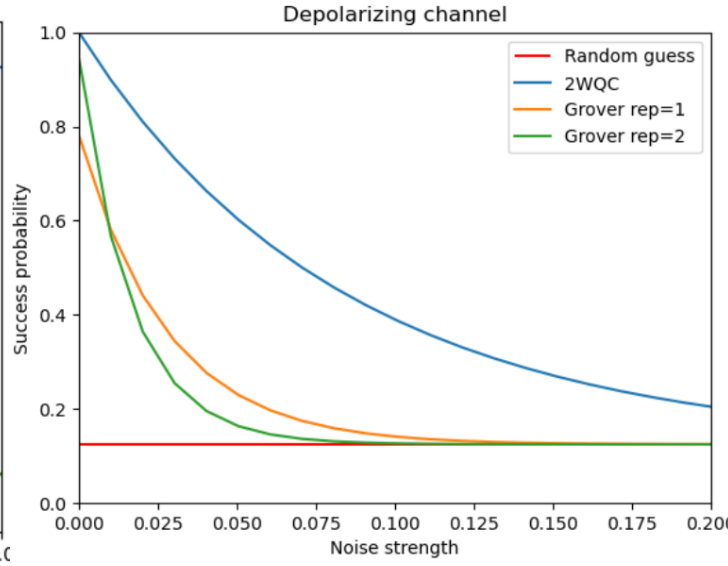


FIG. 6: Quantum circuit for 2WQC Grover solving Sudoku









NP problem: find input satisfying polynomial time verifier

+⟨0| postparation 2WQC in theory allows NP solvers, e.g. **cipher breaking (resistant PQC???) global optimizers** like **drug design** ... Also 2WQC allows **better stability, error correction**

for example 3-SAT problem, like finding $x_1, x_2, \ldots, x_n \in \{0,1\}$:

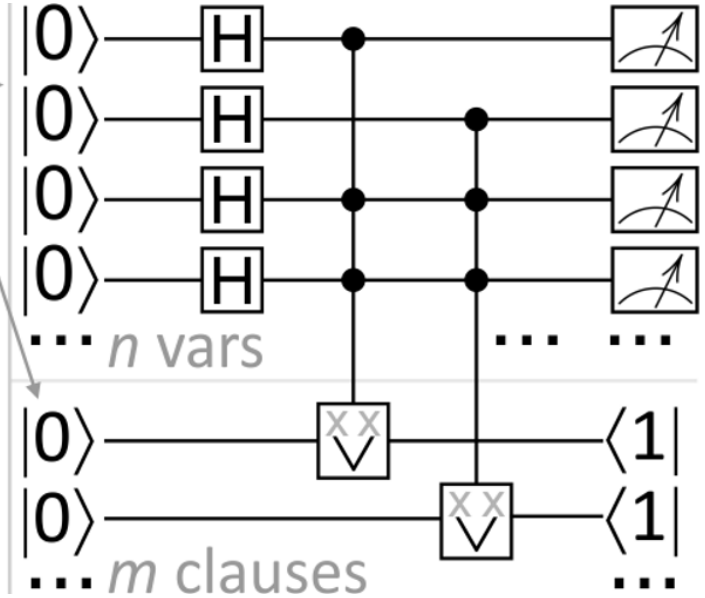
$$\exists_{x_1 x_2 \ldots} (x_1 \vee \neg x_2 \vee x_3) \wedge (\neg x_4 \vee x_2 \vee \neg x_3) \wedge (x_5 \vee \neg x_4 \vee x_2) \wedge \ldots ?$$

basic 3-SAT setting:

***n* variables** used up to 4 times,

***m* clauses** using 3 variables

- prepare ensemble of 2^n inputs
- calculate C-ORs with NOTs:
- enforce all C-ORs to 1 with ⟨1|
- measure inptut qubits



Shor quantum routine, measurement restricts to $\{b: y^b \bmod N = m\}$:

$$|\mathbf{00}\rangle \xrightarrow{H_{\mathrm{I}}^{\otimes n}} \sum_{a=0}^{2^n-1} |a\rangle|\mathbf{0}\rangle \xrightarrow{\text{classic}} \sum_a |a\rangle|y^a \bmod N\rangle \xrightarrow{\text{meas}_{\mathrm{II}}} \sum_b |b\rangle|m\rangle \xrightarrow{\text{QFT}_{\mathrm{I}},\text{meas}_{\mathrm{I}}} |c\rangle|m\rangle$$

3-SAT attack (NP), $\langle \mathbf{1}|_{\mathrm{II}}$ restricts ensemble to $\{b: \mathrm{SAT}(b) = \text{true}\}$

$$|\mathbf{00}\rangle \xrightarrow{H_{\mathrm{I}}^{\otimes n}} \sum_{a=0}^{2^n-1} |a\rangle|\mathbf{0}\rangle \xrightarrow{\text{SAT?}} \sum_a |a\rangle|\mathrm{SAT}(a)\rangle \xrightarrow{\langle \mathbf{1}|_{\mathrm{II}}} \sum_b |b\rangle|\mathbf{1}\rangle \xrightarrow{\text{meas}_{\mathrm{I}}} b$$

for imperfect $\langle \mathbf{1}|$ would leave exponential number of false solutions

Post-quantum cryptography (PQC): now focused on Shor, Grover

What if better algorithms, upgrades like 2WQC are there/coming?

NP solver verifier: does decryption with given key lower entropy?

Are some of current PQC already resistant? (NP-hard is not enough)

Building nextgen PQC: immune/resistant to quantum NP solver?

E.g. **require initialization**: large calculations based on cryptographic key before proper decoding (tough for key superposition)

Maybe based on **higher class like PSPACE** (private/public key?)

https://en.wikipedia.org/wiki/PSPACE-complete

e.g. formal languages, **3-SAT +** ∀ quantifier $\left(\forall_{x,\ldots}\exists_{y,\ldots}(\vee\vee)\wedge\ldots\right)$,

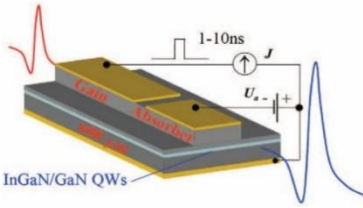
reconfiguration: find path satisfying constraints (~arXiv:1204.5317),

puzzles/games: multiple-interaction cryptography (before low entropy)

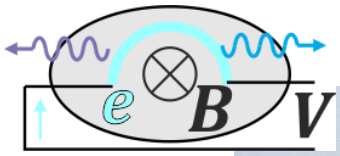
How to generate and measure **negative radiation pressure**?

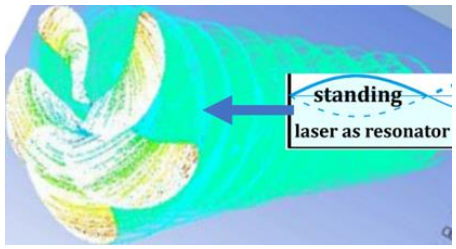
Is CPT symmetry still valid in macroscopic case?

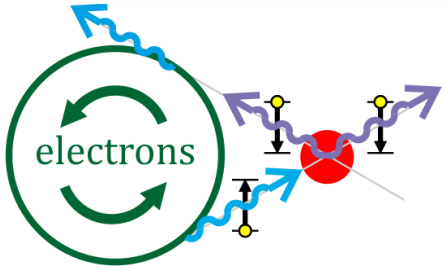
No – we need to modify physics, Yes – many new applications:



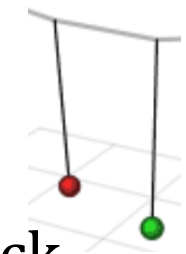
- **Backward beam causing only deexcitation** (transparency?)
  anode tube? antenna?
  impulse, ring laser?
  synchrotron/FEL?



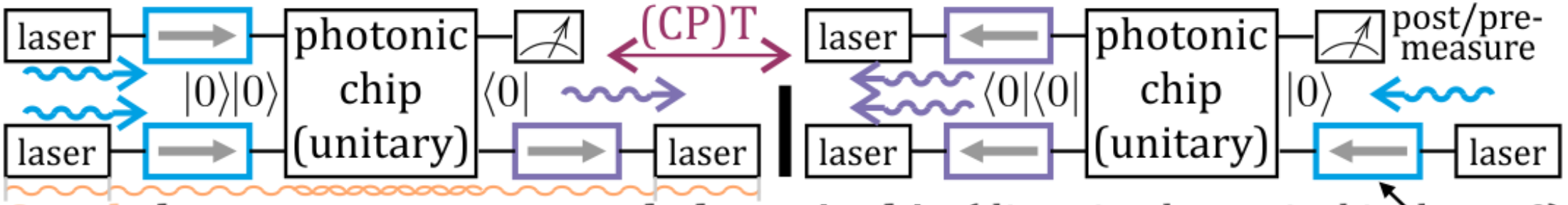




- **Direct Rabi** removing OI, **STED without bleaching** by reversing OI?
- **Causing deexcitation:** radiotherapy, photolithography, nuclear …
- **Backward camera:** e.g. **CPT(black hole) = white** only emitting?
- **Backward lighted camera** enhancing target deexcitation, BB84 attack,
- **Emission CT**: backward beam + backward camera: medical, geology?
- **2WQC: two-way quantum computer:** solving NP, better error correction



2WQC: adding **postparation** as state **preparation** process in CPT perspective



Couple laser resonators around photonic chip (directing by optical isolators?)

Potential tests/applications e.g. in synchrotron Solaris?

- **speedup of nuclear deexcitation e.g. Er-169 (forward/backward)?**
- **linac: forward/backward window in new bending magnet?**
- **mirrors to below(/above) for backward lines e.g. in lower floor?**