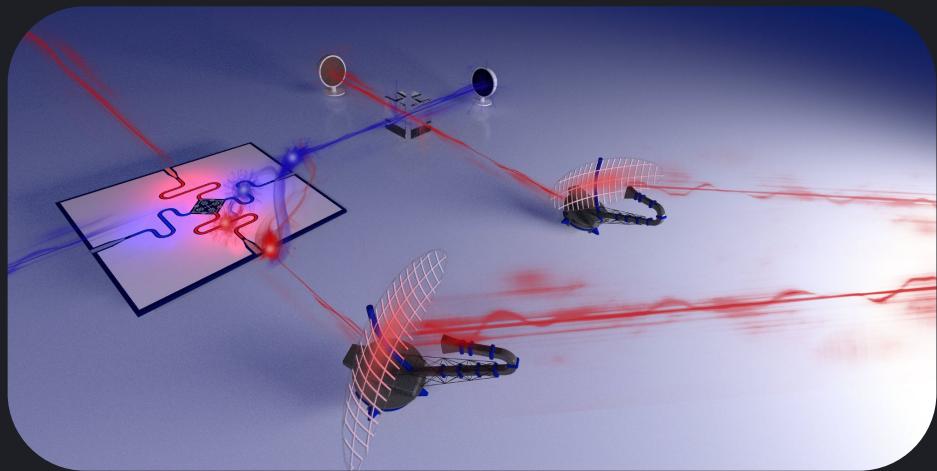


Quantum Radar

A very short/brief explanation



Bo Gardner





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How classical radar functions

01.

Quantum Radar

What is quantum radar?

02.

Quantum Radar

03.



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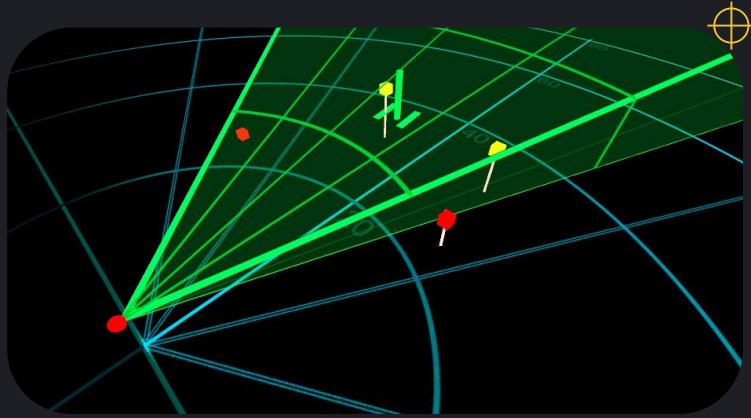




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01.



Classic RADAR



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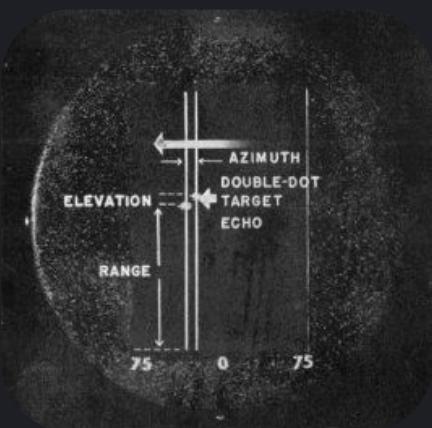
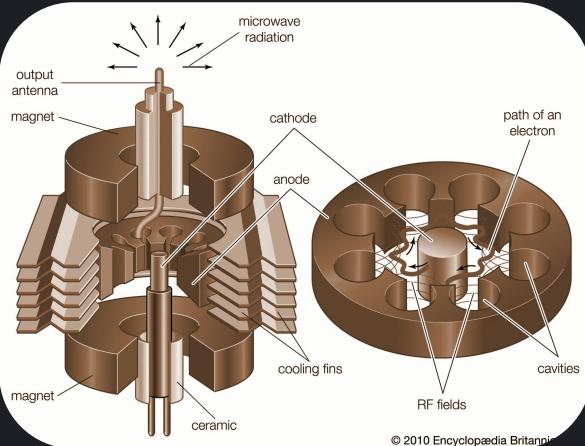
What is classical radar?

A system which uses **radio waves** to identify properties of objects and environments such as distance, direction, velocity, and most importantly position.





History of Radar



- 1886: Heinrich Rudolf Hertz verifies that radio waves can be reflected by objects just like visible light
- 1904: Christian Hulsmeyer builds obstacle detector for ships – fails to gain interest
- 1922: USNRL gets radio waves to reflect off ship in Potomac river
- 1939: Magnetron oscillator built by British physicists
- 1944-1945 Ship radar gives United States advantage against Japan during WW2
- Post war: US Develops tracking radar
- Cold War: Radar used in missile warning and tracking





How radar works in depth:

Electrical energy powers a (PFN) which stores energy temporarily to create a larger controlled pulse

Electronic oscillator creates alternating current (AC) signal.

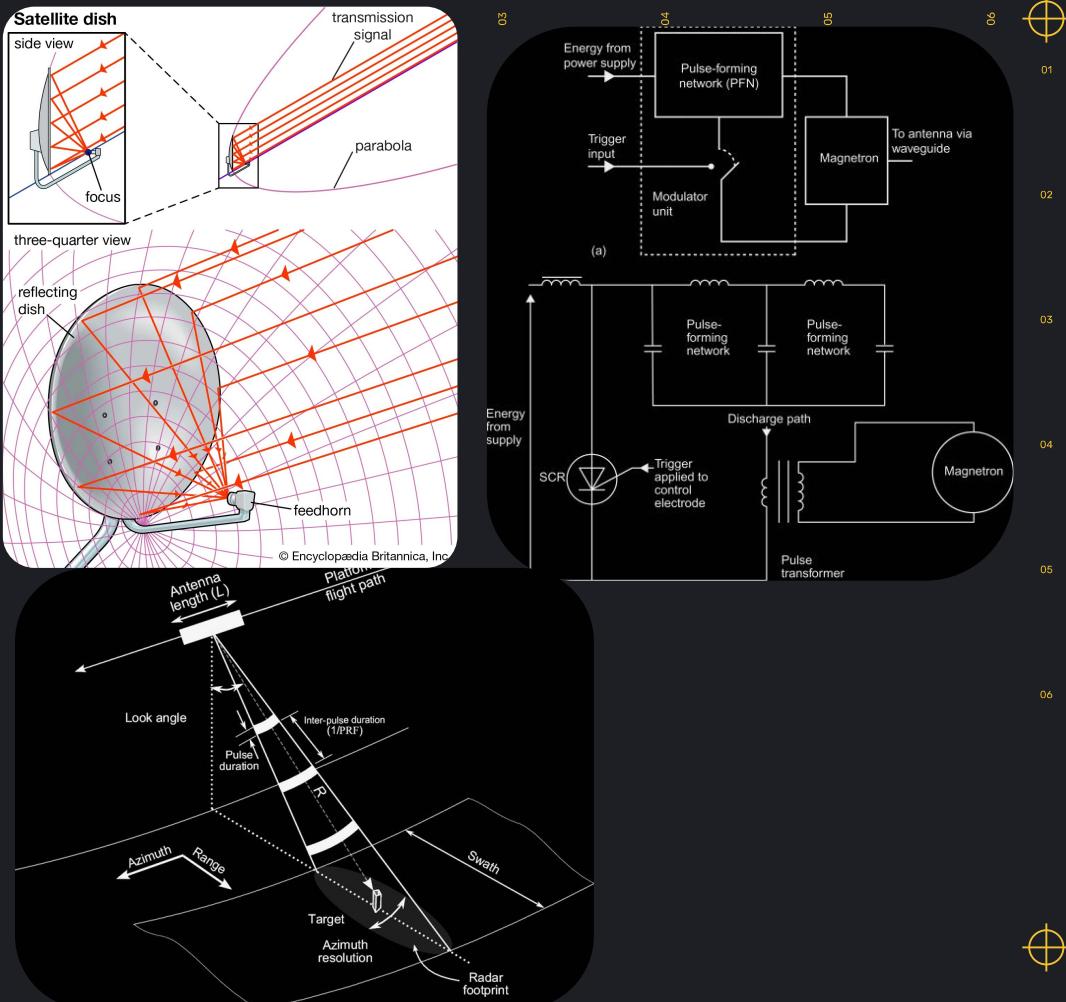
Radio frequency oscillator (RF) creates signals with frequencies in the range of 100 kHz to 100 GHz

These pulses last 0.00000157 (1.57×10^{-6}) seconds, with 0.00099843 second grace period to wait for response.

These pulses of radio waves travel through atmosphere at nearly $299,792,458$ m/s (affected by refraction index)

This process is repeated up to 1,300 times per second

Using $d = vt/2$ with velocity and time being known, d can be found

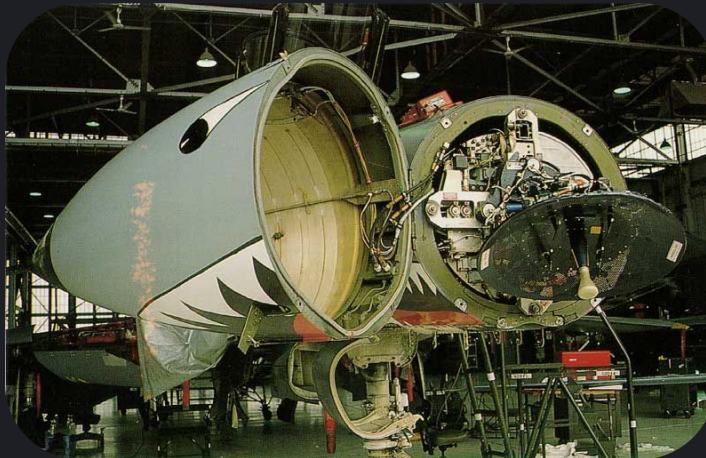
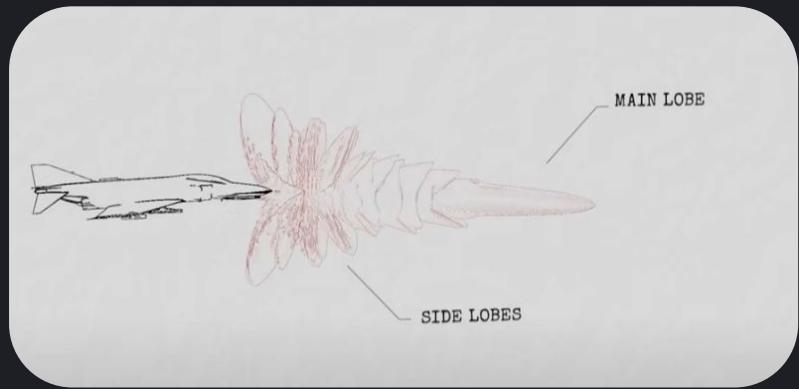


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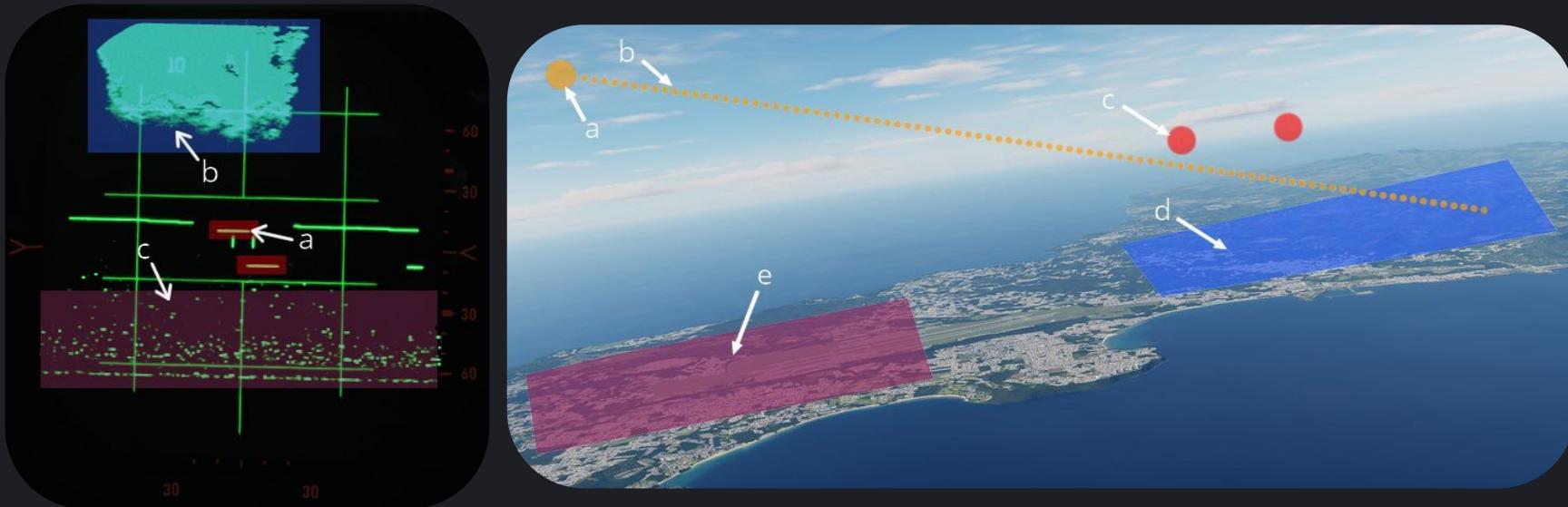


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Same situation: shown on aircraft
display and real life



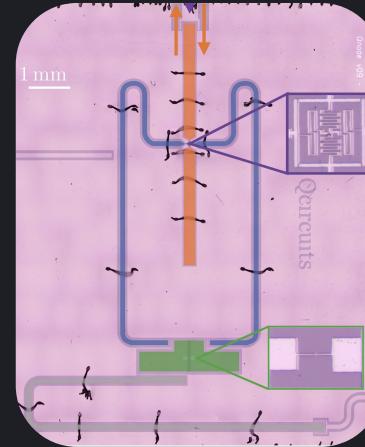


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02.

Quantum RADAR



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The History of Quantum Radar

- **2006** – Lockheed Martin proposes Quantum Radar internally
- September **2008** – Seth Lloyd: *Enhanced Sensitivity of Photodetection via Quantum Illumination*
- May **2008** – Lockheed Martin: Patent No. 7,369,265 “Quantum Radar”
- **2015** – Research team at MIT+Raytheon: Create first quantum radar prototype that outperforms classical radar
- **2019** – Research paper proposes 3D quantum radar
- **2020** – Physicists at IST Austria test microwave quantum illumination
- **2022** – Jeffrey Shapiro: Discovered new type of Quantum Radar: first-photon radar,
 - Outperforms previous theorem from 2011 claiming an error probability rule that means Quantum radar can't really outperform Classical radar
- **2023** – Chinese researchers: Allegedly developed/developing quantum radar, intended for planetary defense from asteroids ect...



2008 Lockheed Quantum Radar Patent



(12) United States Patent Allen et al.

(10) Patent No.: US 7,375,802 B2
(45) Date of Patent: May 20, 2008

(54) RADAR SYSTEMS AND METHODS USING ENTANGLED QUANTUM PARTICLES

(75) Inventors: Edward H. Allen, Lancaster, CA (US); Markos Karageorgis, Palmdale, CA (US)

(73) Assignee: Lockheed Martin Corporation, Bethesda, MD (US)

(*.) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 187 days.

(21) Appl. No.: 11/198,829

(22) Filed: Aug. 4, 2005

(65) Prior Publication Data

US 2007/0296953 A1 Dec. 27, 2007

(51) Int. Cl.
G01C 3/08 (2006.01)

(52) U.S. Cl. 356/4.01; 356/28; 342/105;
342/138

(58) Field of Classification Search 356/4.01
See application file for complete search history.

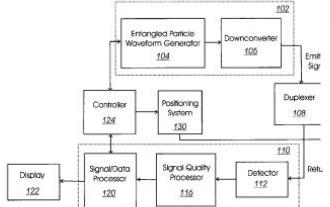
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27 Claims, 5 D

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Ned complex
underling th he qua

linear theory has explained a lot but has a lot of paradoxes can we go to more fundamental quantum theory which include nonlinearities? Who knows but I would like to add one more comment we want to use quantum computing to solve nonlinear problems and even np bu



Both of these guys went to the

now Lockheed
Grumman,
on, and

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Markos Karageorgis

Καραγιώργη



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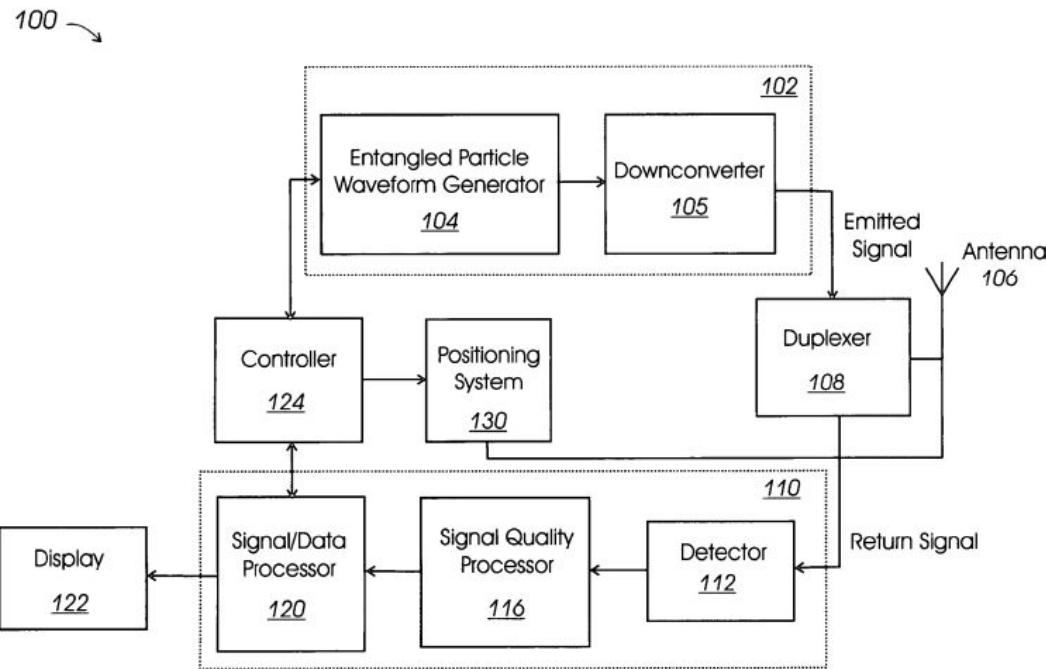
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U.S. Patent

May 20, 2008

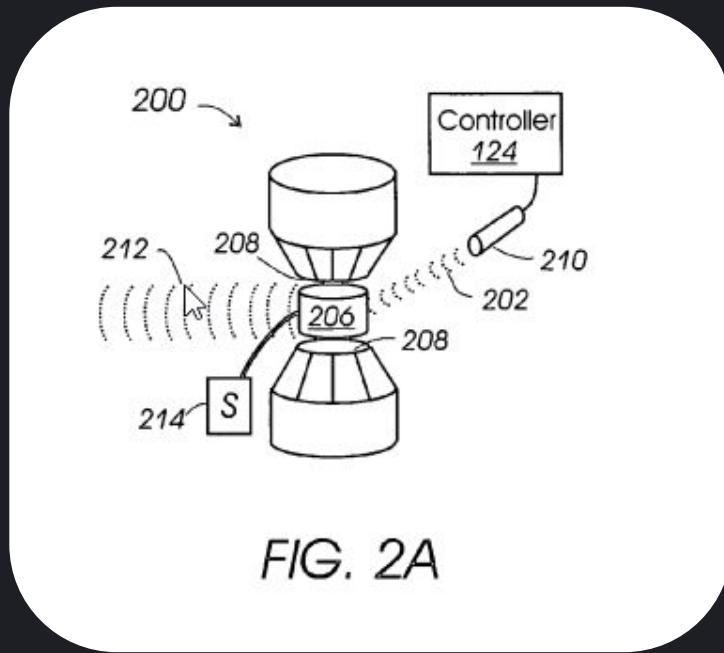
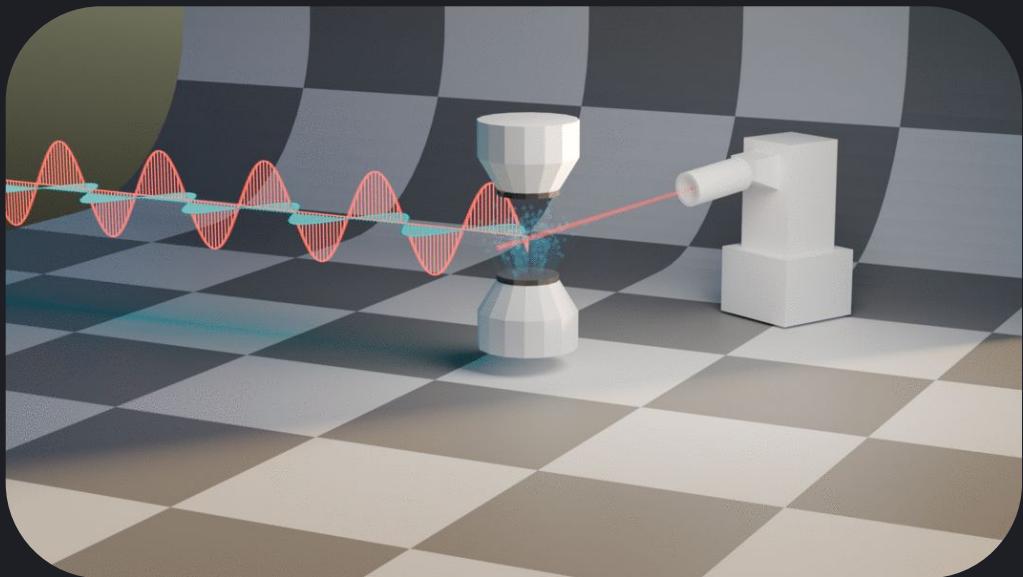
Sheet 1 of 5

US 7,375,802 B2

**FIG. 1**

Animation of patent design

Made by me



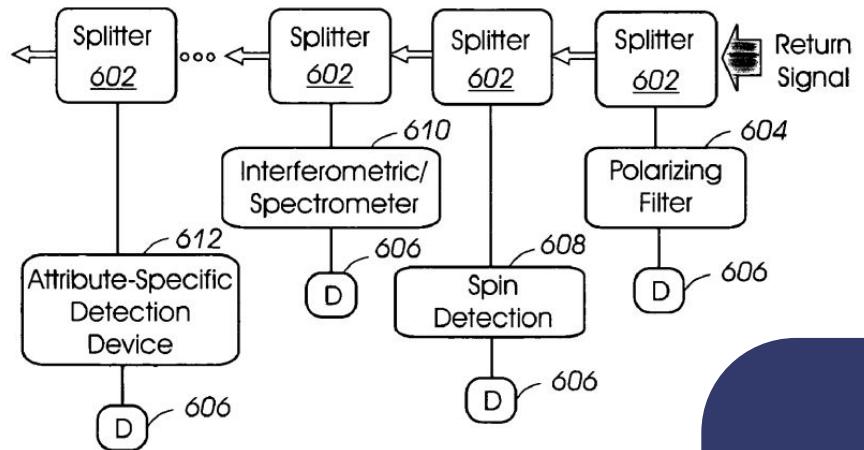
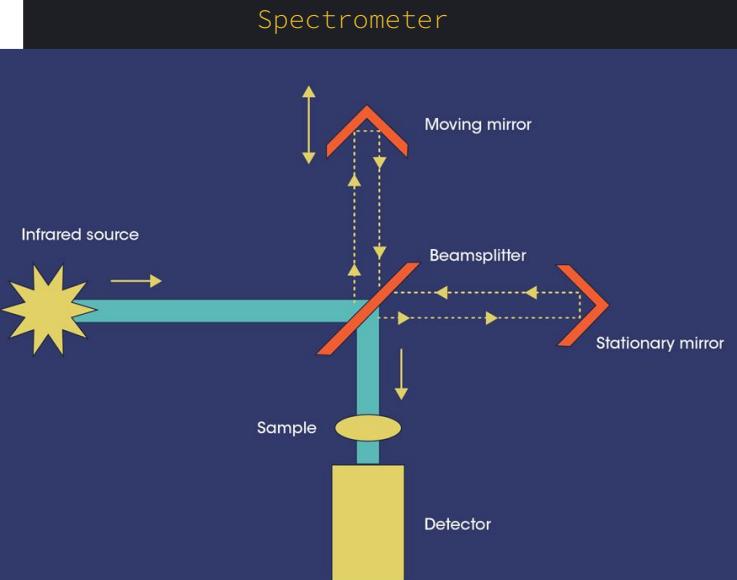


FIG. 6



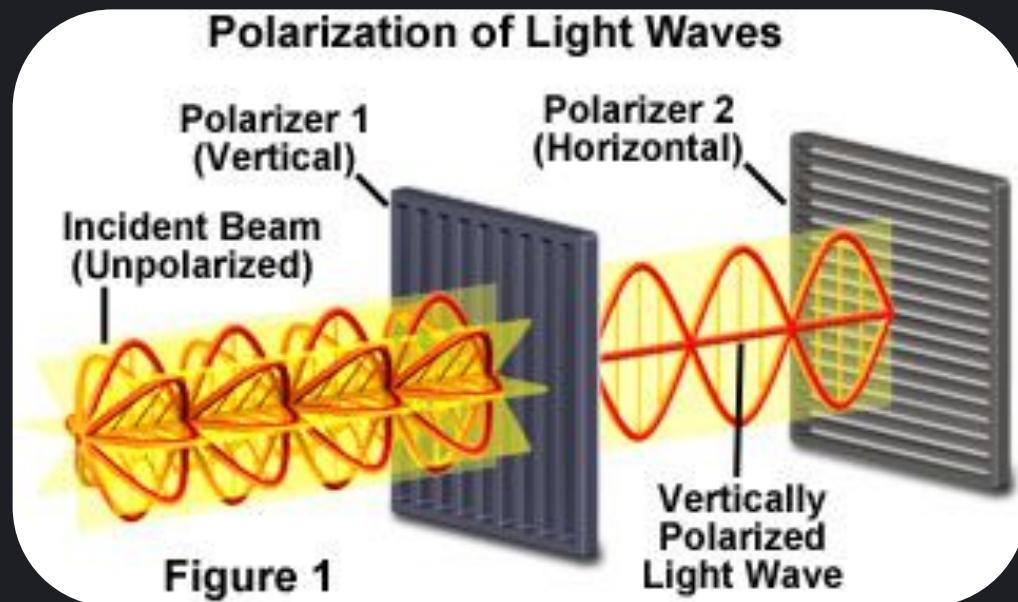
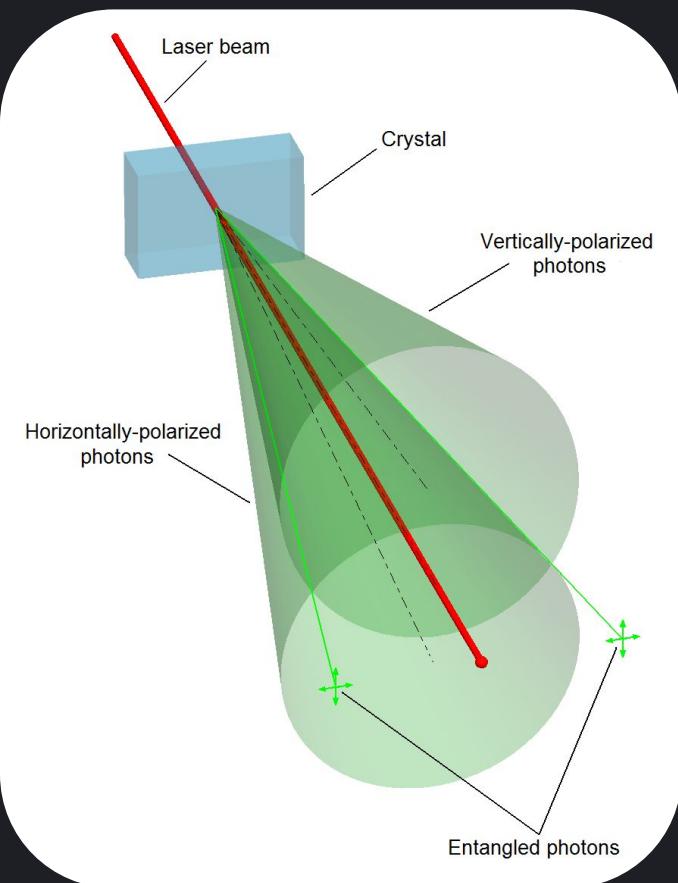
Quantum Illumination

Seth Lloyd*

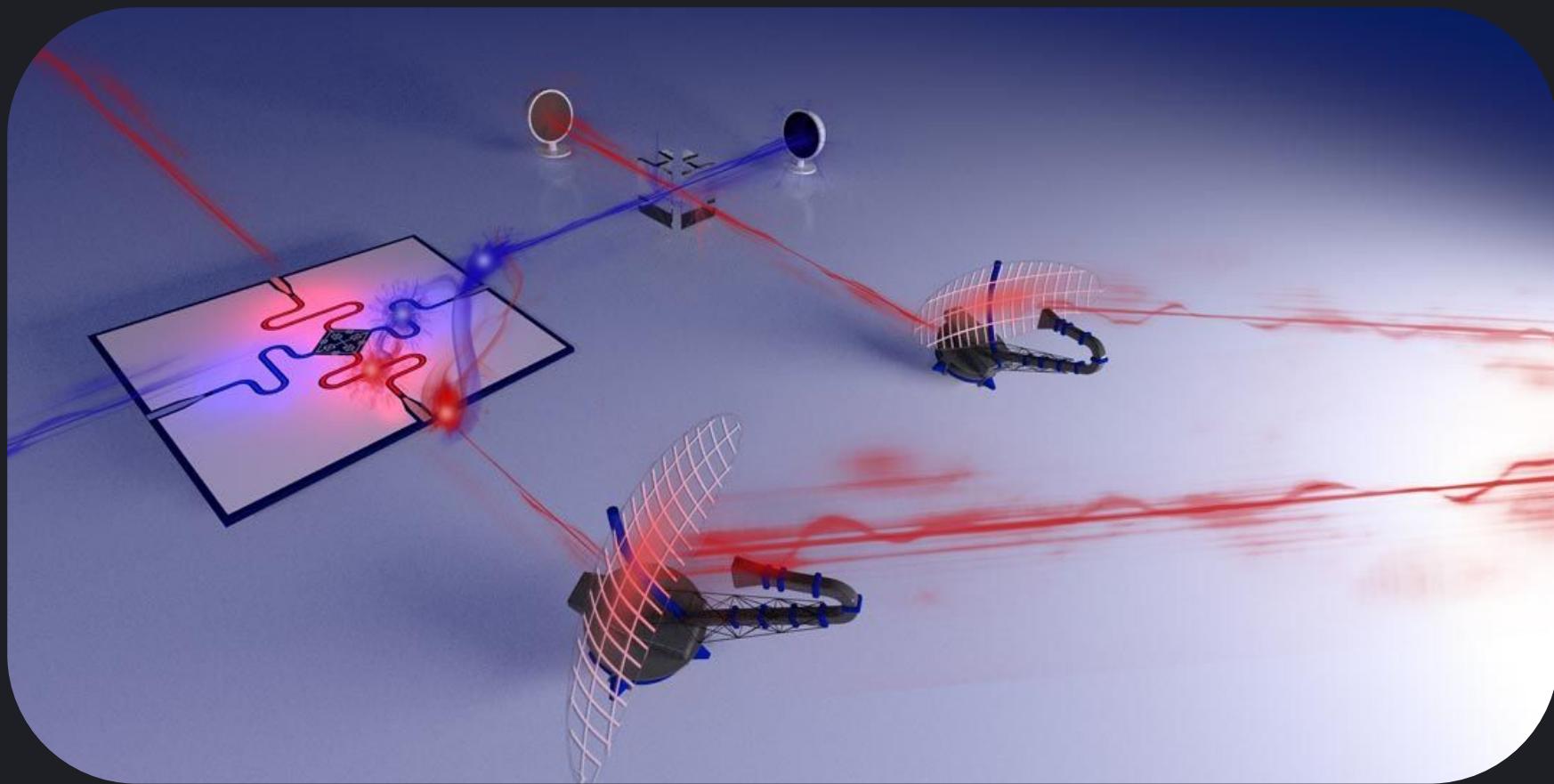


*He was involved slightly in the Jeffrey Epstein Debacle

How are these photons entangled?

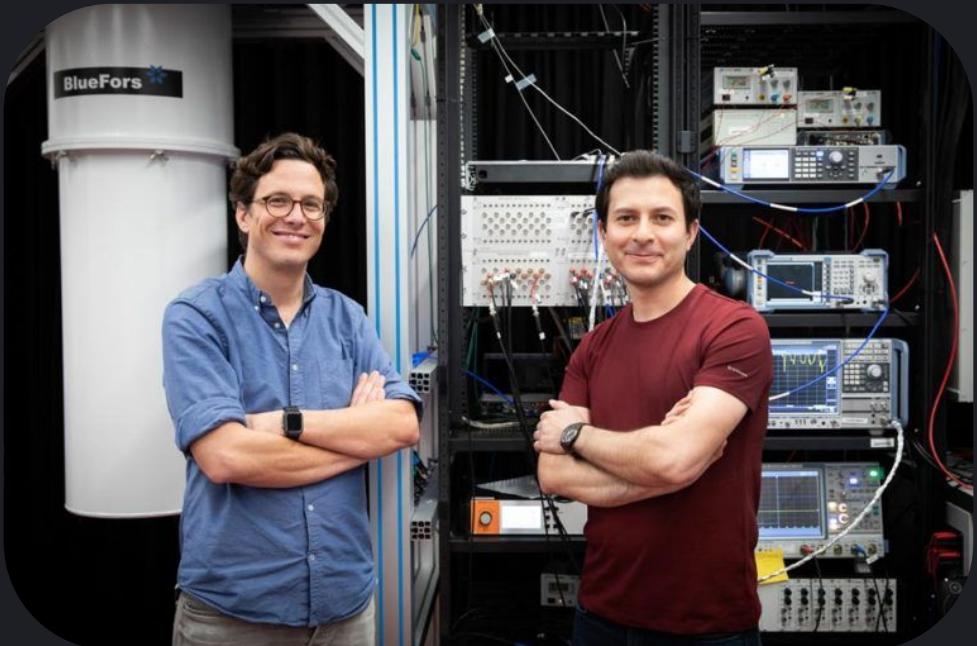


AUSTRIA! - 2020



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Shabir Barzanjeh & Johannes Fink



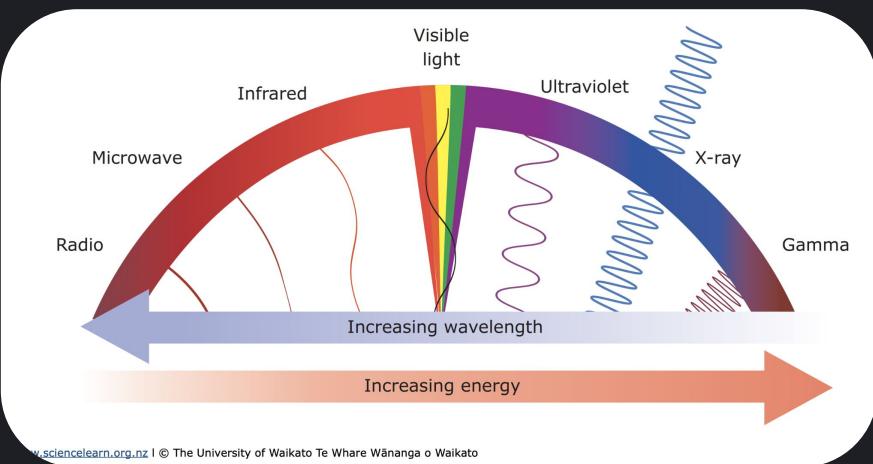
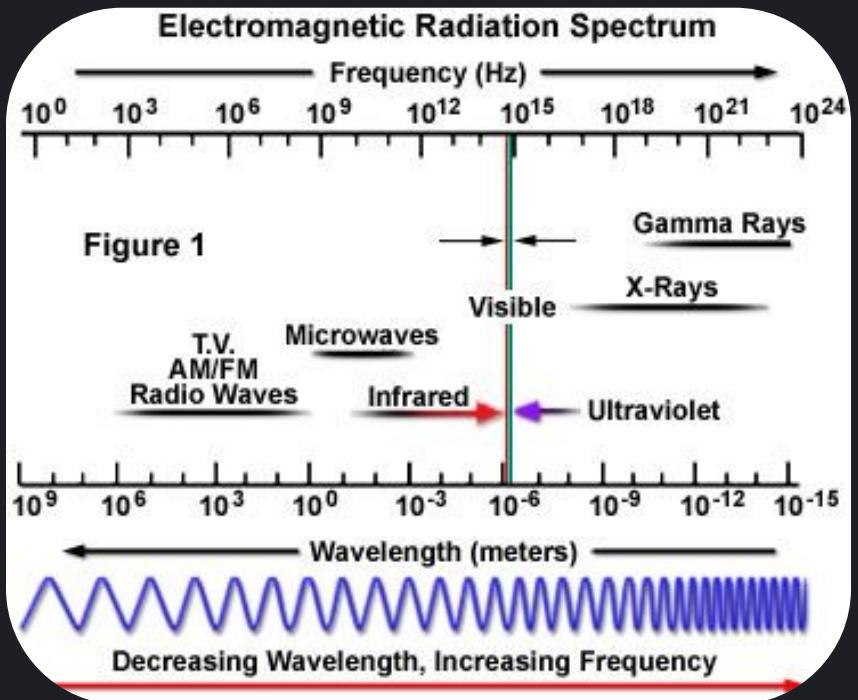
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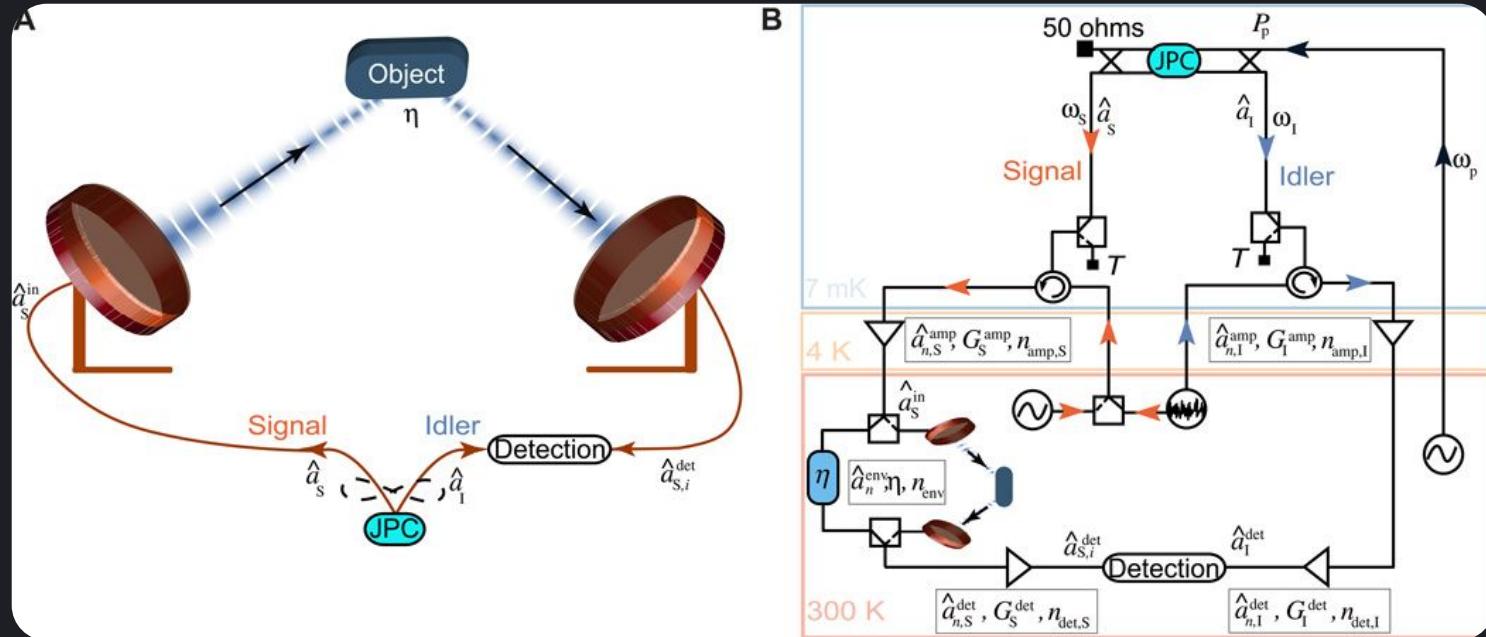
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Reminder



Signal = 10.09 GHz
Idler = 6.8 Ghz

$|\psi| = \sum_{n=0} \sqrt{p_n} |n_s| * |n_i|$
 $|n_s|$ = Signal mode **fock** state
 $|n_i|$ = Idler mode **fock** state



Fock state (Number State)

Written as $|n\rangle$

$|0\rangle$: Vacuum state (no photons)

$|1\rangle$: Single-photon state

$|2\rangle$: Two-photon state

Quantum state with defined number of particles, in this case photons



$$(I_s) \approx \frac{4\pi\epsilon_0^2\sigma_Q}{(4\pi)^2 R^4} \quad (9)$$

The above expression resembles the classical radar equation making replacements:

$$P_t^Q = 4\pi\epsilon_0^2 \quad (10)$$

$$P_r^Q = (I_s)A_r \quad (11)$$

where P_t^Q is the transmitted power of the quantum radar and P_r^Q is the received power at the quantum radar. Then the Quantum Radar Equation is:

$$P_r^Q = \frac{P_t^Q A_r \sigma_Q}{(4\pi)^2 R^4} \quad (12)$$

I_s = Intensity of signal at target

ϵ_0 = Vacuum permittivity (electric constant)

σ_Q = Quantum radar cross section, accounts for quantum properties of objects

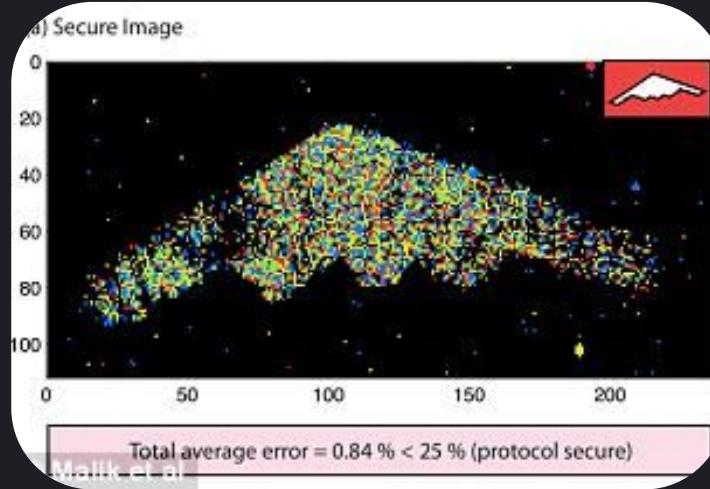
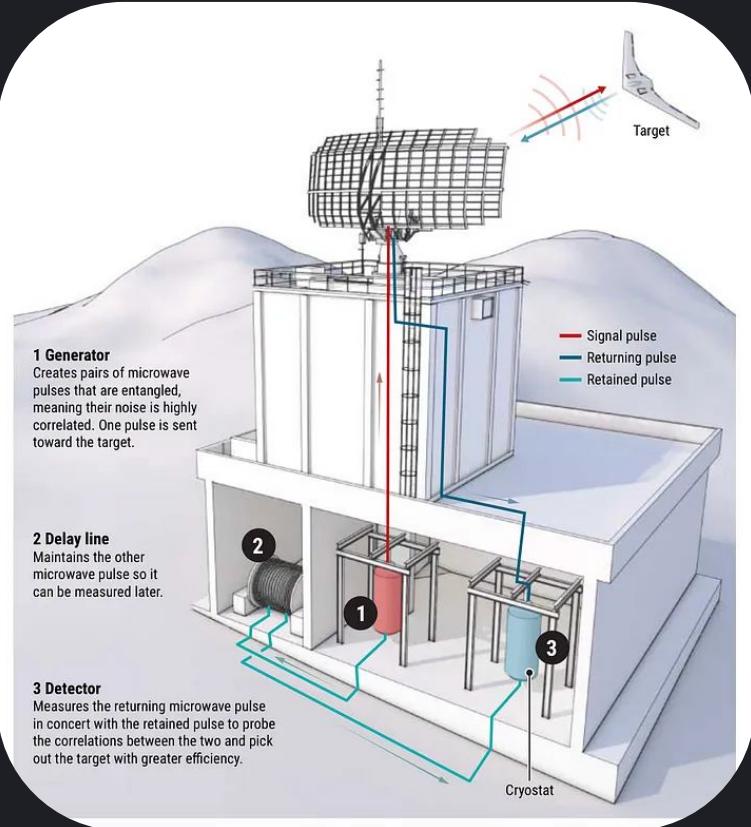
R = Distance to target

P_t^Q = Transmitted power of quantum radar

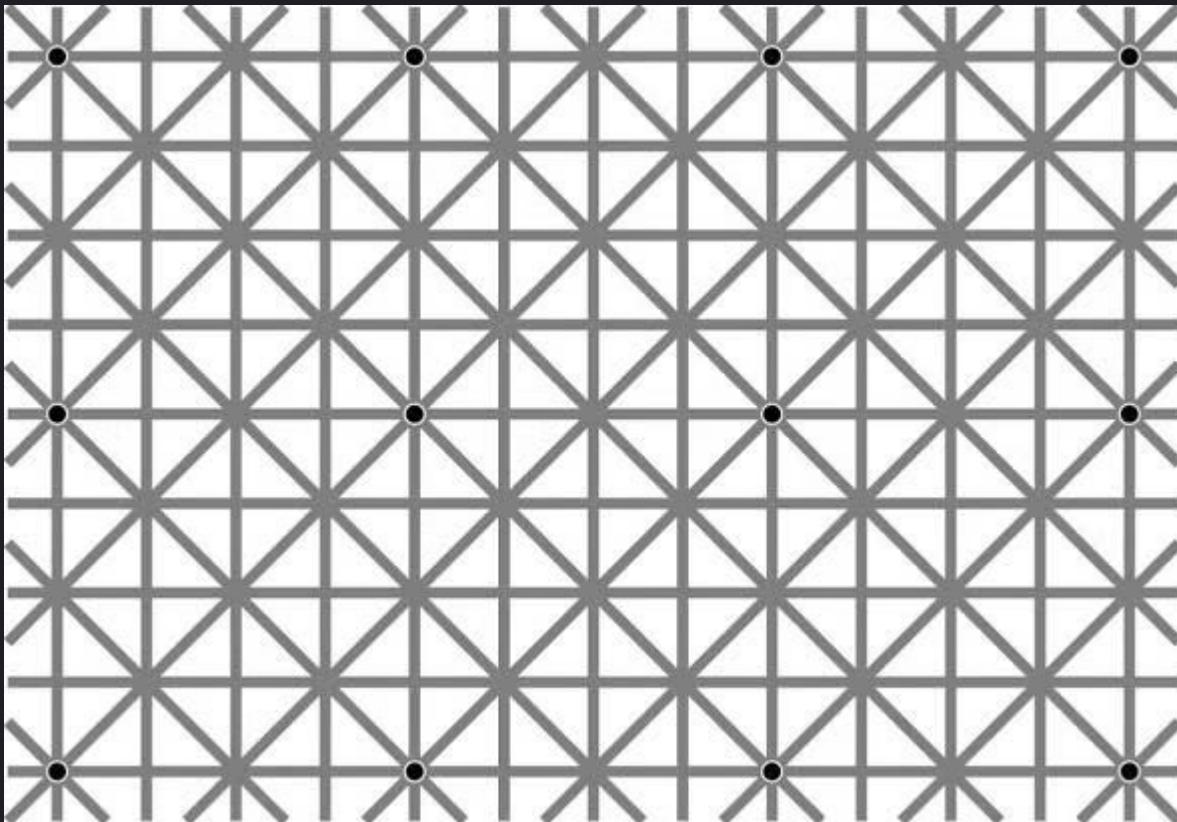
P_r^Q = Received power at quantum radar

A_r = Effective area of radar receiver (Quantum) , aperture

Ground Quantum radar design



Observation of particles



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Undeveloped film analogy





Animation demo

Also made by me

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3:30 AM
4/10/2025



Some jerky camera
movement due to it being
made 3 and a half hours
into the next day

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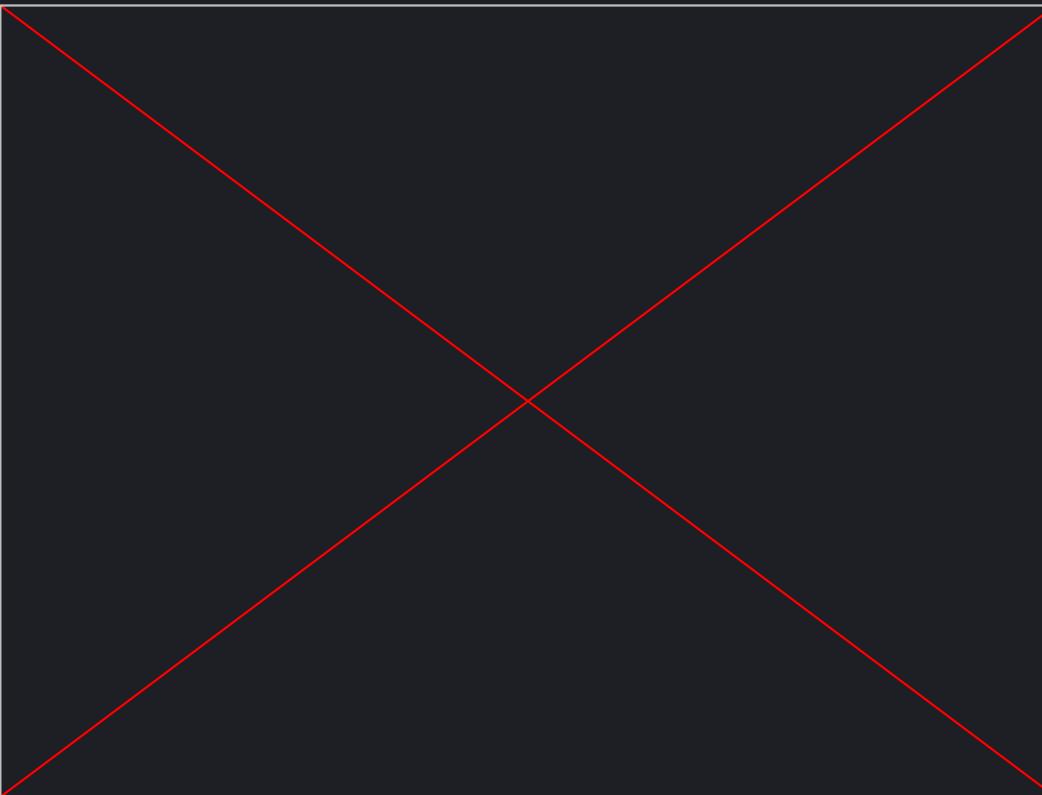
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Anti-radar (Stealth)



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Photos taken by me...



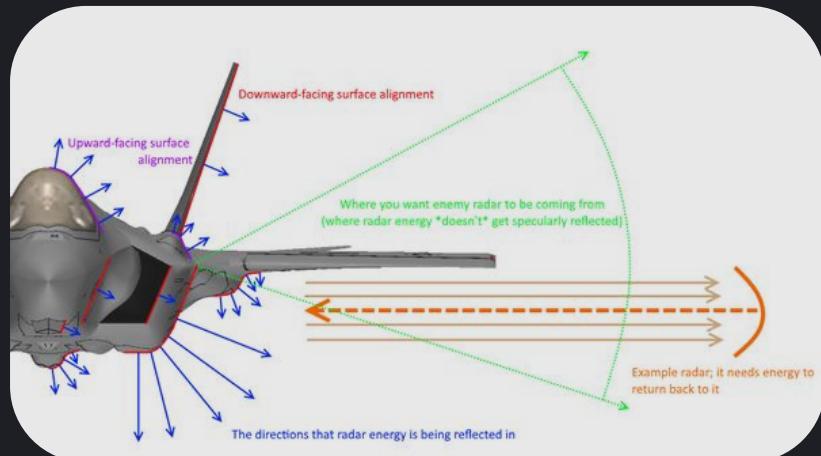
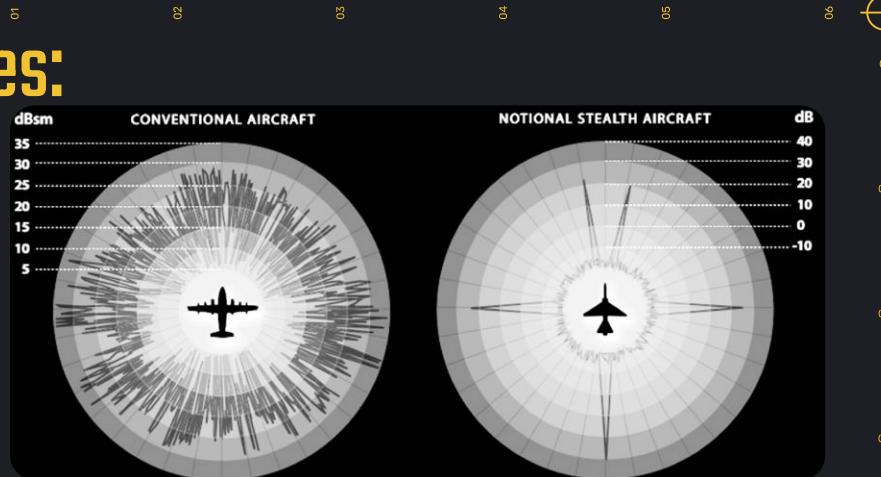


Stealth aircraft design principles:

- Reduced radar cross section
- Radar absorbent materials
- Wave reflection
- Jamming of frequencies*

Helpful to avoid radar tracking and being shot down

Comes with reduced aerodynamic stability, payload capacity, maneuverability, size

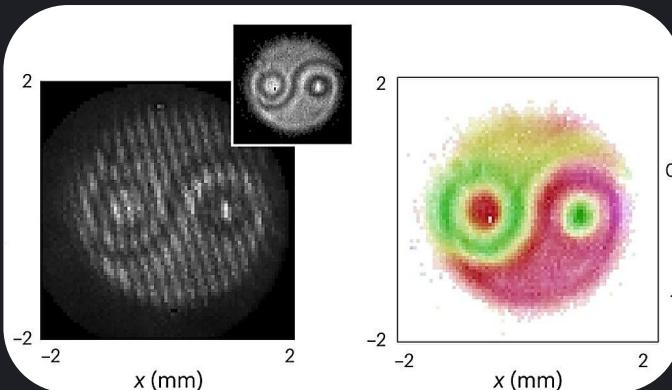
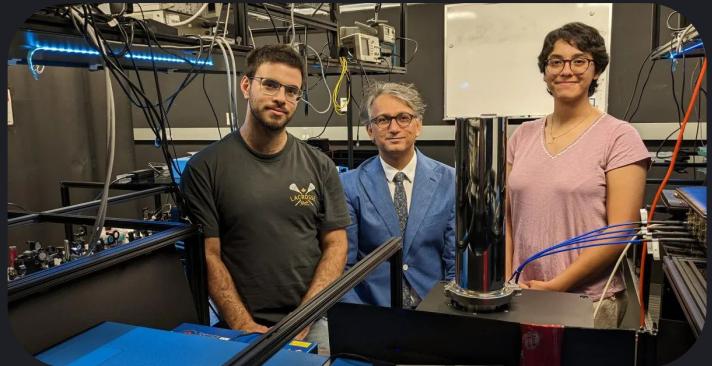
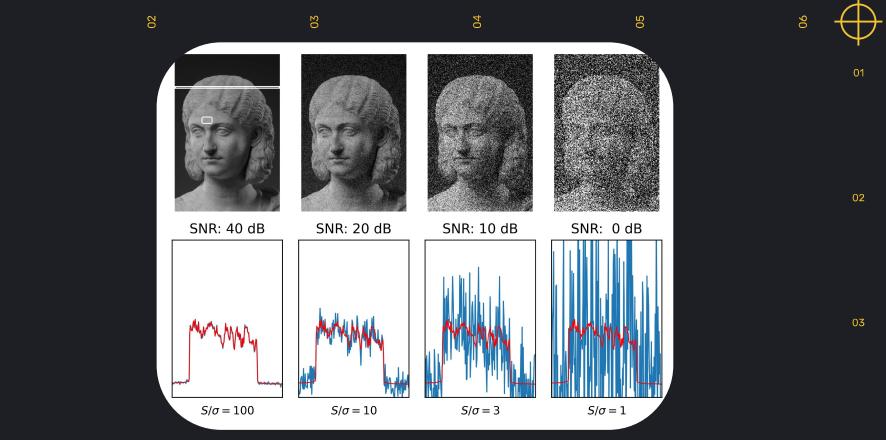


Quantum Radar vs Classical

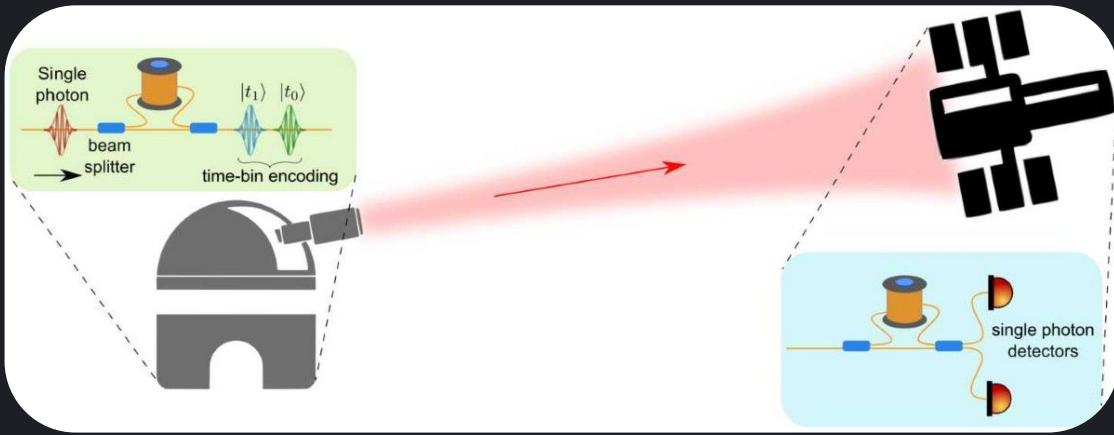
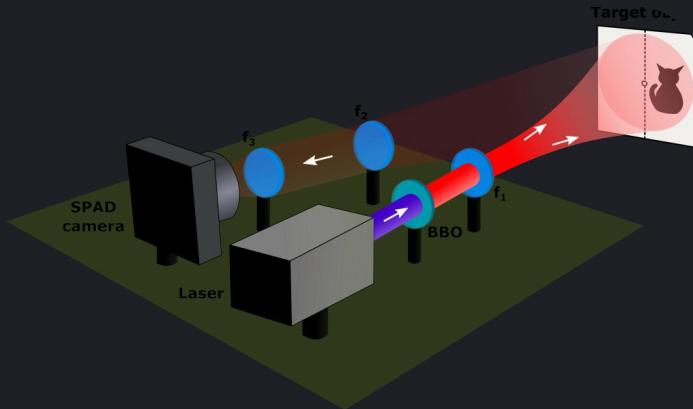
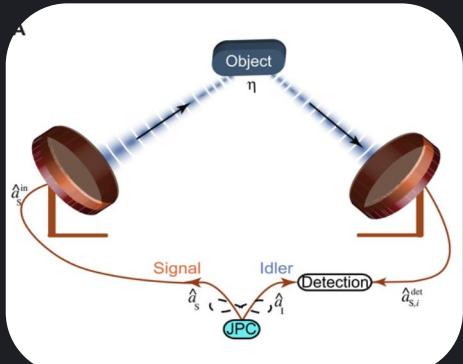
Quantum Radar has a higher Signal to Noise ratio

Quantum Radar has lower error rates

Quantum Radar is underdeveloped and novel



Other applications:



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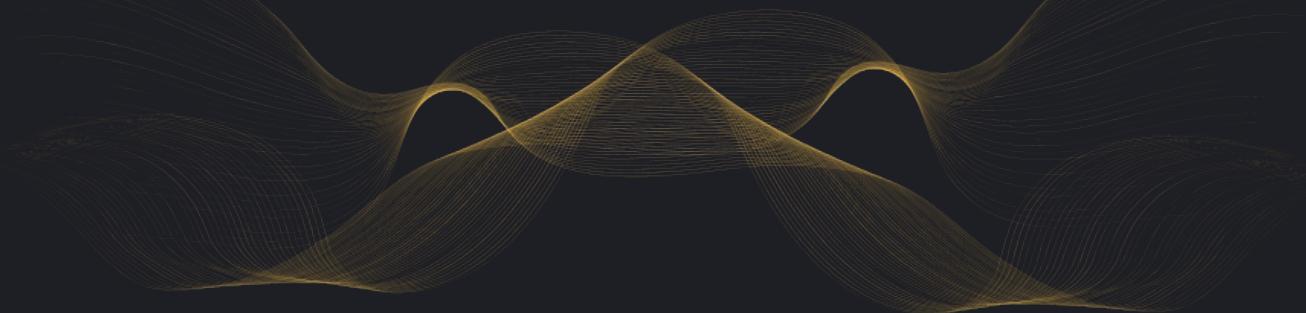
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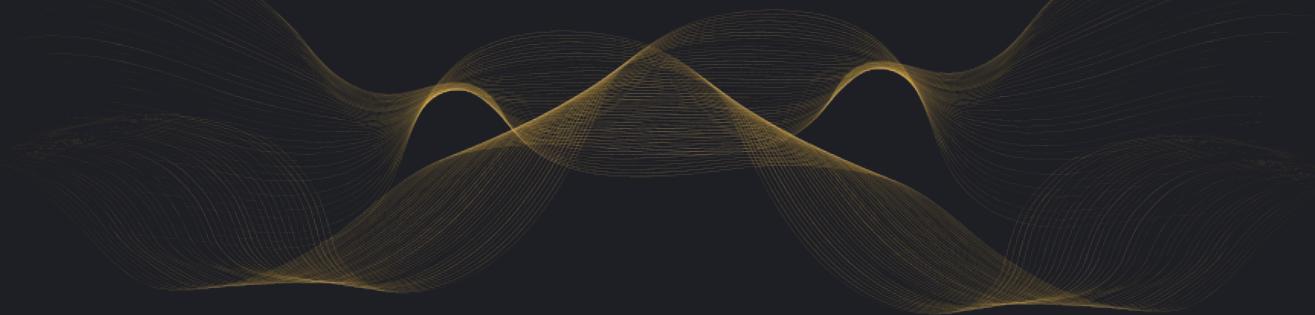




THE END

Questions?





Sorry luca



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