

# Worldly Patterns

Emergence, Functionalism and Pragmatic Reality in David Wallace's presentation of Everettian Quantum Mechanics

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June 30, 2023

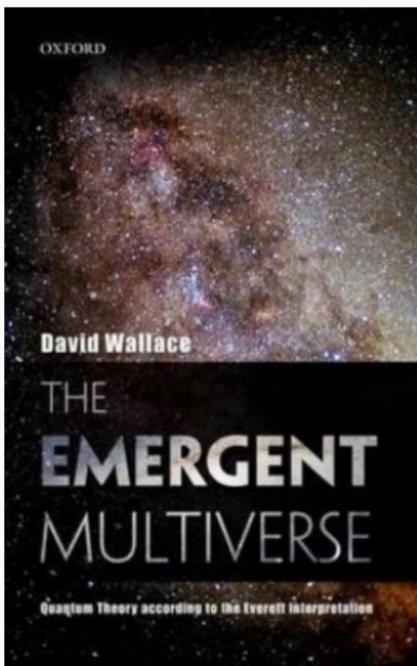
History & Philosophy of Science - Universiteit Utrecht

# Wallace's *The Emergent Multiverse*<sup>1</sup>

Long history since Everett's (1957) →

Finally, one complete vision to criticize:

- A **Multiverse!** Why?
- What kind of **Emergence?**
- Why **the?**  
→ Reality of worlds and functionalism



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<sup>1</sup>I focus on part *I* of the book, completely ignoring the question of the Born Rule and probabilities of part *II*.

5. Measurement Problem & **Multiplicity**

4. **Emergence** of worlds: Weak or Strong ?

3. Functionalism and **Dennett's criterion**: How *Real* are these worlds?

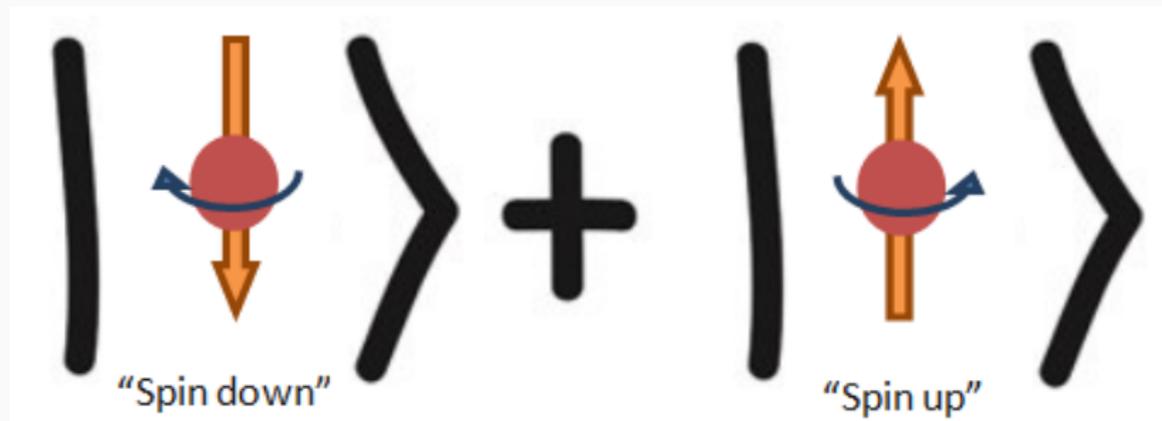
2. **Pragmatics**: analogy with van Fraassen's 'pragmatic explanation'

1. Possible foil: **Many Minds?**

## 5. Measurement Problem and **Multiplicity of Worlds**

# A Wavefunction in Superposition

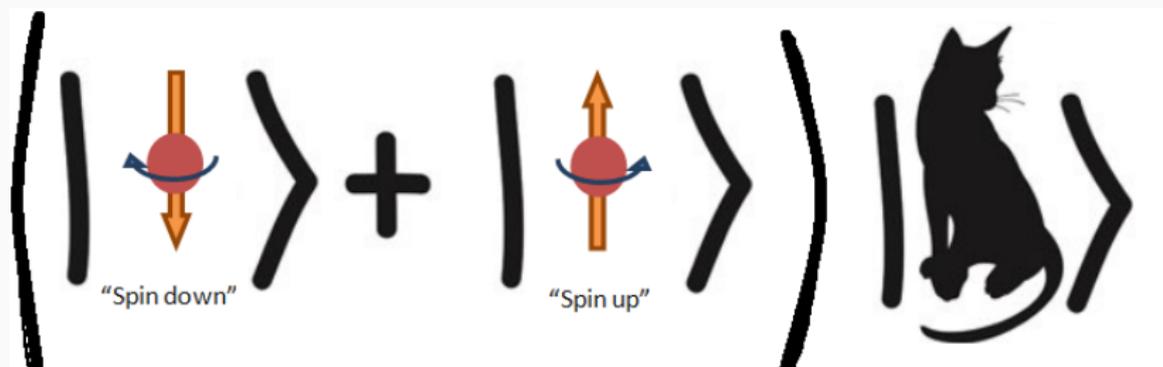
Mutually exclusive properties in quantum mechanics (QM)



Measurement problem: "Both up and down" → "Either up or down"

# Famous and Intuitive example: Schrödinger's Cat

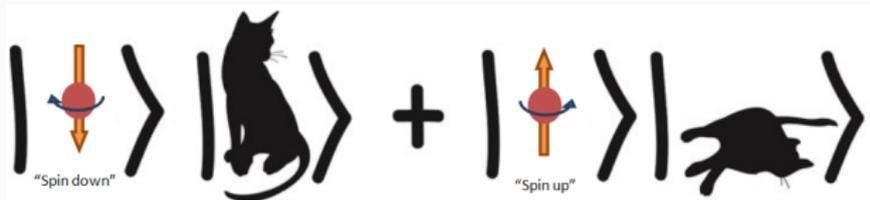
Interaction between micro-world and macroscopic object



Spin of electron *entangled* with (awake, not asleep) cat

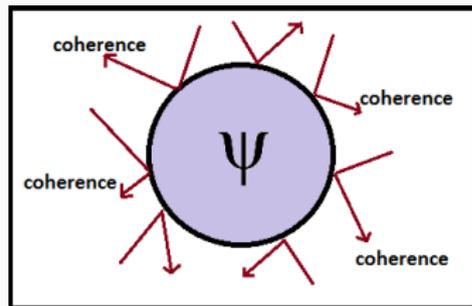
# Multiplicity through decoherence

Mutually exclusive macroscopic properties (measurement problem)



Macro-level: **decoherence** →  
*approximately* no interference in  
*decoherence basis*

$$\rho(x, x') \rightarrow \rho(x, x') \exp -\Lambda t(x - x')^2$$



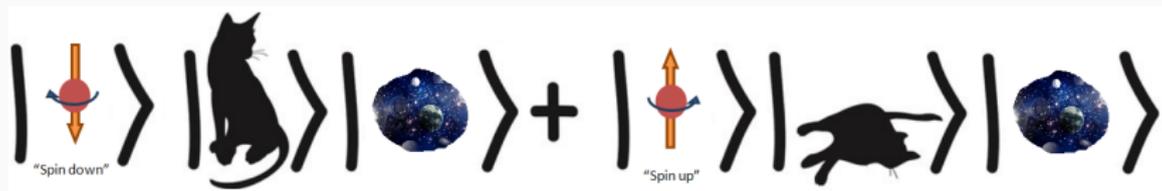
**Figure 1:** Rapid diluting of entanglement over the environment

# Multiplicity of 'worlds'

Further entanglement with environment: large independent branches

“[s]uperposition has become multiplicity at the level of structure”<sup>2</sup>

Result of dynamical laws: other interpretations *add* to this.



- Taking QM literally (Everett-style)! → quasi-classical worlds
- Functionalist leap: Duoverse *emerges* → ~~quasi~~-classical worlds

<sup>2</sup>Wallace, *Emergent Multiverse*, p. 61.

## 4. Emergence



Let's learn everything there is to learn about this bird!

## 4. Emergence



Surprise!

# Weak versus Strong Emergence

- **Weak emergence:** high-level phenomenon are *unexpected*<sup>3</sup> and *autonomous*<sup>4</sup> w.r.t. underlying low-level principles
- **Strong emergence:** truths concerning that phenomenon are *not deducible even in principle* from truths in the low-level domain (even a Laplacian demon would not find it)



**Figure 2:** Tornado: weak emergence.



**Figure 3:** Consciousness: strong emergence?

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<sup>3</sup>David J. Chalmers, "Strong and Weak Emergence" in *The Re-emergence of Emergence* (Oxford: Oxford University Press, 2006).

<sup>4</sup>Mark Bedau, "Weak Emergence," *Philosophical Perspectives*, 11: *Mind, Causation, and World* (Oxford: Blackwell, 1997).

## Weak or Strong Emergence of Worlds

- Result 1: Quasi-classical worlds weakly emergent from unitary dynamics: *autonomous* and (plausibly) *unexpected*: Laplacian creature has no trouble deriving them
- That's good! Wallace would not want strong emergence → worlds should be like other macroscopic objects, like tables or tigers

But! Wallace argues for *real* classical worlds—be careful not to tip the balance towards strong emergence

### 3. Functionalism



**Figure 4:** duck



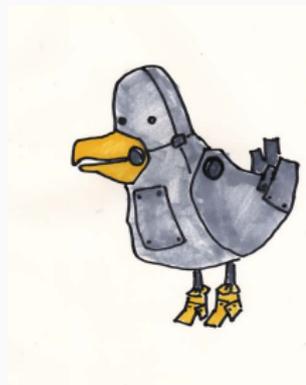
**Figure 5:** the same (?) duck

If it looks like a duck, swims like a duck, and quacks like a duck, then it *probably is* a duck

### 3. Functionalism



**Figure 6:** duck



**Figure 7:** the same (?) duck

If it looks like a duck, swims like a duck, and quacks like a duck, then  
it *might not be* a duck

Wallace's 'Dennett's Criterion':

*A macro-object is a pattern, and the existence of a pattern as a real thing depends on the usefulness – in particular, the explanatory power and predictive reliability – of theories which admit that pattern in their ontology.<sup>5</sup>*

Note three things:

1. Higher-level theories
2. Pragmatic values
3. The realist language

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<sup>5</sup>David Wallace, "Everett and Structure," *Studies in History and Philosophy of Modern Physics* Vol. 34, (2003), p. 93.

## Dennett's Criterion applied to quasi-classical worlds

Applied as:

*A quasi-classical world is a pattern, and the existence of a worldly pattern as a real classical world depends on the usefulness – in particular, explanatory power of classical concepts and robustness under decoherence – of classical physics which admits the pattern of a classical world in its ontology.*

From quasi-classical to 'real'!

## A closer look at functionalism:

*A macro-object is a pattern, and the existence of a pattern as a real thing depends on the usefulness – in particular, the explanatory power and predictive reliability – of theories which **admit that pattern in their ontology**.*<sup>6</sup>

- Higher-level theories

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<sup>6</sup>David Wallace, "Everett and Structure," *Studies in History and Philosophy of Modern Physics* Vol. 34, (2003), p. 93.

## Higher-level theories: Trading predictive power for accuracy

- Zoology admits tiger-pattern into its ontology
- Zoology is a higher-level theory more useful than QM to make predictions
- The language of zoology is more explanatory than QM: 'the tiger is hungry' works better than 'the equations of motion show that ...'

What goes for tigers goes for worlds: classical physics more useful (deterministic) and more explanatory (cf. Bohr)



**Figure 8:** Don't use quantum mechanics to predict what will happen to you in this situation.

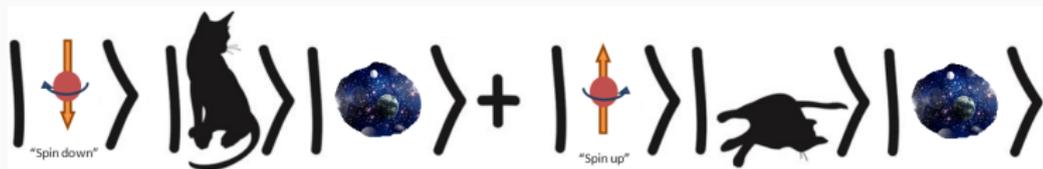
# Intertheoretic reduction of CM to QM,

Weaker version of Nagelian reduction: *derivation + bridge laws*

→ Quantitative match: pattern-matching through instantiation  
(decoherence only FAPP)

→ Qualitative match: patterns don't explain, concepts of higher-order theories do

Instead of an ontological picture like universal  $\Psi$ :



We have a multiplicity of *real* classical worlds:



## 2. Pragmatic factors and Context

*As in all explanations, the correct answer consists in the exhibition of a single salient factor in the causal net, which is made salient in that context by factors not overtly appearing in the words of the question.*

— Bas van Fraassen<sup>7</sup>

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<sup>7</sup> Bas C. van Fraassen (1980), *The Scientific Image* (Oxford: Oxford University Press, Reprinted 2013), p. 132.

## A closer look at functionalism: Pragmatics

*A macro-object is a pattern, and the existence of a pattern as a real thing depends on the **usefulness – in particular, the explanatory power and predictive reliability** – of theories which admit that pattern in their ontology.<sup>8</sup>*

Note three things:

- Higher-level theories
- **Pragmatic values**

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<sup>8</sup>David Wallace, "Everett and Structure," *Studies in History and Philosophy of Modern Physics* Vol. 34, (2003), p. 93.

# Van Fraassen's pragmatic theory of explanation: *context!*

Van Fraassen claims that explanation is

- not a two-place relation between theory and fact
- a three-place relation between theory, fact, and context
- not a goal of science, but antropocentric desire to answer 'why-questions'



**Figure 9:** Science = web of causal relations.

One 'thread' in the causal web is 'highlighted' or made salient by a specific question.

# Why does the bus stop?

*If the answer is satisfactory depends on the pragmatic goals of the human questioner.*

- Because of the hydraulic brake mechanism



**Figure 10:** Why does the bus stop?

# Why does the bus stop?

*If the answer is satisfactory depends on the pragmatic goals of the human questioner.*

- Because of the hydraulic brake mechanism
- Because Otto Mann steps on the brake



**Figure 11:** Why does the bus stop?

# Why does the bus stop?

*If the answer is satisfactory depends on the pragmatic goals of the human questioner.*

- Because of the hydraulic brake mechanism
- Because Otto Mann steps on the brake
- Because of friction



**Figure 12:** Why does the bus stop?

# Why does the bus stop?

*If the answer is satisfactory depends on the pragmatic goals of the human questioner.*

- Because of the hydraulic brake mechanism
- Because Otto Mann steps on the brake
- Because of friction
- Because Bart needs to go to school



**Figure 13:** Why does the bus stop?

# Salient Structure and the Anthropic Principle

Quasi-classical pattern preferred by decoherence, but not more *real* by itself → smeared-out patterns just as real

Fundamental democracy of bases in Hilbert space: stressed by Everett (who was not a realist) with the **relative state**

Classical basis/pattern **subjectively motivated** as useful:

→ classical concepts (explanatory, cf. Bohr) predictions.

→ determinate (predictability)

Why do the classical basis and the decoherence basis coincide?

Maybe some anthropic reason?: In the *context of our existence* the classical pattern becomes salient, à la van Fraassen's causal web

1. **Many Minds** - a possible foil for the *reality* of classical worlds?

## A closer look at functionalism: Reality

A macro-object **is** a pattern, and **the existence of a pattern as a real thing** depends on the usefulness – in particular, the **explanatory power** and **predictive reliability** – of theories which admit that pattern in their ontology.<sup>9</sup>

Note three things:

- Higher-level theories
- Pragmatic values
- **The realist language**

Why?

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<sup>9</sup>David Wallace, "Everett and Structure," *Studies in History and Philosophy of Modern Physics* Vol. 34, (2003), p. 93.

# Many Minds: reality is superposition, but you don't see it

- Many minds = Many worlds at the mental level of observer
- Physical level indeterminate
- Multiplicity of mental states: *illusion* of being in one determinate world
- Wallace's use of Dennett's criterion undermines many minds → there is a *real* classical world *out there*



**Figure 14:** The real world is in a superposition, only the mind registers a unique outcome

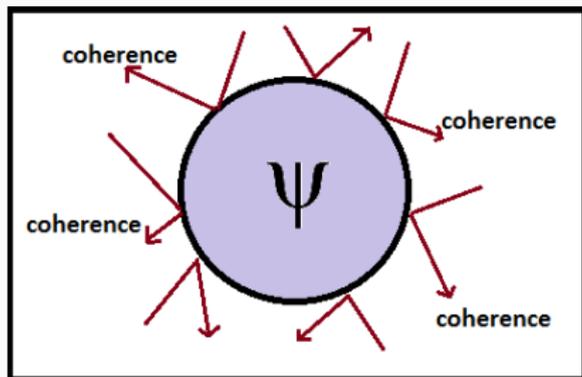
# Conclusion

- Quasi-classical worlds → **weakly emergent**.  
*Functionally real* classical worlds? → not so clear.
- From quasi-classical to *really* classical à la Dennett:  
metaphysical baggage (on top of the admitted naturalism).
- Quasi-classical patterns are **objective**. Decoherence basis is special, but that does not give a preferred basis. Wallace's 'real' worlds derive from a **subjective** goal.
- Classical pattern salient in the **context** of our existence, à la van Fraassen. **Anthropic** motivation: other patterns are there, but irrelevant to us
- Why do we want 'real'? I don't know, but  
→ Undermines the **many-minds** theory.
- *To remain objective, the prefix 'quasi' should be honored!*

## 0. Decoherence

# Decoherence

Decoherence is the rapid diluting of entanglement (the typical 'quantumness') over the environment.

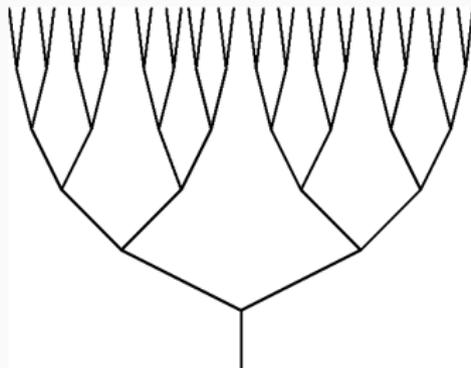


**Figure 15:** Decoherence, the environmental states (red arrows) continuously bombard the quantum system (blue 'ball'), carrying away the coherence of the system, which in turn loses the off-diagonal terms in its density matrix.

$$\rho(x, x') \rightarrow \rho(x, x') \exp -\Lambda t(x - x')^2, \quad (1)$$

## The universal wavefunction: *Multiverse*

The emergence of multiplicity happens whenever superpositions become entangled to the environment (i.e., always): **branches** for all possible combinations!



- So the worlds (world=branch) are not postulated: they are *'derived'*
- Branching structure is a result of unitary Schrödinger dynamics. Other interpretations *add* to this

The dynamics picks out a preferred basis: the position basis is robust (because we write Hamiltonian in terms of position). This solves Everett's determinate record problem.

## **-1. Instantiation**

*Given two theories A and B, and some subset D of the histories of A, we say that A instantiates B over domain D iff there is some (relatively simple) map  $\rho$  from the possible histories of A to those of B such that if some history h in D satisfies the constraints of A, then  $\rho(h)$  (approximately speaking) satisfies the constraints of B,<sup>10</sup>*

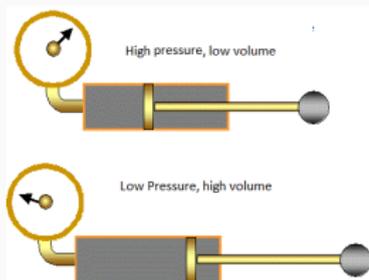
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<sup>10</sup>Wallace, *Emergent Multiverse*, p. 54.

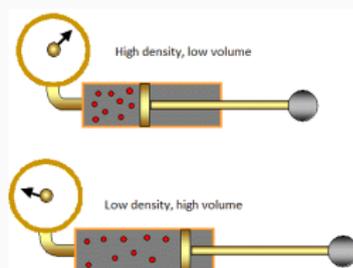
## **-2. Reduction**

# Nagelian reduction

- Nagelian<sup>11</sup> Reduction is logical deduction (via DN-model) of reduced theory  $T$  from reducing theory  $T^*$ .
- Terms in  $T$  that are unfamiliar to  $T^*$ , are connected by 'bridge laws' that translate *meaning*.



**Figure 16:** Thermodynamics (theory  $T$ ). State functions like pressure, temperature.



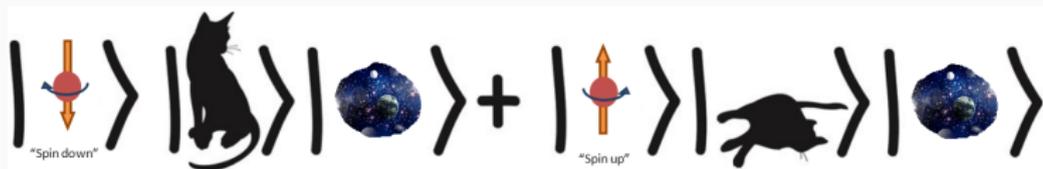
**Figure 17:** Statistical physics (theory  $T^*$ ): from positions and momenta the thermodynamic state functions are derived *and* conceptually linked.

<sup>11</sup> Ernest Nagel, *The Structure of Science* (Harcourt: Brace & World, 1961), pp. 338–345.

# Reducing Wallace's many worlds to classical mechanics

- Instantiation instead of DN-Derivation (because decoherence is only FAPP, there is non-zero overlap between worlds)
- Functionalism instead of bridge laws:

Instead of an ontological picture like this:



Wallace wants an ontological picture of *real* classical worlds:



I think this is a step too far: quasi-classical objective. More than that is subjective: *our* need to *explain* things like classical mechanics.

-3. Another foil? - **Local Beables** and ontological 3-space?