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Macroscopic Quantum Mechanics and the SoSE Design Approach

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This talk will present a possible research program

Some Instances of Super Systems

- Language (alphabets; words, sentences)
- Natural Kinds (tables; chairs; trees; etc.
- Complex Systems (weather; eco-systems)
- Technology (*All* machines)

What is a super-system?

I shall discuss this topic from a few different angles

Part/Whole Relations

Mereology : "The relations of part to whole and the relations of part to part within a whole"

The 'Whole' is:

- "nothing but the parts and their interaction"
  - Classical Reductionism
- "more than the parts"
  - Emergence; Complexity theory

- "Different from the parts"
  - Macroscopic Quantum Mechanics (MQM)

Super-System Identity Defined in terms of

- Relation between its parts – Classical SoSE

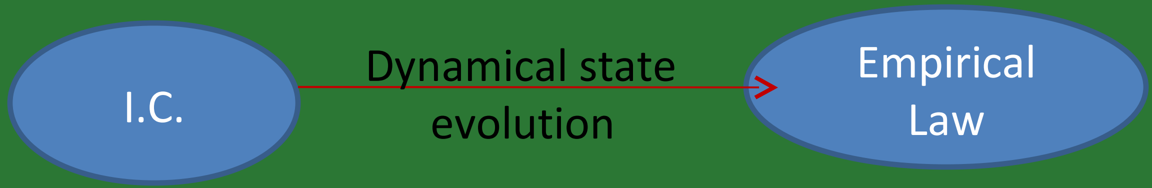
- Relation between the Super-system and its environment
  - SoSE under MQM

The ‘environment’ is that *part of the world with respect to* which the super-system carries out its *function*

- A super-system of UAVs functions as a complex reconnaissance vehicle in relation to the terrain it surveys

- A robot designed to navigate space functions as such in relation to the terrain it is required to navigate

Newtonian Mechanics



F = ma   Describes the evolution of initial conditions

Given a set of initial conditions, all acts of the experimenter play no causal role within the theory. For example,

- Our free choices about *which measurement* to carry out do not change the equation of motion

- The fact of our experiencing the observations are not part of the theory

Both of the above are not true in quantum mechanics

SQM – Foundational problems

$\Psi(x,t)$ - Probability density

$$\int_x^{x+dx} \Psi\Psi^* \, dx$$ - Probability (Area under the curve)

Probability of finding a particle *at a point* is vanishingly zero. Thus, a quantum object can be detected only in a finite spatial interval.

The Schrödinger's equation is linear . If α_1 and α_2 are solutions, then $\Psi = \alpha_1\psi_1 + \alpha_2\psi_2$ is also a solution, *simultaneously.*

Measurement Problem: An observation does not correspond to all three. Consequently, the world has to be divided into two parts, one that is unobservable and corresponds to Ψ, and another part that is observable and corresponding *one* of the eigenstates

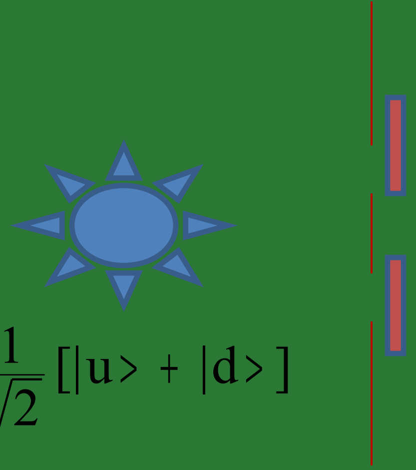
QT and Human Experience

Ψ —*x*-observable→ The quantum state evolves in *x*-space

Ψ —*p*-observable→ The state evolves in *p*-space

Classical coin tossing → In the air, result Indeterminate → On the ground; result determinate, not known → We observe; result determinate and known

quantum coin tossing



$$\frac{1}{\sqrt{2}}\,[\,|u> + |d>\,]$$

$$\frac{1}{\sqrt{2}}\,[\,|u>\,|D_{top}> + |d>\,|D_{bottom}>\,]$$

Our experiences are part of the theory, *if* we are to predict definite outcomes

QT and Human Experience . . .

Current Responses

- Quantum measurement is same as classical; interaction with a macroscopic measuring device brings about a definite outcome; Macroscopic world is ‘classical’ (in principle – Bohr; FAPP- Bell)
- Quantum measurement process is non-classical; mind-matter interaction is involved (von Neumann; London & Bauer; Wigner; Stapp; Goswami; Penrose]
- None of the extant interpretations have won universal acceptance. They are all compatible with the predictions of QT, but none is entailed since none make new predictions. In addition, none leaves us with the feeling of quantum theory being now “understood”
- The issue of the ontological content of quantum theory must be said to be unresolved.

QT and Human Experience . . .

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My Proposed Response

- Quantum theory describes physical reality in terms of certain "phenomenological aspects" of our experience. Hence a conscious registration of the outcome is required before we can talk of the objective reality underlying the outcome

Links to SoSE design

Some of My References

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(2004) “Physics and Commonsense—Relearning the Connections in the Light of Quantum Theory.” In D.P. Chattopadhyaya, & A.K. Sen Gupta (eds), 2004, *Philosophical Consciousness and Scientific Knowledge*, CSC: New Delhi:, p. 179-207.

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"It is probably justified in requiring a transformation of the image of the real world as it has been constructed in the last 300 years, since the re-awakening of physics, based on the discovery of Galileo and Newton that bodies determine each other's *accelerations*. That was taken into account in that we interpreted the velocity as well as the position as instantaneous properties of anything real. That worked for a while. And now it seems to work no longer. One must therefore go back 300 years and reflect on how one could have proceeded differently at that time, and how the whole subsequent development would then be modified. No wonder that puts us into boundless confusion!"

[Erwin Schrödinger, Letter to Einstein, 18 November 1950]

Introducing MQM

The Schrödinger equation (SE) is applicable, in principle, equally to the micro and macro regimes. Furthermore, any application of the Schrödinger equation to the micro realm properly depends on our ability to apply the SE to the macro realm since our observations are always at the macroscopic level.

However, Born's rule is so contrived as to link the wave function to the realm of observations interpreted classically. The measurement problem is a direct result of this approach.

Thus, the application of the Schrödinger equation to the *macroscopic* regime in a manner such that (a) is independent of the current microscopic quantum mechanics, and (b) does not reduce to classical description at the point of observation is an outstanding, and more fundamental problem than the measurement problem.

I call this Macroscopic Quantum Mechanics (MQM)

Introducing Physical, Relational Properties

Primary Properties – Properties that an object will have, independent of all other objects and conscious observers (mass, position, velocity etc. Entirely a function of the classical matter content of the object.

Relational Properties – Properties that an object will have, only in relation to other objects (paperweight, doorstop, blackbody)

Secondary Properties – Properties that an object will have, only in relation to *any* conscious observer (color, taste, smell, hardness, wetness etc.) Partially reducible to primary properties with predictive but no explanatory capacity.

Subjective Properties – Properties that an object could have, only in relation to *a* conscious observer (good table, bad location)

Note: *All these, including primary properties, are epistemically relational*.

Physical, Relational Properties (RPs) . . .

The idea behind MQM is that the properties corresponding to the quantum mechanical observables are RPs. RPs answer to all the features of the quantum formalism.

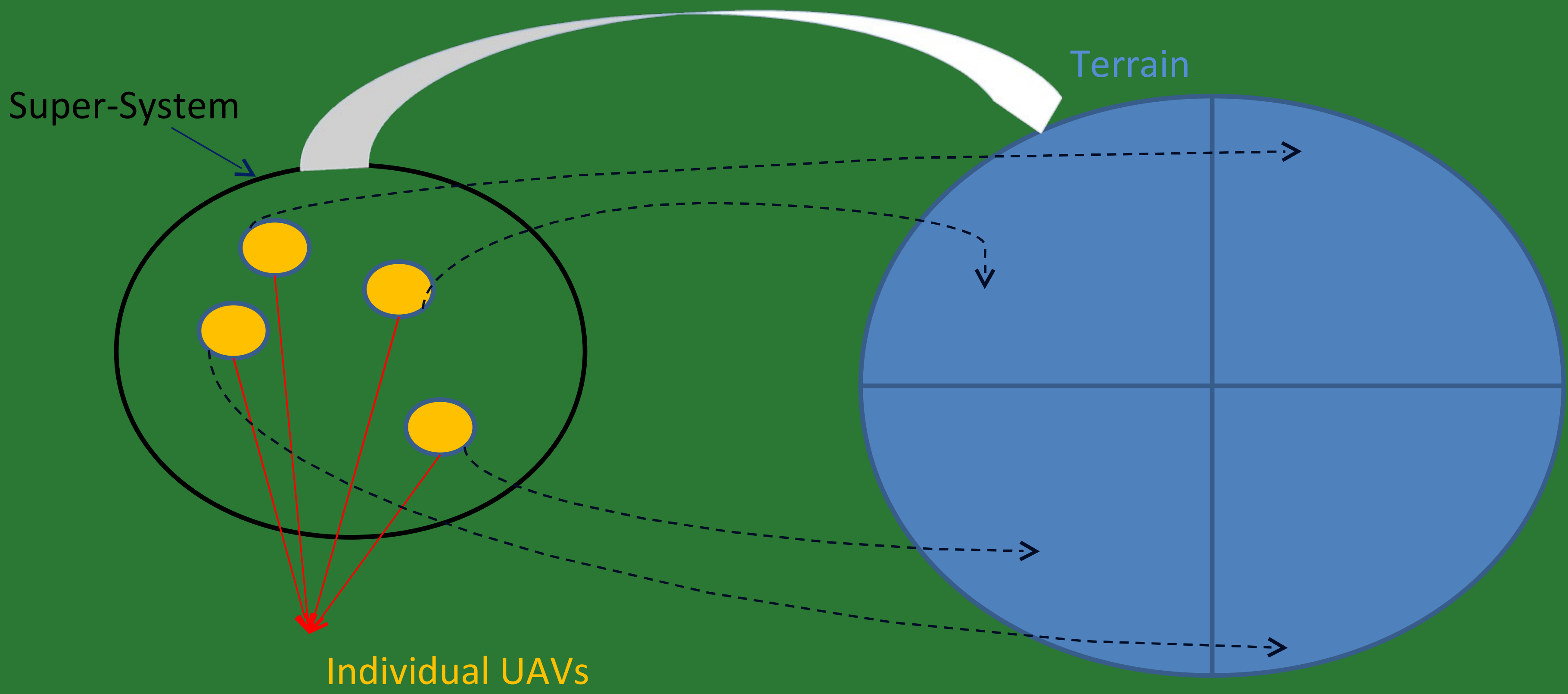
Whereas current SQM tries to apply the quantum state to the *detector* in interaction with a microscopic quantum particle, MQM will apply the quantum state to the macroscopic *source.* RP makes this possible.

An RP is a direction-oriented property.

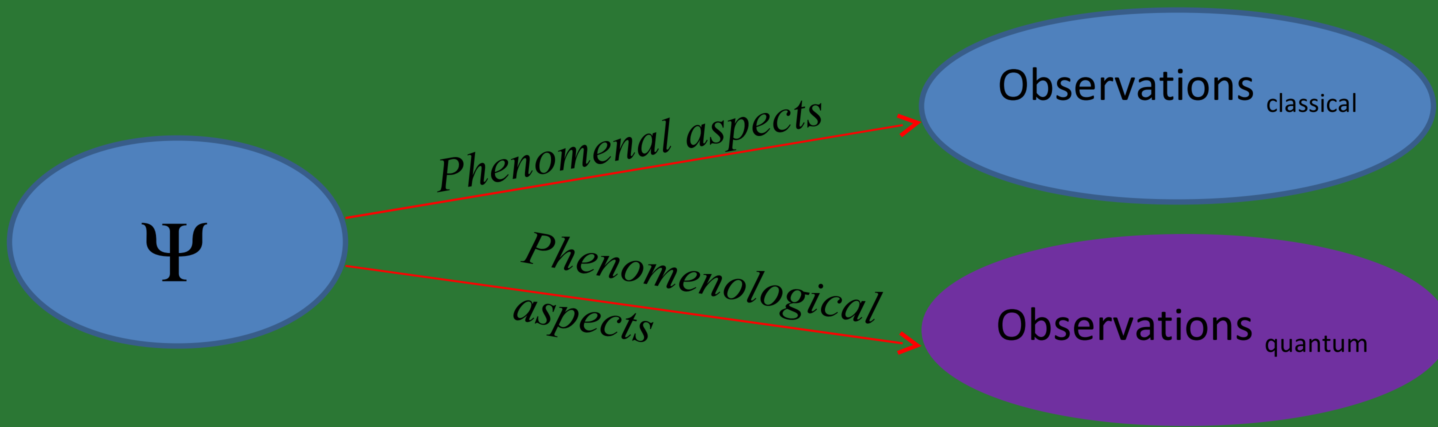
The quantum state is a ray in the Hilbert space. A ray ψ and $k\psi$, where is a k is *any* scalar, will represent the *same, identical quantum state.* We can therefore conclude that the quantum mechanical state is essentially a pure "direction-based" property i.e an RP.

Thus, MQM will give a non-classical description of a super-system, namely the source, in terms of its purely direction-based properties in relation to another macroscopic body or region.

MQM and SoSE



MQM …



"The top detector clicked" – *Our Experience*

SQM : Location where the click occurred (phenomenal aspect)
Sound is taken to have been produced in the world.

But such 'sound' is a primary property (wave length/frequency)
SQM can afford to ignore how our observation experience arises

But slide #11… Our experience is an integral part of quantum theory.

MQM : Relate to the phenomenological aspects
sound quale exists <u>*in*</u> the world

Generalizing, qualia underlying the 5 sense modalities exist in the world

MQM's treatment of 5 sensations …

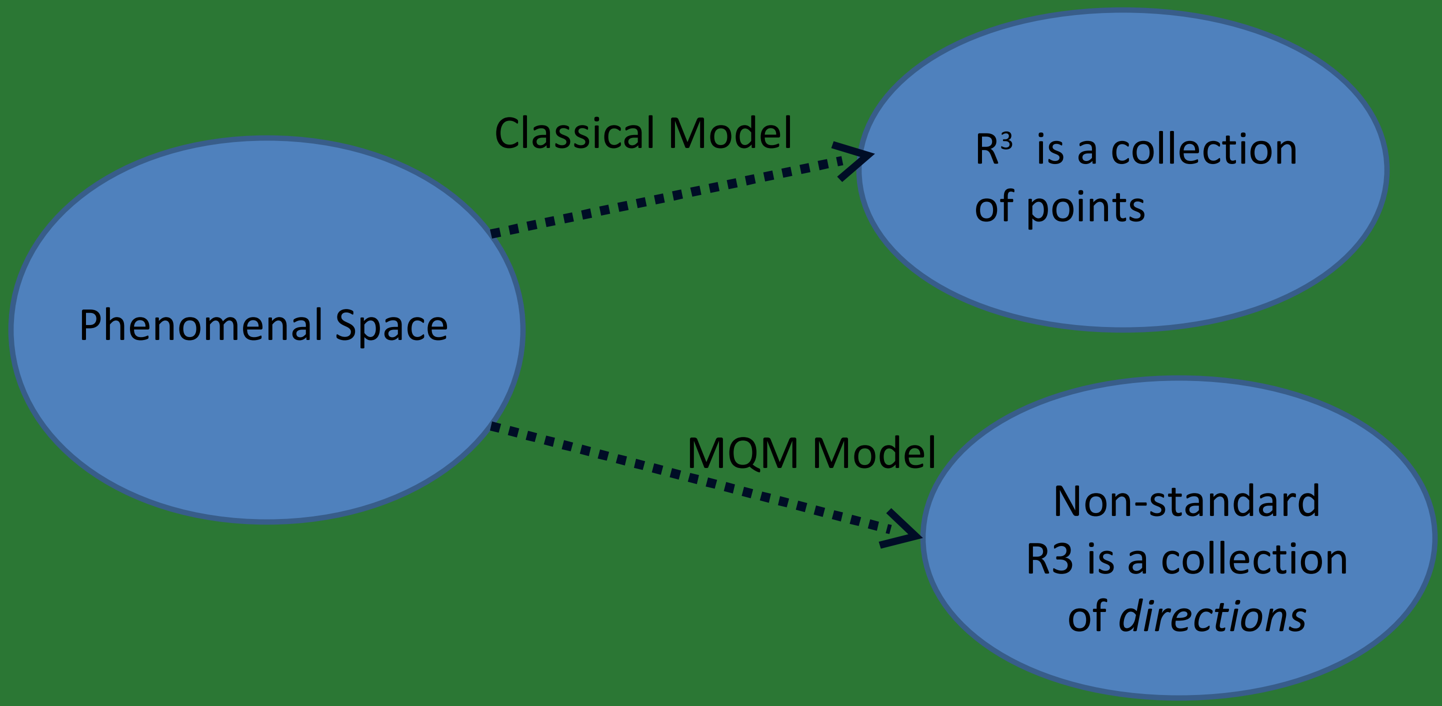
The relevant insight of MQM here is the recognition that all aspects of our experience are qualitative. The experience of "position" is as qualitative as the experience of "sound". It is a relation between the observed system and a subject.

Thus, the mathematical idea of a point in Euclidean space is the objective counter-part of position experience. In SQM the same idea is retained when the 'sound' heard is interpreted as revealing a location where the detection event occurred.

In MQM, however, the qualitative aspect of 'sound' is sought to be objectified, <u>*not*</u> as a point but as a *direction. How?*

In classical physics, 'position' is objectified by replacing the subject by a standard scale. "Sound" is a relation between some objective situation and the observing subject in MQM. The subject is replaced by treating 'sound' as a relation between the observed system and the macroscopic detector.

MQM's model of space



A 2-tuple (x_1, y_1) will denote a "classical vector" – having length and direction in the same space.

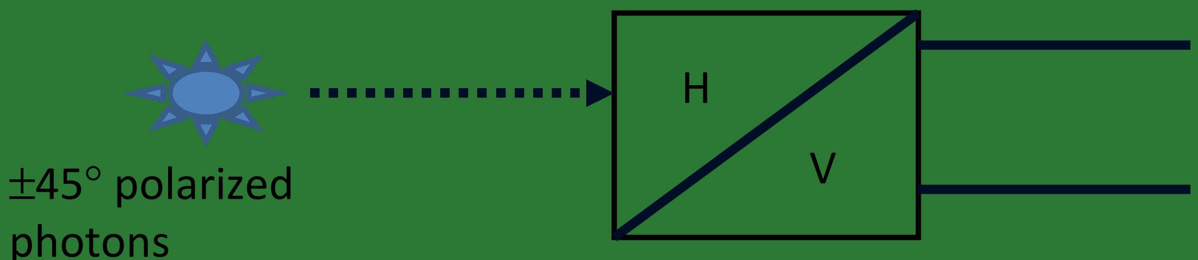
A 2 –tuple of the form (x_1, iy_1) will denote a scalar and a direction, but in two different spaces, the former in standard R^3, and the later in non-standard R^3. i will continue to represent a rotation, but now between these two spaces.

MQM – In Essence

By the combination of RP viewpoint and treating our observation experiences as corresponding to *objective qualia* in the world, MQM is able to give a quantum mechanical treatment of the macroscopic source in relation to the macroscopic detector.

In such a world of MQM, a macroscopic object is essentially characterized by physically real properties that express its relation to the world that correspond to how we experience the world through the five sense modalities. It is an intrinsically semantic model of the macroscopic objects interacting with a well-directed part of the world.

Will we need to build macroscopic machines from scratch based on MQM or simply use the existing machines, reinterpreting them as per MQM?



MQM – The Road Ahead

Philosophy

- P-mode R-mode distinction in ordinary language
- Tandem Realism
- OBJECT-KIND distinction
- Quantum haecceity

Mathematics

- Lowenheim -Skolem theorem
  - Non-standard numbers
  - Non-commutative Arithmetic
- Exotic manifolds; Hilbert space without function spaces

Physics and other fields

- Quantum mechanical observable Relational Properties
- Motion *qua* single integrated experience
- Quantum kinematics

The “Gap” between MQM and SoSE

Macroscopic Machine
Classically constructed

Machine to be interpreted under MQM

THE GAP

MQM in physics can at best give a quantum view of a simple macroscopic object

But… RPs for different systems will be different. Thus, application of MQM in different fields can proceed in parallel.

MQM based SoSE design – A Preliminary Conception