# *Visualising the Quantum Ecology*

*Sensing across Sights, Imaginations and Design*

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**Entangled Visions Workshop**
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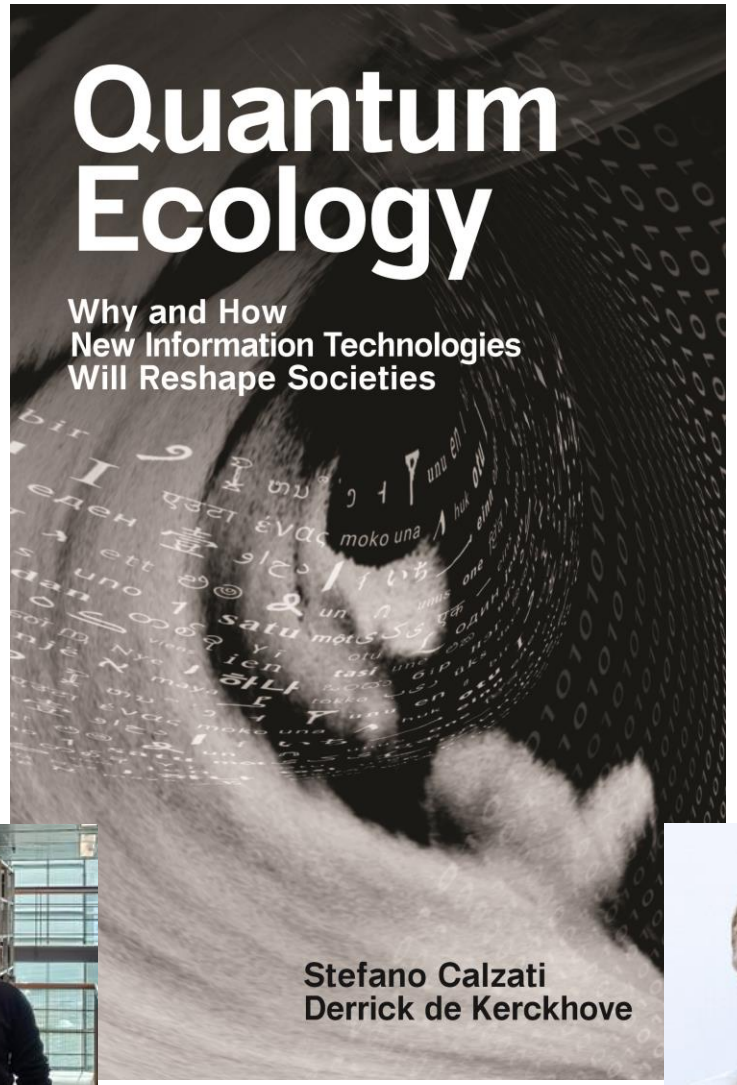
# Quantum Ecology

Calzati & de Kerckhove 2024, MIT Press

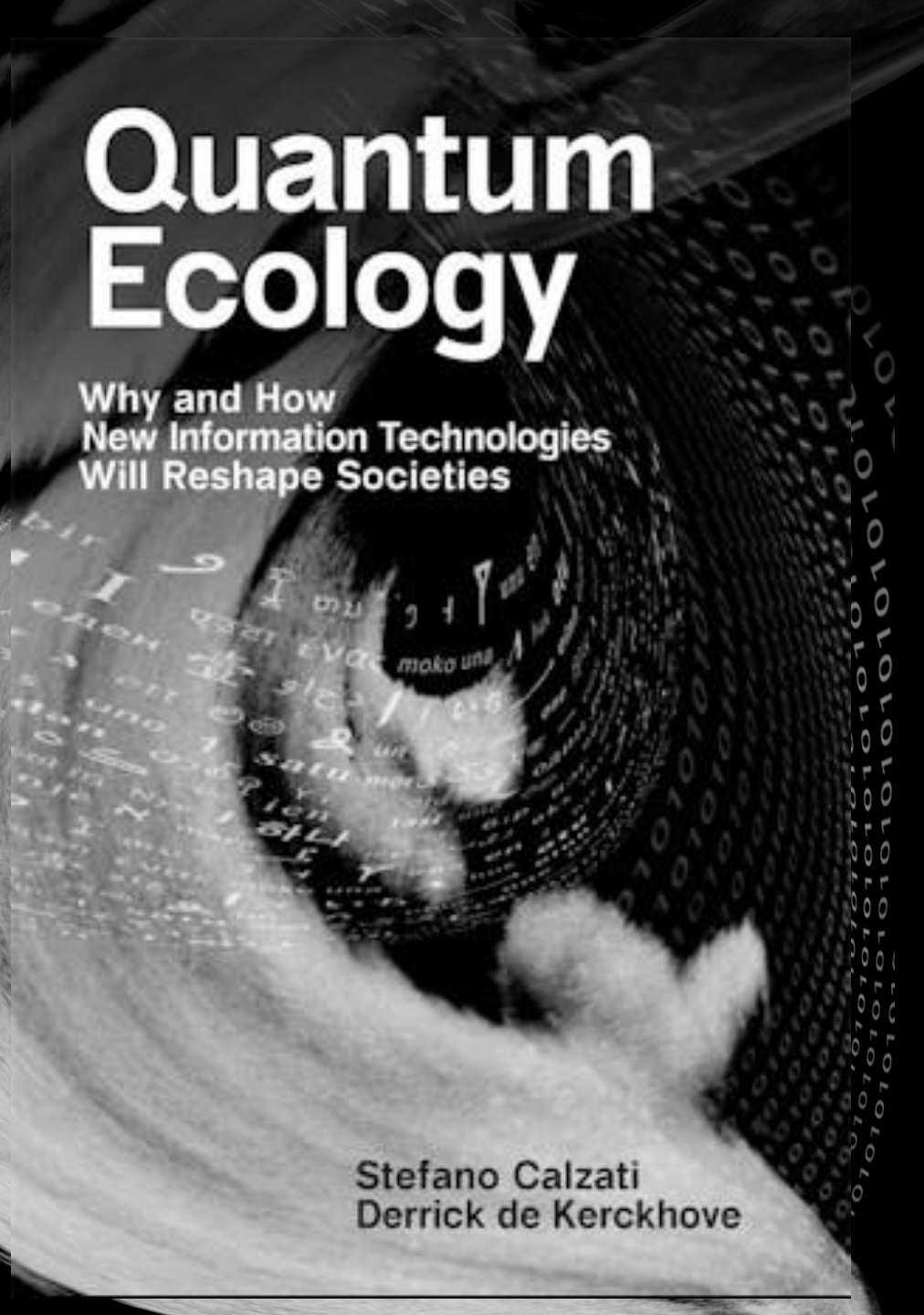



**Onto-epistemological framework**, whose pillars are, among others, entanglement, uncertainty, complementarity

**Technological paradigm**, pivoting around emerging Quantum Information Technologies (QITs)

"**An ecology has effects, but not causes**, at least not causes in the ordinary sense of a direct relationship between cause and effect."
(Calzati & de Kerckhove 2024)

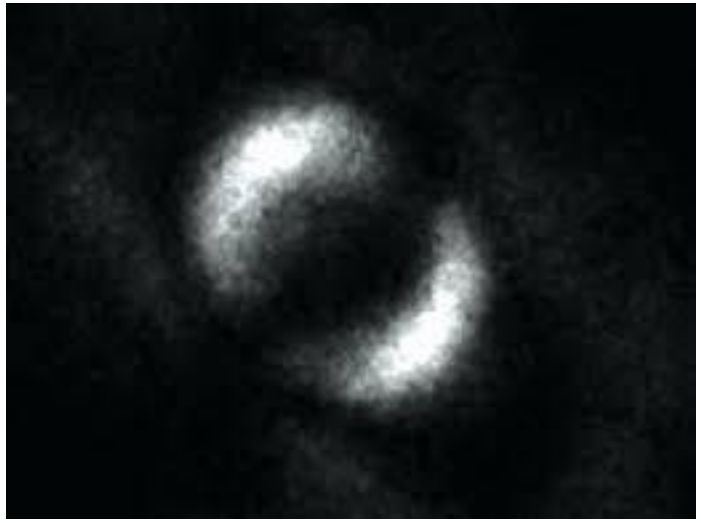
"A key teaching in design is how to **visualise abstract concepts**."
(Mi Lin, book cover's artist, Milandia 瀰瀾之域)



# What’s at stake

This talk weaves together **cognition**, **perception**, and **expression**, exploring *quantum-inspired* links across **sights**, **imaginations**, and **visualizations.**

How have we passed from these visualisations…



Entanglement (2019)

Black hole (2019)

# to these images?

What does it mean to eventually «**see**» – **beyond our sensorial faculties** – what we have so far only **cognitively imagined** and visualised through design?

# Sight vs imagination

"We have to remember that what we observe is not nature itself, but nature **exposed to our method of questioning**." (Heisenberg 1958)

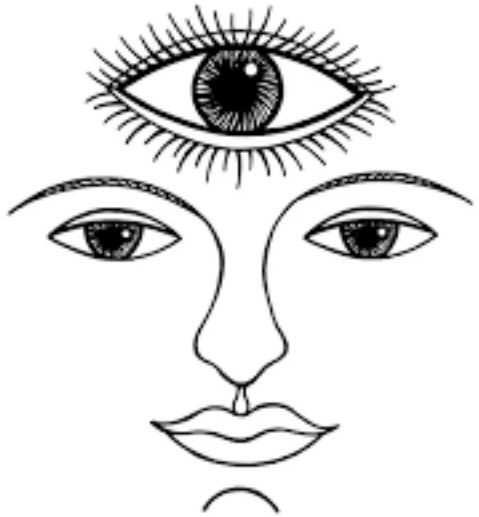
→ **sight** and **imagination** are **dispositif-dependent** and (partially) **incommensurable modes of experience.**

→ "translation" is possible but always as a **partial betrayal**

# To see…

Sight is a **prosthetic faculty**: it can be extended and enhanced, based on certain technological apparatuses

# To imagine…



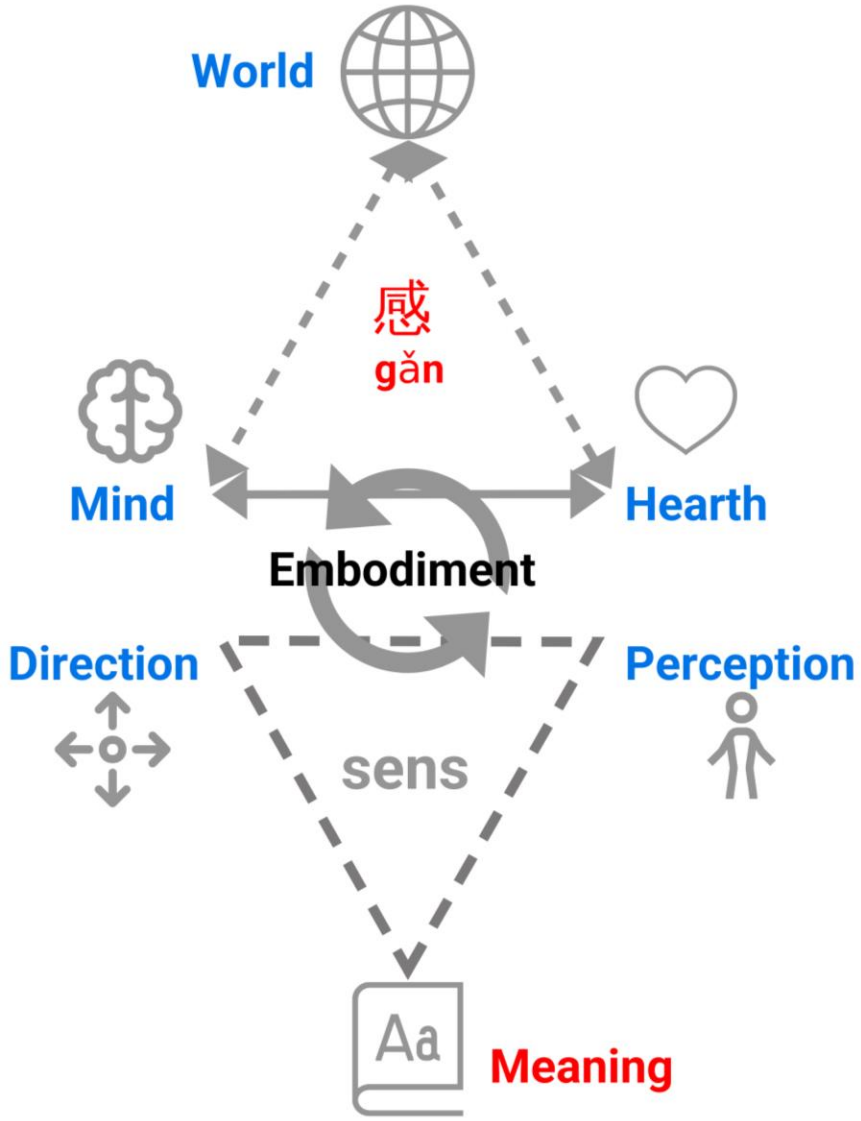
Imagination triggers **in-sights** rather than sights

- "**Creativity is not deductive, it is insight**… **We cannot find new features of the world** by deduction, induction or abduction. Insight is required." (Kauffman & Roli 2023)

- "**All theories are insights**, which are neither true nor false but, rather, **clear in certain domains, and unclear when extended beyond these domains**." (Bohm 1980)

# A synthesis

From world-*view*…




…to world-*sensing*

# Sens & 感

**Direction** & **Perception** are relative terms: they depend on a certain **point-of-being** in the world (de Kerckhove & Almeida 2016)

**Meaning**: frames (and is framed by) the other two

→"meaning as a **('sixth') sense modality for 'perceiving' psychophysical correlations**." (Atmanspacher 2020)

感 as: whole 咸 + heart-mind 心 = **whole cognition-moral attitude**

**Three compenetrating movements**: outside→inside; outside←→inside; inside→outside

# Emergent co-development

Sensing arises as the entanglement of the **I-world co-emergence**

Sensing is **expressed (meaningful) perception+cognition**

→"Consider a bacterium swimming up a glucose gradient. The sugar *matters* to the bacterium" (Kauffman 2019)

Being always already entails mattering/valuing, i.e., **sensing as embodied information processing**

# What kind of process is *being as sensing?*

1) It is “**technical**”

→ **Grasping of information:** any-thing exists out of an information symmetry breaking (Simondon 2020)

2) It is “**from within**”

→ Embodied information grasping always occurs **from within** (cf. the “blind spot” Frank et al 2024)

3) It is “**open-ended**”

→ the I-world co-emergence is “**unprestatable**” (Kauffman 2019)

4) It is “**autopoietic**” (Maturana & Varela 1987) + “**sympoietic**” (Haraway 2016)

→ the enactment of any ecology is “**collectual**”

# Unpacking the Quantum Ecology

# Three (technological) ecologies

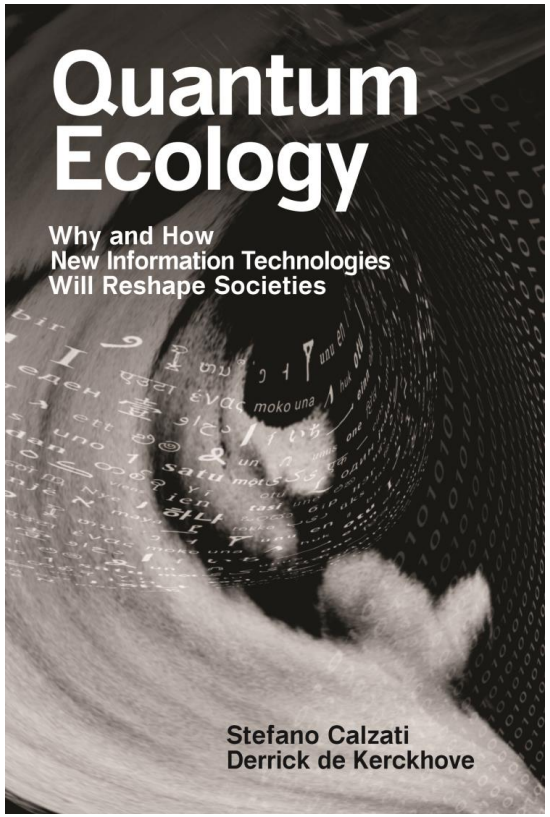
1) Language → based on **meaningful world-sensing** (e.g., alphabetic & logographic writing systems)

Partial onto-epistemological incommensurability (LLMs are here!)

2) Digital → based on **computable world-sensing** (formatting of «sensing» into 0s & 1s)

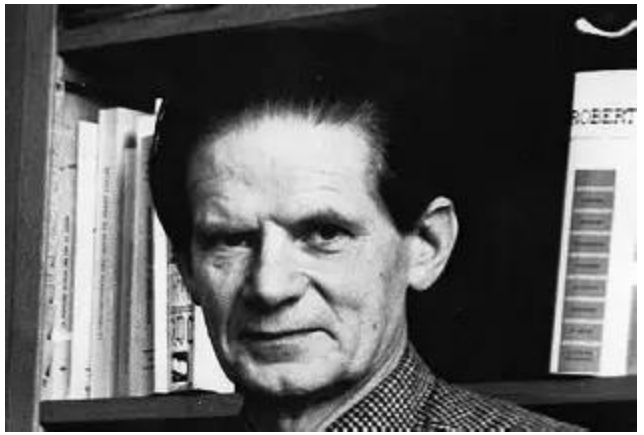
Partial onto-epistemological incommensurability

3) Quantum → based on a **probabilistic world-sensing** (synthetic sensing)



# (Embodied) language ecology

**Language is a technology of the mouth** as much as tools are technologies of the hands. (Leroi-Gourhan 1965)

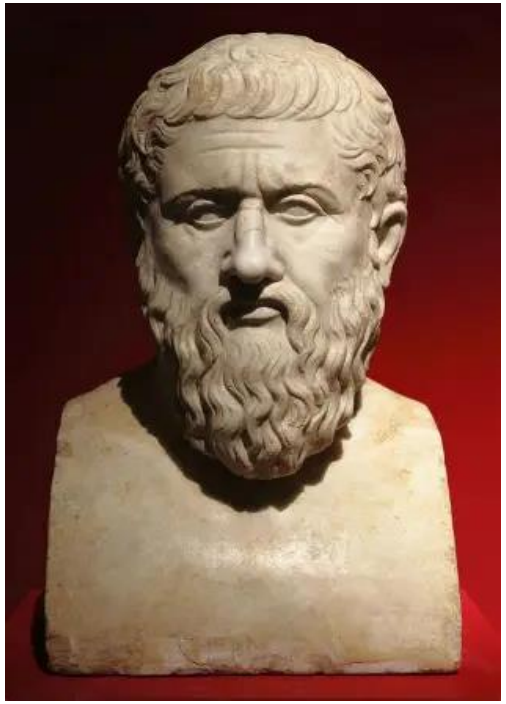


→ "**Language as a co-ontogeny**. With language arises the observer as a languaging entity" (Maturana & Varela 1987)

# Fixating language

"**Tell me** and *I'll forget*; **show me** and *I may remember*; **involve me** and *I'll understand*." Chinese proverb

"If men learn this [writing], it will implant **forgetfulness** in their souls. And it is **no true wisdom** that you offer your disciples, but only the semblance of wisdom, for by **telling** them of many things **without teaching** them you will make them seem to know much while for the most part they know nothing."
(Plato, *Phaedrus*)



# Writing as a technology of language

"Writing is the most momentous of all human technological inventions."
(Ong 1986)


→the fixation of sounds on supports that could overcome the time and space of oral contingency contributed to **restructure human cognition** (Havelock 1976)

# Alphabets and logograms

Writing systems' effects vary, contributing to shape **different techno-cultural fields.**

→Alphabetic systems represent **speech**; they establish an **arbitrary relation** between signifier and signified; the context (referent) is evoked **through** reading.

→Logographic systems represent **things or ideas**; each character condenses **shape, sound, and meaning**; the referent is **in** the character.

| English | Chinese Character | Pinyin |
|---|---|---|
| A | 诶 | ēi |
| B | 比 | bǐ |
| C | 西 | xī |
| D | 迪 | dí |
| E | 伊 | yī |
| F | 艾弗 | ài fú |
| G | 吉 | jí |
| H | 艾尺 | ài chǐ |
| I | 艾 | ài |
| J | 杰 | jié |
| K | 开 | kāi |
| L | 艾勒 | ài lè |
| M | 艾马 | ài mǎ |
| N | 艾娜 | ài nà |
| O | 哦 | ó |
| P | 屁 | pì |
| Q | 吉吾 | jí wú |
| R | 艾儿 | ài ér |
| S | 艾丝 | ài sī |
| T | 提 | tí |
| U | 伊吾 | yī wú |
| V | 维 | wéi |
| W | 豆贝尔维 | dòu bèi ěr wéi |
| X | 艾克斯 | yī kè sī |
| Y | 吾艾 | wú ài |
| Z | 贼德 | zéi dé |

# Writing systems as techno-cultural fields

Chinese language presents **higher usage efficiency** (requiring less cognitive effort), but **lower acquisition efficiency** (requiring longer time to learn it).

Alphabetic language is **easier to learn** but requires **more cognitive effort** to use.

→ Alphabetic speakers have a **more flexible inferential space in STM**; logographic speakers have **more stable knowledge in LTM** (Wang 2013)

# Linguistic metaphors

Metaphors are **sensing Gordian knots** expressing abstract ideas in figurative ways through embodiment

Time & space metaphors (Boroditiski 2010):

- English speakers visualise the past at the back and the future in front
- Chinese speakers are more flexible: they can face the past, with the future behind; they can also enact time as above (past) and below (future)

→Implications: if the link before-after is not an objective universal but a **linguistically embodied construct**, then causality gets relativized, depending on **how people sense "facts".**

# Expressing quantum through language

"A reliance on **nominal language** containing conceptual metaphors founded on the notion of **substance** and **entity renders misleading** any attempt to describe what amounts to **potentialities** of being" (Burwell 2018)

"Schrödinger, Bohr, and Heisenberg spent so much time talking about **why any attempt to describe quantum concepts in language was likely to end in failure**." (Burwell 2018)

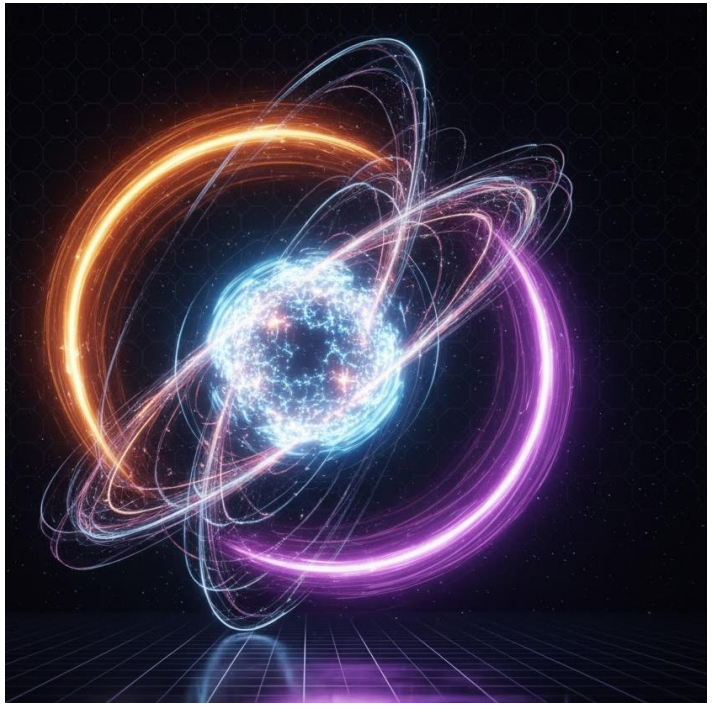
# To spin or not to spin

Particles' spin is… not *really* a spin

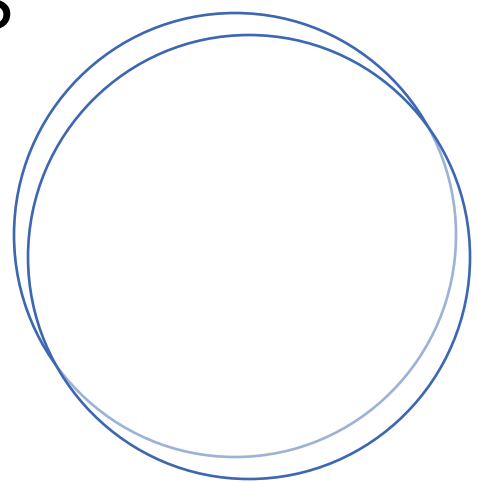
Spin is a **conceptual-linguistic proxy** (→ angular momentum)

- The idea of spin was introduced to describe a fourth degree of freedom of the electron (beyond the three-space dimensions), which Pauli defined as something "**which cannot be described from the classical point of view**."

→Language always provides a **certain** expression of the experience of the world – **but this also applies to mathematics!**



# On the limits of mapping territories



"Ordinary language is a map which has a **certain flexibility** so that it can follow the curved shape of the territory" In math "**the relation of the symbols to our experience is no longer evident**." (Capra 1976)

"The laws behind the number shall be inscribed in a **much wider context**, which includes **any possible sign** or forms of expression, of which is clear **the deficiency and inadequacy before the infinite sea of possible meanings**." (Zellini 2020)

→ Math as the **most imaginative** & **less sight-based** of all notation systems; yet, **always created, not discovered**: "while the number avoids meaning something, it cannot refrain from **being significant**, establishing a relation with the world." (Agamben 2025)

# At the roots of mathematics

**Neoplatonism**: numbers as a cognitively universal idea(l)s

**Neurobiology**: numbers as a sense encoded in the human brain (Dehaene 2011)

**Phenomenology**: number sensing as a cognitive-perceptual embodiment (Calzati & de Kerckhove 2025)

Language and math configure **complementary "fictionalisations"** (etymology: "models") of "reality".

# Digital ecology

- **Principle**: binary formatting of the sensible
- **Driving logic**: sheer efficiency
- **Effects**: global networkedness

→ The digital transformation has brought forth a **computability transition** that **challenges biological world-sensing**

# Practical Implications

Pervasive computing «**envelops**» (Floridi 2019) reality into an efficient scenario

Envelopment fits **computational agents** but less so **biological agents** "unprestatable", Kauffmann 2019)

→ implosion of the «rational subject»: **human agents as inherently inconsistent** (behavioural ethics; Pink et al 2024)

→These inconsistencies will exacerbate and multiply alongside the consolidation of **QITs** – such as ultraprecise quantum sensing – as forms of **diffraction** (Barad 2007) in the sociocultural realm of the **complementarity** between **computation and biological**

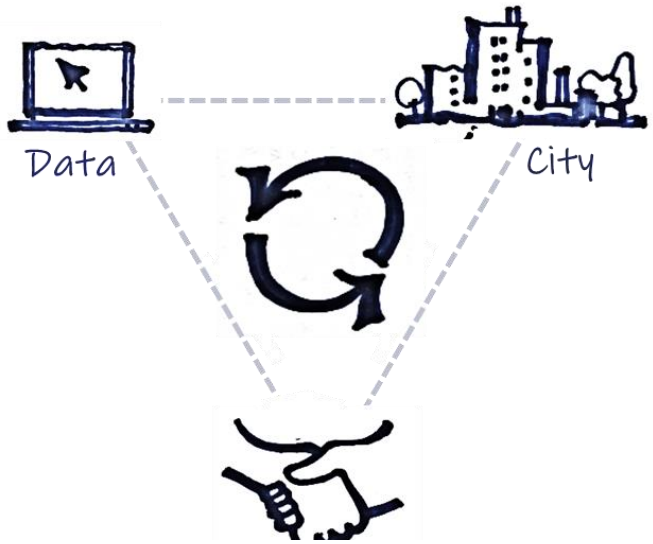
# Applying the Quantum Ecology Framework

# Ethics for the data driven-city

(Calzati & Ploeger 2024)

**Pillars**:

- Data as **sociotechnical bundlings**
- Ethics as a **collective ongoing practice**
- City as a **complex system**



# Problem-opening approach

**Transdisciplinary standpoint** (Nicolescu 2006):

- "Technology is neither good nor bad; **nor is it neutral**." (Kranzberg 1985) – Technology as *pharmakon*

→their use in complex scenarios produce **value-laden entanglements** (good **and** bad) **uncertain consequences** (intended **and** unintended)

**Goals (reflect, research, design):**

- Think critically about the **definition of problems** (beyond problem-solving)
- Translate such thinking into the **analysis of a case study** (TU Delft campus)
- Materialize the analysis into a **digital or physical artefact** (final assignment)

# Research & design

**Research**:

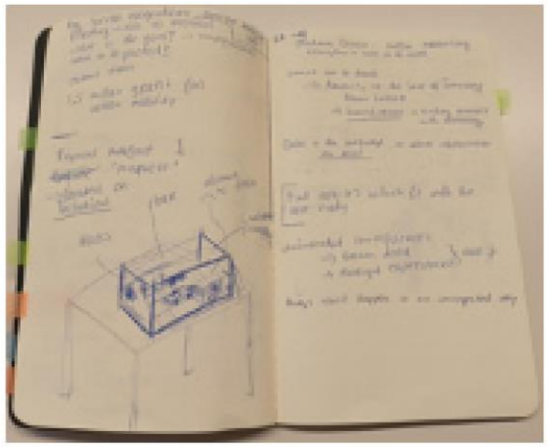
1) **Identification** of a case study
2) **framing** of the case study (e.g., how it is presented; how it works; etc.)
3) **data-value entanglements** (e.g., values in/excluded; data in/excluded)
4) **open-ended scenarios** (e.g., results and possible unintended consequences).

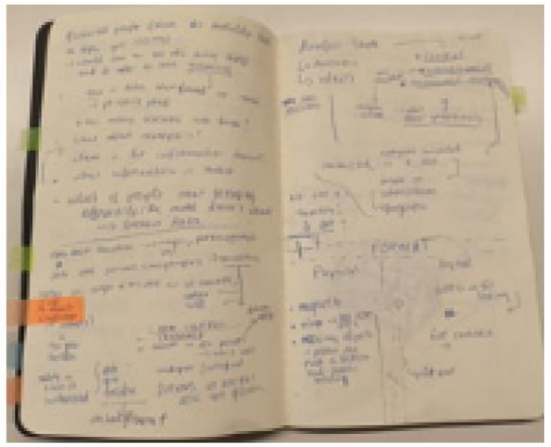
**Design**:

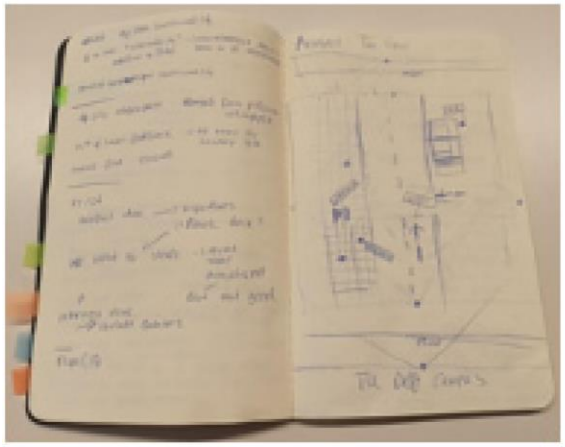
a) **project journal**

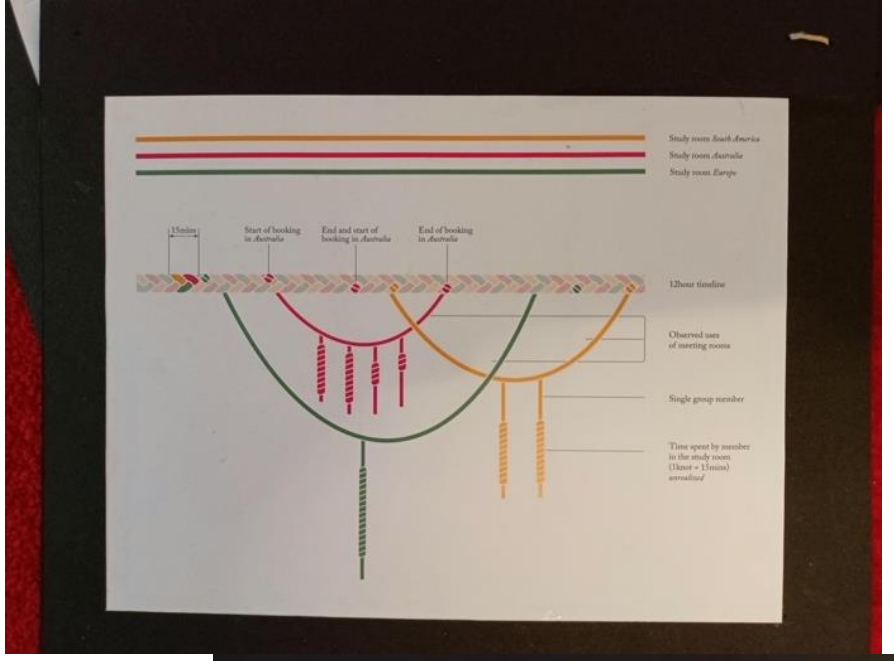
b) **artefact** (e.g., physical or digital object exposing and redressing the ethical tensions identified).

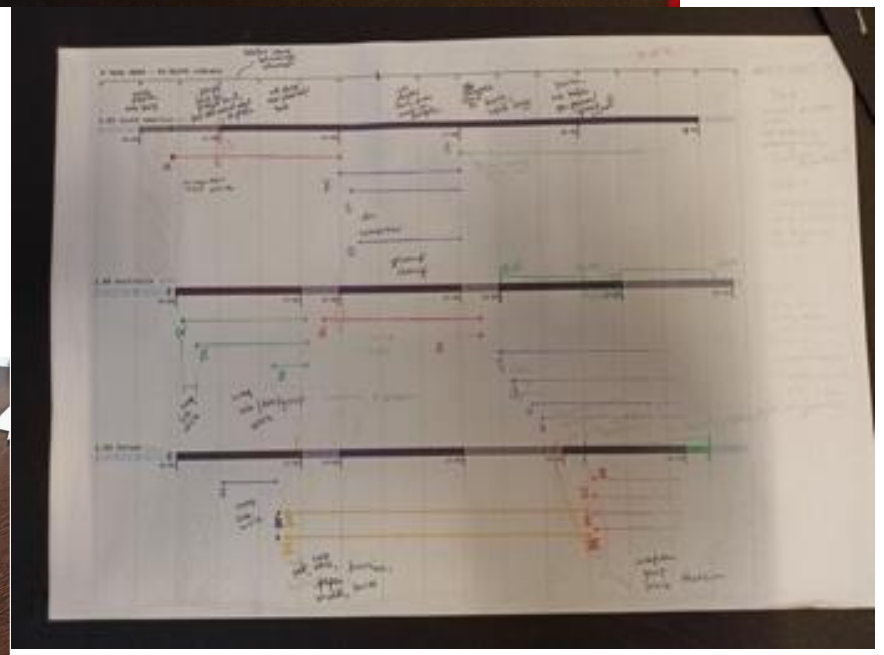
c) **author's statement** describing the artefact









“Design is **indeterminate** in order to be practical” (Easterling 2021)

# Challenging Visualisations

# Gearing up…

Every ecology is always **trans-ecological!**

Ecologies are **onto-epistemological configurations**: they coexist, overlap, nest into each others – but they are **neither coextensive nor coessential** (mutual irreducibility)

→ Each ecology **needs recursively other dispositifs to explicate itself**

“**At whatever size, all the partners making up holobionts are symbionts to each other**” (Haraway 2016)

# Ecology as a fractal hologram

A **fractal** is a pattern recurring progressively across scales
→ from the micro to the macro, **a fractal always already contains its own autopoietic be-coming**

In a **hologram**, «the whole is present in the parts, not made up of them" (Wendt 2015)
→ the **parceling of the whole and its own whole-making coexist**

# Some ideas in the making

**If being is sensing**, then

- Ecologies are not connected as if in a network; they are **nested into each other**, through a mutually implicated order of emergence (Bohm 1980)
- Yet they also maintain a **degree of relative autonomy** among them ("lumpability" of complex systems, Rosas et al 2024)
- This autonomy is a **discretional configuration** (Gershenson & Heylighen 2003) and **mappings** across configurations are possible
- From within, each ecology **emerges as a happening**: its becoming can be qualified – i.e., spatio-temporally – through **intra- and inter-ecological comparisons**

# How to visualise ecologies as fractal holograms to yield insights into the nature of reality?

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# Thank you!

https://stefanocalzati.com

*Digital Society* upcoming issue

Untangling the Quantum Ecology:
Charting the Impact of Quantum Theory and Quantum Technologies on Technoscience and the Digital Transformation