25-26 July 2022 Vienna

The Future of Decision Making in SAR
Quantum technology & distributed intelligence

Future of Decision making on the edge with input from corner stone projects

ECO Design, Efficiency, Material substitution, reduce yield losses

Carbon dept visibility, environment impact bill, supply chain resources,

components and data for cyclic economy

ECAS2030

Society 5.0

Sustainability,

www.mobilitye.eu

Mobility.E

2009 2010 2012 2014 2016 2019

E3Car

Castor

Motorbrain

3CCAR

AutoDrive

Architect

Monitor device,
Life time monitoring
Certification framework

Fail-aware

Fail operational

Complexity

Redundancy

Multiphase

Multi-propulsion

Functional Integration

Efficiency

Prystine

NewControl

Industry 5.0 Complexity explosion

2018 2020

AI4DI

Platform for cross-cutting requirements

AI for cloud to edge

Multi-domain

AI4CSM

ECAS2030

Fleets

Vehicle in Traffic

Emergence

Cyclic economy

Green Deal

Ecosystems

Complexity solved by trustable AI

Quantum encryption
Quantum sensor
Quantum computing

Scalable embedded Intelligence for Edge and edge/cloud operation

Propulsion

Perception

Connectivity

L3, L4, L5 Control

Autonomous

Digitalization

Methods to improve signal quality during the past decade since computing power becomes more cheap and available everywhere

Filter, estimations, noise reduction, Kalman……..

Time Update ("Predict")

1. Extrapolate the state

$$\hat{\boldsymbol{x}}_{n+1,n} = \boldsymbol{F}\hat{\boldsymbol{x}}_{n,n} + \boldsymbol{G}\boldsymbol{u}_n$$

2. Extrapolate uncertainty

$$\boldsymbol{P}_{n+1,n} = \boldsymbol{F}\boldsymbol{P}_{n,n}\boldsymbol{F}^{\boldsymbol{T}} + \boldsymbol{Q}$$

Measurement Update ("Correct")

1. Compute the Kalman Gain

$$\boldsymbol{K_n} = \boldsymbol{P}_{n,n-1}\boldsymbol{H}^{\boldsymbol{T}}\left(\boldsymbol{H}\boldsymbol{P}_{n,n-1}\boldsymbol{H}^{\boldsymbol{T}} + \boldsymbol{R_n}\right)^{-1}$$

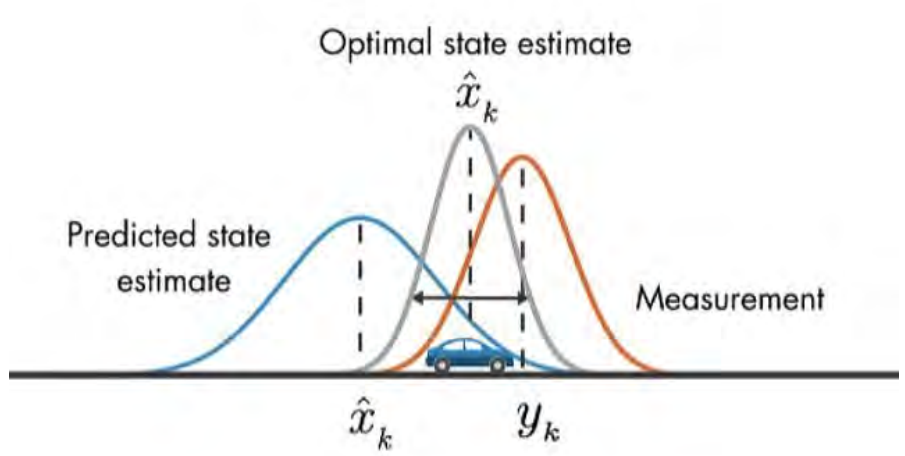
2. Update estimate with measurement

$$\hat{\boldsymbol{x}}_{\boldsymbol{n,n}} = \hat{\boldsymbol{x}}_{\boldsymbol{n,n-1}} + \boldsymbol{K_n}\left(\boldsymbol{z_n} - \boldsymbol{H}\hat{\boldsymbol{x}}_{\boldsymbol{n,n-1}}\right)$$

3. Update the estimate uncertainty

$$\boldsymbol{P_{n,n}} = (\boldsymbol{I} - \boldsymbol{K_n}\boldsymbol{H})\boldsymbol{P}_{n,n-1}(\boldsymbol{I} - \boldsymbol{K_n}\boldsymbol{H})^{\boldsymbol{T}} + \boldsymbol{K_n}\boldsymbol{R_n}\boldsymbol{K_n^T}$$

Initial Estimate: $\hat{\boldsymbol{x}}_{0,0}$, $\boldsymbol{P}_{0,0}$



Search and Rescue (SAR) in sub-terrain operation

Sub-surface, no satellite connection, distributed intelligence -> Sensor for magnetic field navigation, federated learning….

The Urban Operational Environment must be understood in all levels of movement the “Triple S".

Super-surface, surface and subsurface represent a contiguous operational space that must be considered in its entirety.

The experts in the Urban Operations Support Cell assist HQ in understanding this environment.
Context, situation, position assist in better understanding and decision-making.

Related requirements based on SAR in sub-urban context

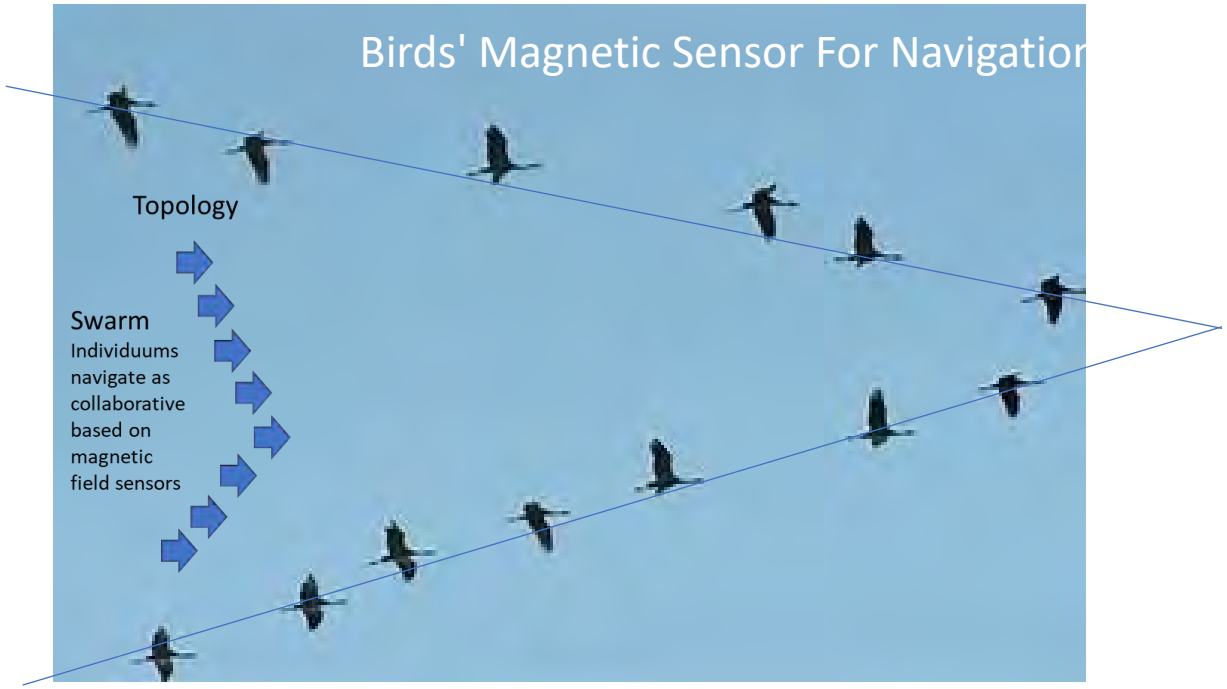
- Context awareness: to ‘understand’ the current situation
- Accurate localization: to perform precise motion planning
- Artificial Intelligence: to handle undefined situations
- Connectivity: to gain information beyond the own sensors
- Cooperativity: to anticipate and coordinate maneuvers together
- Digital Infrastructure: to give environmental information, more accurate localization and extended field-of-view beyond sensors

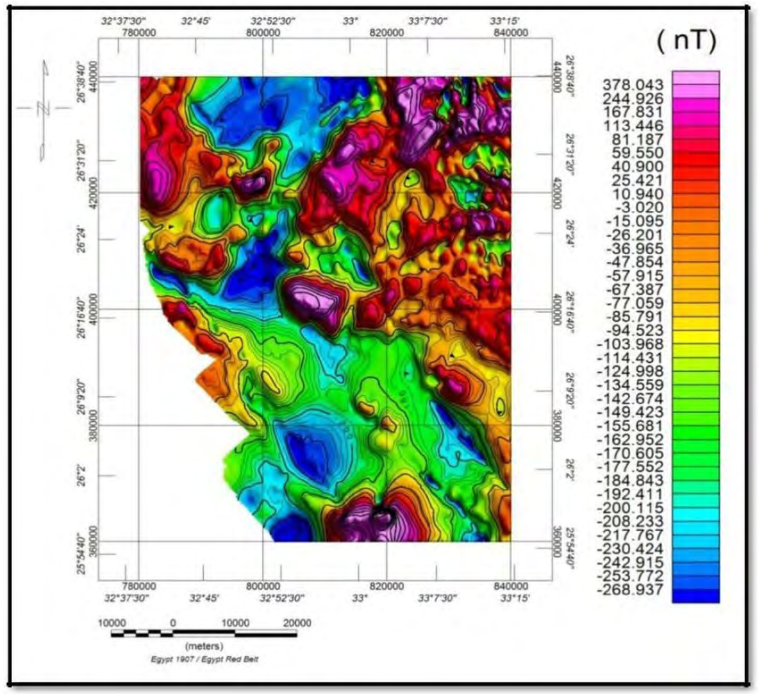
High potential technologies for disruptive innovations for the future information society

1. Perfect quantum correlations have double information than perfect classical correlation
2. Distributed intelligence in swarms enables Emergence, which means 1+1 is more then 2
3. AI-Edge Continuum for decentralizing the development from cloud to edge

“We have reasons to believe that quantum information is the key of the upcoming information era”

Collaboration is not only energy saving -> Navigation with magnetic map by swarm

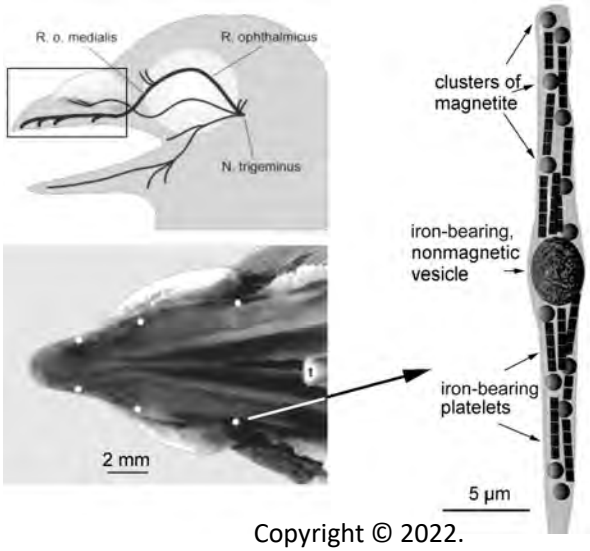




Birds' Magnetic Sensor For Navigation Might Rely On Quantum Mechanics In Their Eyes

In the era of smartphones, getting home has never been easier, but for animals who have escaped the grasps of digital dependency, some pretty nifty adaptations for navigation have emerged. Some of the greatest migrators are birds, making enormous journeys year on year to nesting grounds and warmer climes, and it's long been suspected that the Earth's magnetic field has played an integral role in helping them work out where the hell they're going. Now, new research believes to have cracked the mechanism that underpins this magnetic sensor, revealing that a lot goes into a birds' eye view.

Published in the journal Nature, the study's insights hinged on a first-time achievement in producing the photoactive protein cryptochrome 4 (CRY4) successfully carried out by the study's first author Jingjing Xu, a doctoral student in Henrik Mouritsen of the University of Oldenburg's research group. This molecule is found in the retinas of birds but until now had never been produced in a lab. Xu was able to make CRY4 of several bird species by extracting its genetic code and combining it with bacterial cell cultures who would happily churn out an identical copy of the birds' proteins.

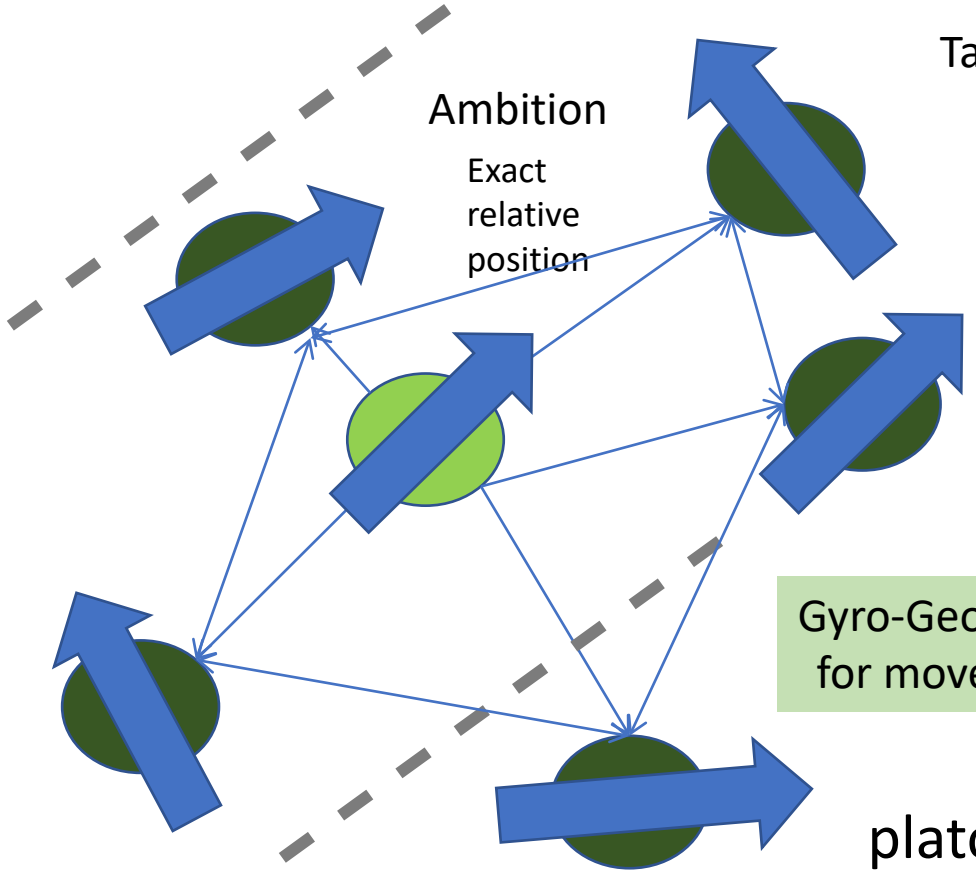


https://www.iflscience.com/plants-and-animals/birds-magnetic-sensor-for-navigation-might-rely-on-quantum-mechanics-in-their-eyes/

Co-existence of highly automated systems and less automated systems

Safety depends on the position tracking

Context awareness and continuous awareness on position



Task : find synergise

Ambition

Ontologie
Swarm

agent , multi agent awarness

Emergenz

Ontologie
individual agend

Swarm

Agents navigate as swarm based on Magnetic field sensors

Gyro-Geosensor
for movement

platoons

- How much can I change my direction to generate still stable movement for others to achieve more harmonious driving, avoid frictions, overload points and critical conditions.
- With controlled traffic flow conditions, where the driving not only depends on the single driver but also from the co-operation with other, Harmonization increases the overall throughput.
- If the traffic is too dense throughput optimal due to safety distances, about Ai more knowledge from the other traffic participants.

Traffic in industriell Environment and co-existence of autonomous and semi-automated mobile systems on street and logistical context

Environment
changes

Swarm: Smart intralogistics
Swarm: federated learning
Transfer to Robotics

Quantum correlations and advantages

Entanglement // Verschränkung

X0.2

Zina zina@teraglobus.lt

The Advantage of Quantum Correlations

The mutual information $I(A:B)$ of two variables A and B quantifies the amount of information obtained about variable A, through the measurement of variable B.

Perfect classical correlations:

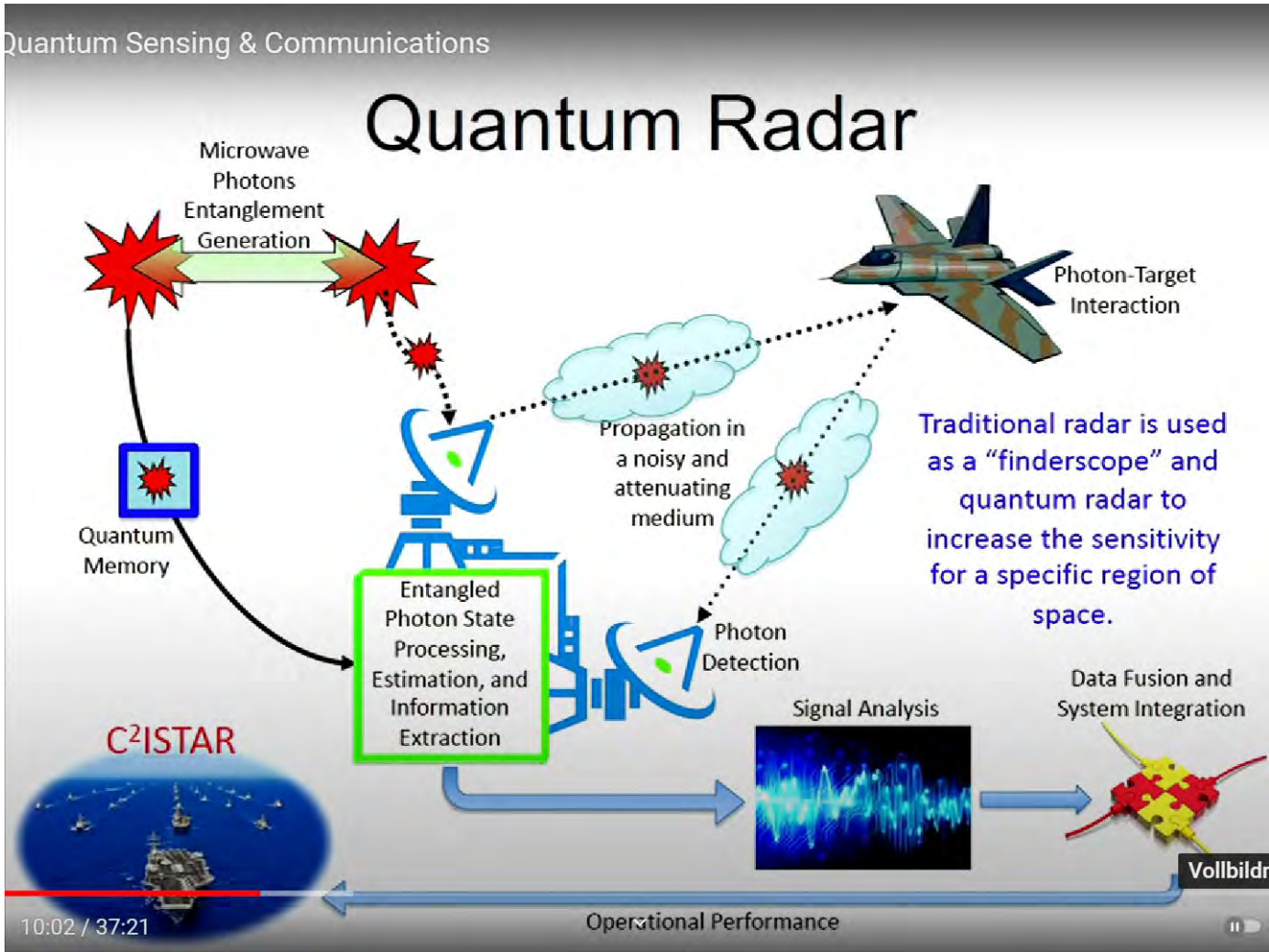
$$p(x,y) = p_x \delta_{xy} = \frac{1}{2}\delta_{00} + \frac{1}{2}\delta_{11} \Rightarrow I_c(A:B) = 1$$

Perfect quantum correlations (entangled states):

$$|\psi\rangle = \frac{|00\rangle + |11\rangle}{\sqrt{2}} \Rightarrow I_q(A:B) = 2$$

Perfect quantum correlations have **double mutual information** than perfect classical correlations.

Two photons in a quantum entangled state may have twice as much mutual information as two perfectly correlated classical entities. The use of this extra amount of correlation to better distinguish between signal photons and noise photons. In other words we can hide the signal photons in the environment noise and the entanglement correlations are the key to detect them .



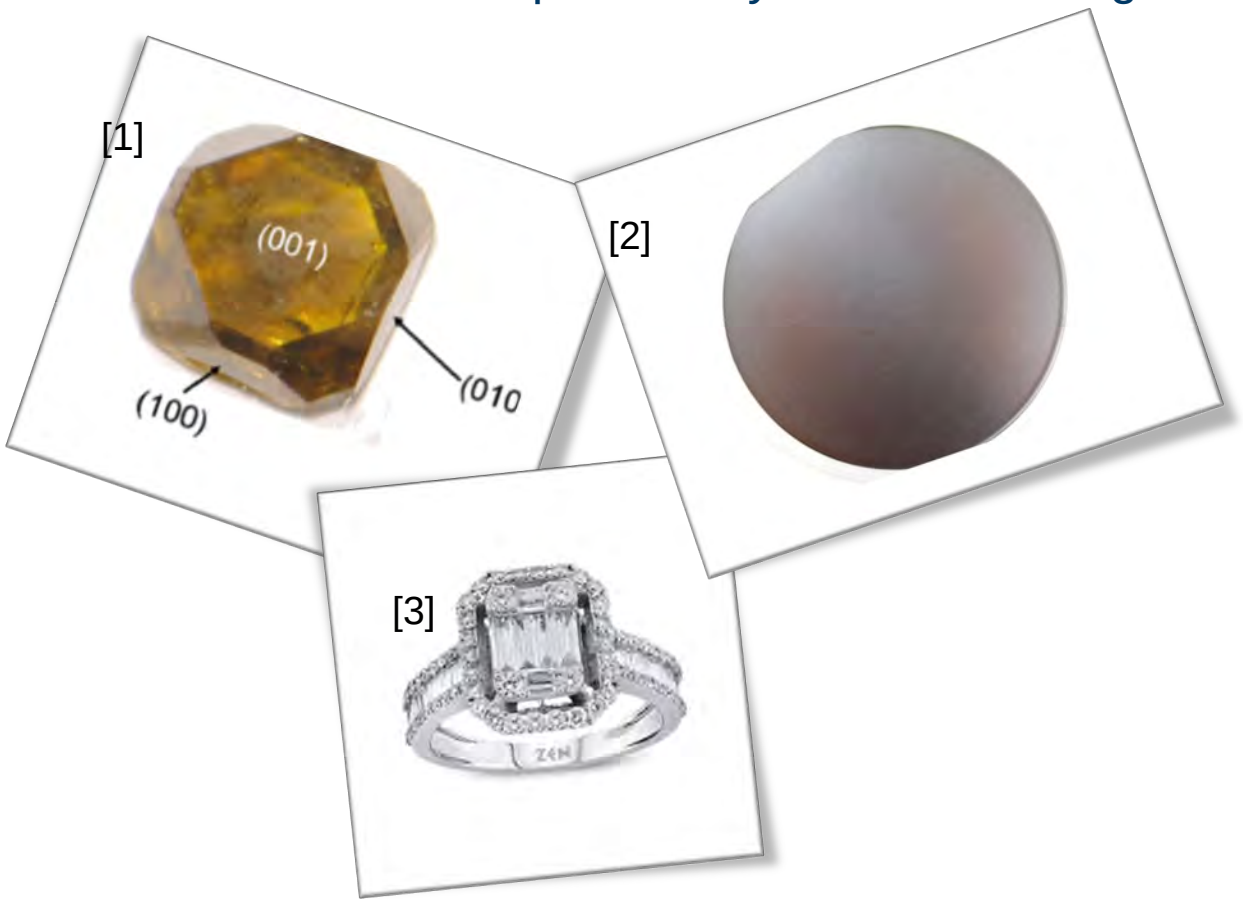
Somewhat similar to cheating in poker using marked cards: the photons are the cards and the entanglement correlations are the marking in the cards

The Future of Quantum Sensing & Communications - YouTube

https://www.youtube.com/watch?v=5uqiQ_mP3PM

Quantum Sensor

Color defects as a quantum system for sensing



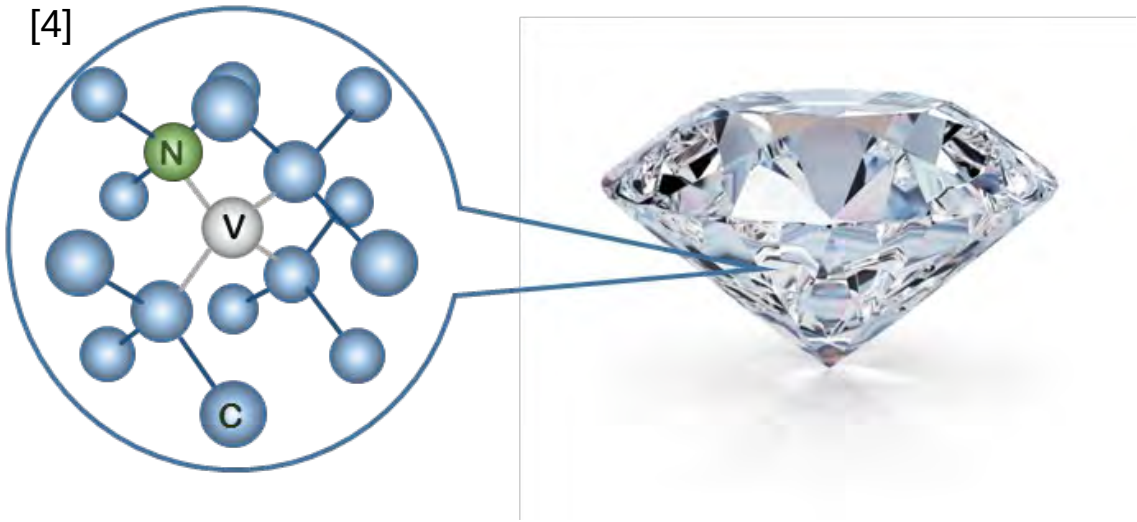
[1] R. S. Balmer et al., J. Phys.: Condens. Matter 21, 364221 (2009)

[2] zen-diamond.de

[3] MTI Corporation

What is the NV-Center in Diamond

Use Carbon

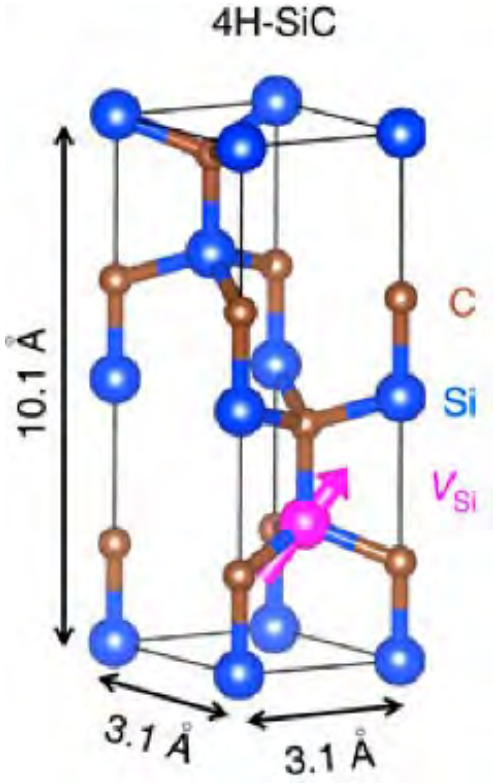


- Substituted nitrogen atom
- Carbon vacancy
- Can be manually created by Nitrogen-Implantation and annealing

[4] Spinnanoblog.com

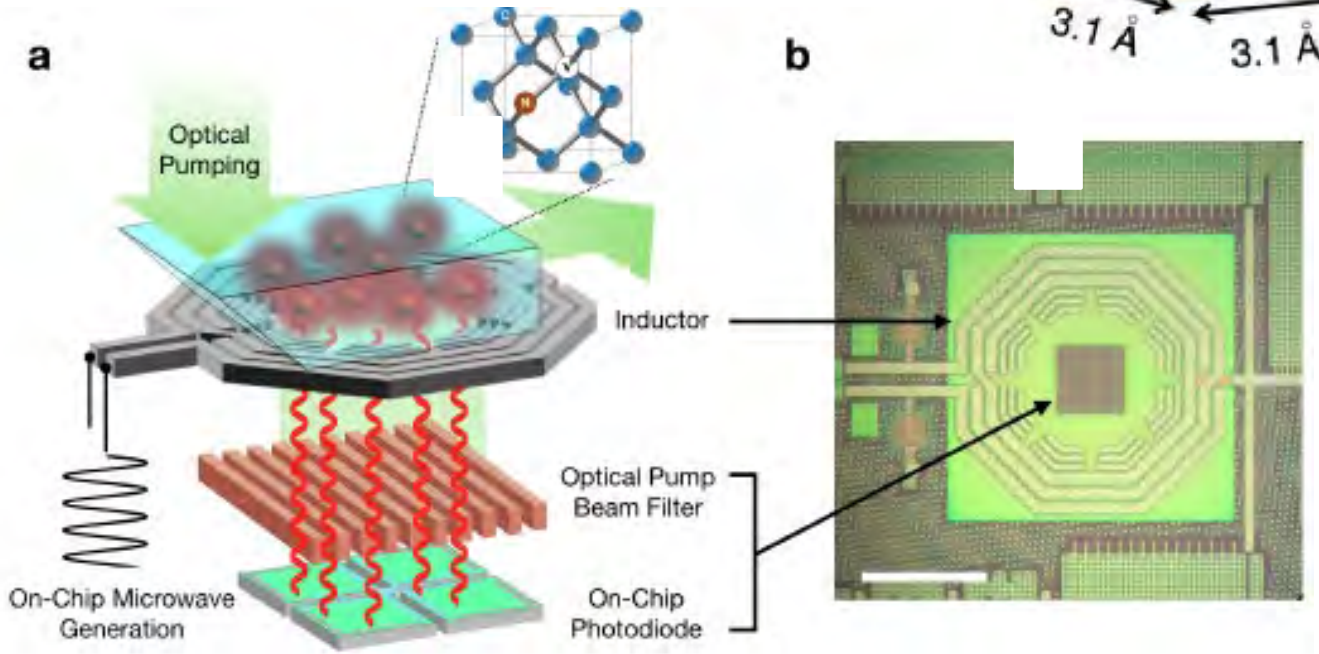
New Approach: Fully integrated semiconductor quantum sensor

- Using SiC as host material for quantum sensors
- We can use Silicon Vacancy Centers to realize a quantum sensor
- We can build a microwave free quantum sensor
- We can integrate all necessary electronics on Chip
- The whole quantum sensor can be fabricated in a semiconductor clean room
- The price of a SiC quantum sensor would be much lower as a diamond quantum sensor
- The magnetic field sensitivity of such a quantum sensor would be in the range of ~ $^{nT}/_{\sqrt{Hz}}$



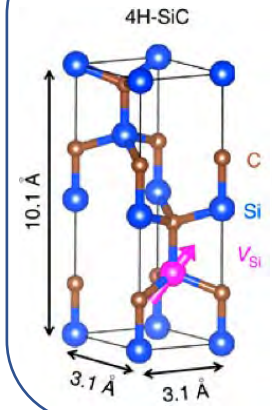
Use Silicon-Carbide

Nano/ micro scale -> Photonics

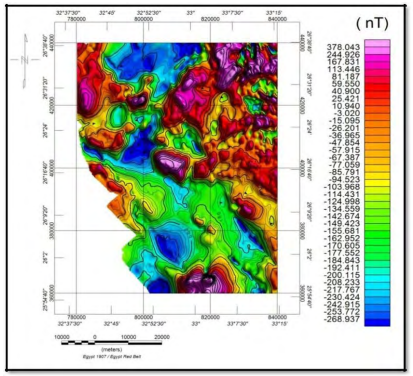


SC5.1 SoS: Q-Sensors for multi-modal, multi-physical and multi-scale digitalisation

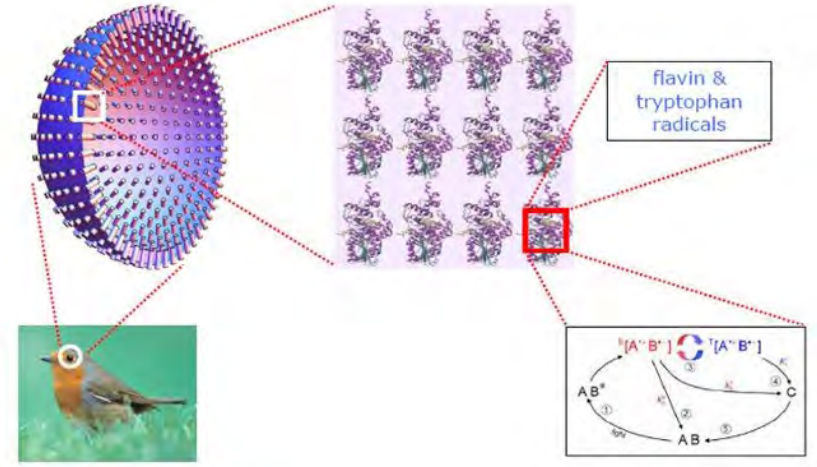
Q-Gyro sensor
Magnetic field

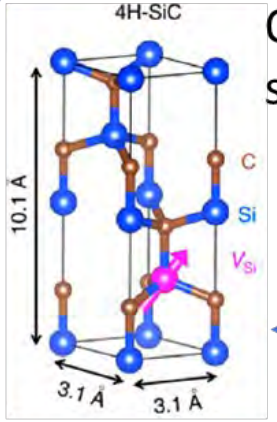


for magnetic map

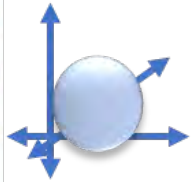


Can a ‘quantum compass’ help birds navigate via magnetic field?

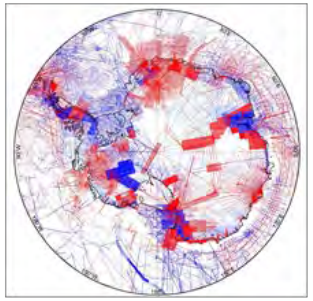


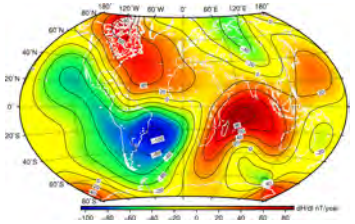


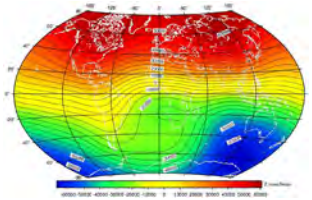
Q-Gyro sensor



for magnetic map







https://www.extremetech.com/extreme/200051-can-a-biological-quantum-compass-help-birds-navigate-via-magnetic-field

It’s difficult to prove that a device said to be a quantum computer actually is one. While entanglement is a requirement for the quantum performance of machines like D-Wave, it is not a proof. But the remarkable abilities of birds to navigate using Earth’s minute magnetic field are now similarly believed to depend on a biological quantum compass — although proving it is another story.

At a meeting of the American Physical Society this Wednesday in Texas, Peter Hore will be describing new experimental results that help explain how avian magnetoreception might actually work. Like many other organisms, birds have many special adaptions to help them navigate. In addition to the ability to detect things like polarized light, they have any number of ways they might use to sense magnetic fields. The idea that they use magnetic particles within the neurites coursing through their beaks, while conceivable, is no longer the best explanation for their abilities.

Closer inspection now suggests that those particles are just incidental iron concretions packaged in macrophages with no direct link to their nervous systems. A better way to try to do it, a way birds appear to have found, may be to use a chemical compass instead. The main idea is that light-activated chemical reactions occurring within the bird’s eyes are sensitive not just to the strength of a magnetic field, but to its direction.

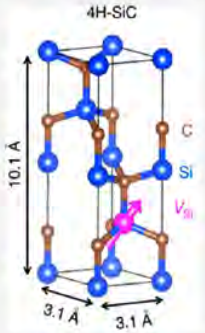
Enabling different application through quantum sensor technology

- The project is to **connect SC2, SC4 and SC6** by **leveraging on the quantum sensor technology**.
- In fact **the same QS technology** will be **integrated** into **different processing platforms** thus enabling **different applications** in **different SCs**

Quantum-sensors

highest precision & sensitivity for multi-physical characterisation to optimize systems on the edge

Quantum Sensor for multi modal, multi-physical, multi-scale measurements

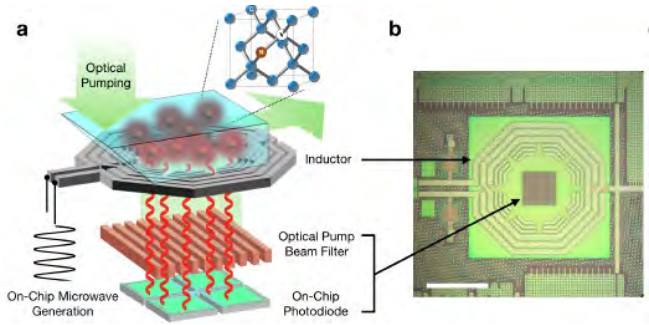


- Temperature (T)
- el. Current (I)
- el. Voltage (V)
- magn. Field (H)
- mech. Tensioning

Multi feature extraction for models

SC6

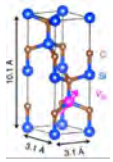
Development of the QS, HW interface and toolbox



FAU, EDI, I&M

SC2

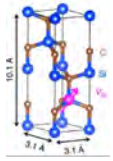
QS for detection of magnetic field orientation on UGV

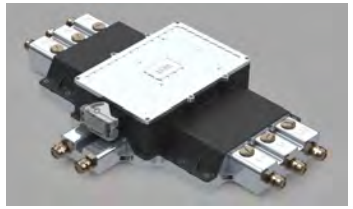


VIF, MUL, FAU, AIT, OTH, EDI I&M, UNIMORE

SC4

E-motor equipped with the quantum flux sensor





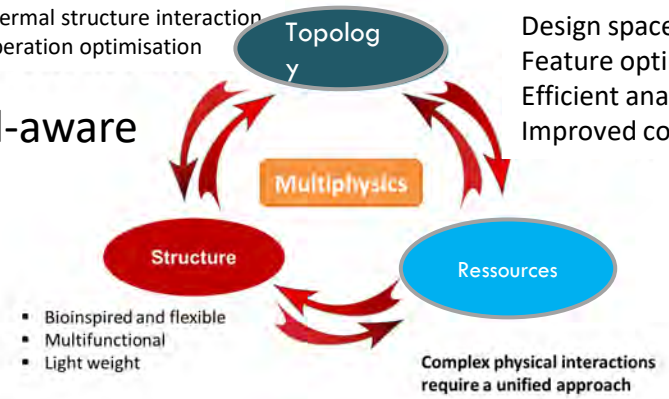
MBAG, HSO, AVL, BUT, I&M, UNIMORE

Reference architecture for resilient, collaborative reasoning driven by multi-physics in harsh environment

Fail-aware, predictive maintenance, self-diagnostic, self-monitoring, self-x, aprioi knowledge, empiric knowledge

Highest precise & sensitive, multi-physical Quantum-sensors to optimize the system on the edge

Advanced Performance
Thermal structure interaction
Operation optimisation

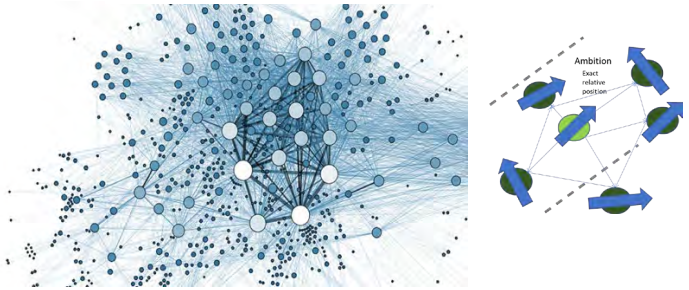


Design space exploration
Feature optimization
Efficient analysis
Improved control effectivness

Fail-aware

Resilient reasoning in Distributed, collaborative, autonomous organizations (multi-agent)

Network topology &
Non-hierarchical structure



Trusted AI / Federated learning

Intelligence for sustainability & civil safety in harsh environment

Design of sustainable systems on the edge with optimized operation

Trusted tools to built AI-platforms for safety critical sectors

Symbolische regression

Key digital technologies and novel ECS

Noah, Jossip, Mathias

AI-READY “edge technology”

Warum? 2-3 Seiten

The disruptive way to sustainability, resource souverainity and civil safety

X0.1

Final page:
Thank you very much,
Many greetings to Vienna