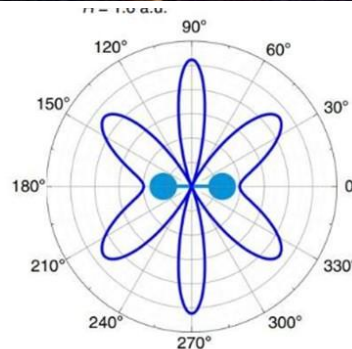
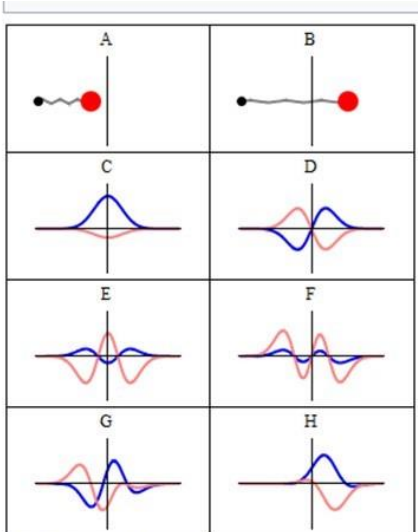
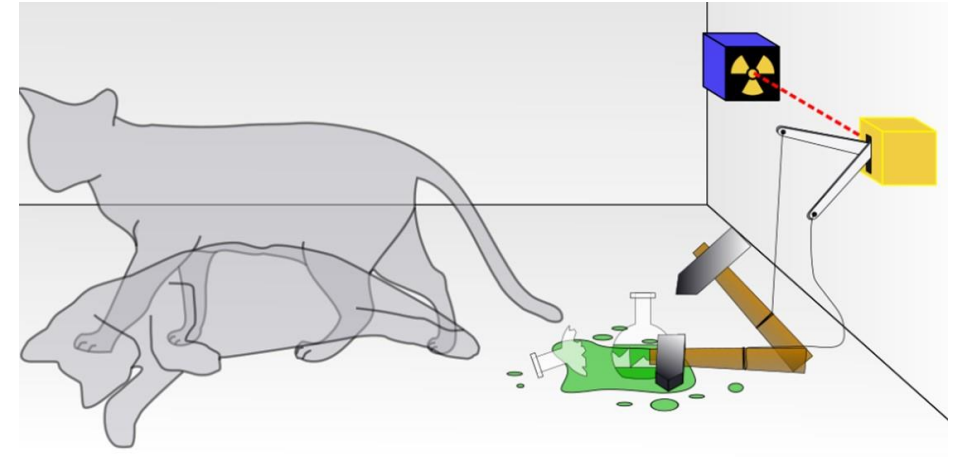


# Immanuel Kant meets Quantum Mechanics

$$H\psi = i\hbar \partial \psi / \partial t$$

$\psi$

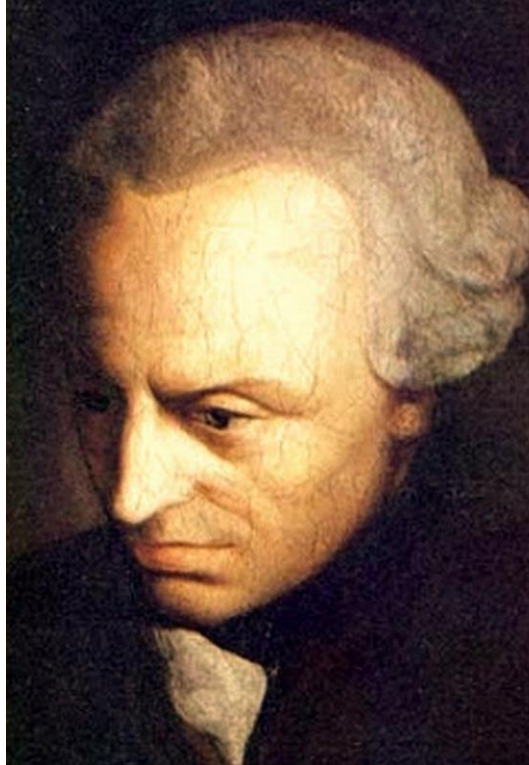
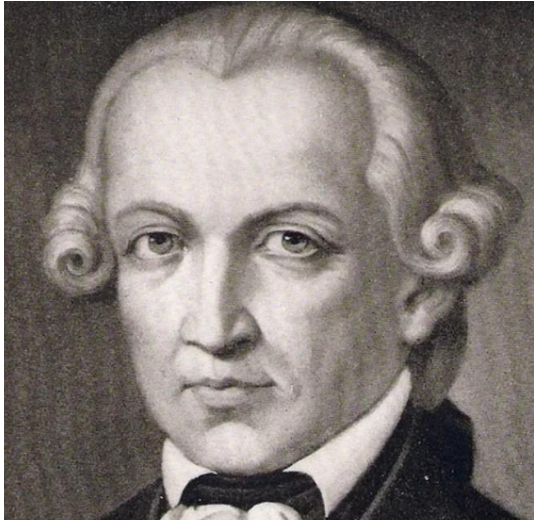


$$\Delta p \cdot \Delta x \geq \hbar$$

$$\Delta E \cdot \Delta t \geq \hbar$$

# Immanuel Kant

22<sup>nd</sup> April 1724 – 12<sup>th</sup> February 1804



See **Manfred Kuehn (2001)**  
for a full biography of Kant

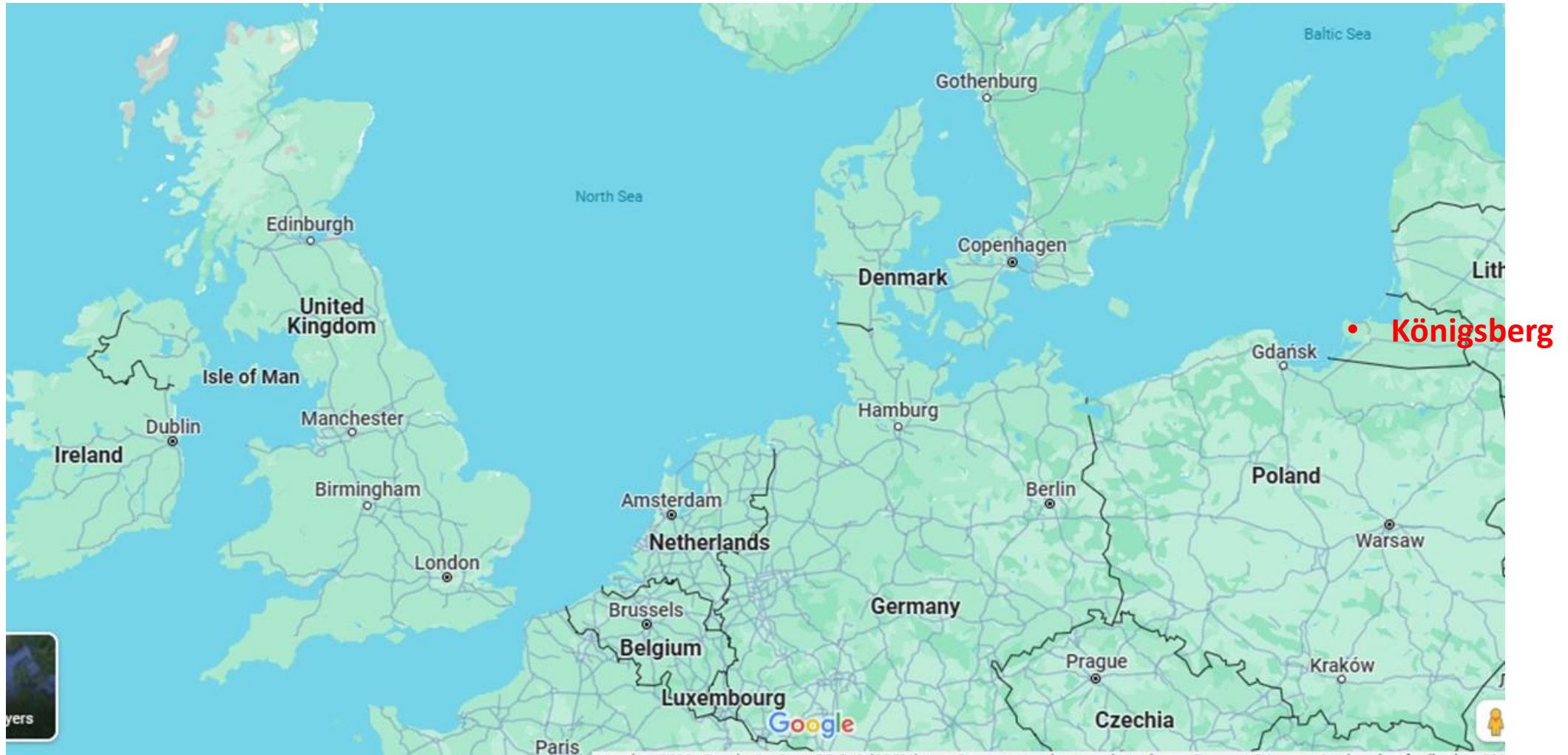


For general introductions to Kant, see Scruton (2001), Steinbauer (2024) and *Philosophy Now* articles.



# Königsberg in East Prussia

Now Kaliningrad in Russia



# Organization of the Talk

1. Kant's **Physics** and **Critical Metaphysics**
2. **Updating** Kant's Metaphysics
  - What **must** go
  - What **should** stay
3. Kant's **Realism**
4. **QM** as a theory of **Phenomena**
5. **Time** in **Kant**, **Relativity** and **QM**
6. **Causality** - Kant's approach and a Neo-Kantian approach
7. Overview

# 1. Kant's Physics and Critical Metaphysics

- Kant mused on, studied and developed theoretical physics all the way through his intellectually-productive life. A major motive for his desire to reform **Metaphysics** - through his '**Critical**' Philosophy - was his desire to establish a sound basis for **Physics**.
- There is a huge scholarly literature on '**Kant and Physics**' (including '**Kant and QM**'!) which is continually being added to. I've only dabbled in it ...
  - ... here I am pursuing my own thoughts on the topic: insights & inspiration from Kant that I've found useful when trying to grapple with **Quantum Mechanics**

***'If you think you understand Quantum Mechanics,  
then you don't understand Quantum Mechanics'***

– attributed to Richard Feynman - see Philip Ball (2015).

# Kant's Pre-Critical Physics (1747 - 1768)

- Kant specialised in Theoretical Physics – his earliest work was highly speculative, but **Martin Schönfeld** (1963 – 2020) made a special study of it
- Schönfeld pointed out that some of Kant's work: (i) on **momentum and energy**, (ii) the **creation of space** from interactive forces, and (iii) **the evolution of complexity** in the Universe, is much closer to speculative theories of **Quantum Gravity** of today than to the mechanistic Newtonian physics of Kant's day!
- Once Kant had adopted his own interpretation of Newtonian Physics, he made real contributions to theoretical physics/astronomy which stand today:
  - **The Nebular Hypothesis for the Solar System**
  - **The Milky Way as a lens-shaped collection of stars.**
  - **Tidal friction slows the rotation of the Earth**  
See Ferrogia & Fiolhais (2020)

See Schönfeld, 'Physics', Ch. 3, pp. 23-33 in Sorin Baiasu & Mark Timmons (eds), 'The Kantian Mind', (2023), Watkins & Stan (2003 & 2023) and Schönfeld & Thompson, 'Kant's Philosophical Development', (2003 & 2019)

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- Once Kant had adopted his own interpretation of Newtonian Physics, he made real contributions to theoretical physics/astronomy which stand today:

- Right for the Right Reasons**
    - The *Nebular Hypothesis* for the Solar System
    - The Milky Way as a lens-shaped collection of stars.
    - Tidal friction slows the rotation of the Earth
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**Highly Speculative!** –  
arguably 'right'  
but for the  
**Wrong Reasons**  
X



# Kant and Newtonian Physics

- Kant adopted his own interpretation of Newtonian Physics from ~ 1755.
- ... it described **Phenomena** in the physical world very successfully.
- Kant had moved away from Newton's own **Metaphysical/Theological** concept of **Space and Time** as being independent of and unaffected by what was happening on their stage (**Space and Time** being 'God's Sensorium' for Newton).
- Kant's **Relational** concepts of **Space and Time** were closer to those of Leibniz – they arise from how objects relate to one another and not to some '**Absolute**' **Space and Time** independent of everything (except God).
- Not only is this closer to Kant's later '**Critical**' view that **Space and Time** are **Ideal**, but (*in an entirely different way*) it is closer to our **Post-Einsteinian Relativistic** conceptions of **Space and Time**!



# CPR – usually called *The First Critique*

1. '*Critique of Pure Reason*' A – 1781 – '*Kritik der reinen Vernunft*'.
2. '*Prolegomena to any Future Metaphysics that will be able to come forward as a Science*' – 1783
3. '*Critique of Pure Reason*' B – 1787

The contents of **A** & **B** are usually published together in a single volume.

## Good English Editions:

- **Norman Kemp Smith** *trans*, (Palgrave Macmillan, originally 1929),
- **Werner S Pluhar** *trans*, (Hackett, 1996),
- **Paul Guyer & Allen W Wood** *trans*, (Cambridge, 1999).

# What was Kant trying to do in his Critical Philosophy? - 1

*Among many other things ...*

- Answer the Question: ***‘How is Human Freedom Possible?’*** in the light of ***Newtonian Mechanistic and Deterministic Natural Philosophy***
- Answer the Question: ***‘How is “Nature” (and Science) Possible?’*** .... i.e:
  - ***What is it about us*** that enables us to relate to the world and study ***“Nature”***?
- Promote a **Secular Philosophy: God is not a Premise** in the ***Critical Philosophy***.
  - But Kant limits Reason (*Vernunft*), in order to retain a role for Faith.
- Invite us to ***join an ongoing Kantian/Enlightenment Project***  
see CPR Bxliii & A855/B883, also O’Neill (1989), pp. 8-9
- Base his ***Critical Philosophy*** upon ***‘a priori’*** principles so that its foundations would be ***‘Certain’*** ...

See the CPR itself, Kant’s *Prolegomena*, Scruton (2001), Steinbauer (2024) and Robinson (2012)

# What was Kant trying to do in his Critical Philosophy? - 2

... *In the process, he:*

- ... sought to reconcile **Enlightenment Rationalism** with **Empiricism**.
  - He adopted some of Hume's scepticism: Reason (*Vernunft*) is compromised and very limited.
- ... promoted his '**Copernican Revolution**' as a solution to the major problems.

... hear Melvin Bragg and guests discuss this: '*In our Time*' (2021)

**Kant's Copernican Revolution** (CPR A42/B59): '*All our perceptions are nothing but representation of appearance ... the things we perceive are not in themselves what we perceive them as being, nor are their relations so constituted in themselves as they appear to us ... As appearances they cannot exist in themselves, but only in us. What objects may be in themselves ... remains completely unknown to us ...*'.

**So: We cannot be acquainted with 'The Things in Themselves' – 'Die Dinge an sich'**

see e.g. CPR Bxxvii, also Blumenau *Philosophy Now* (2001)

In general, see the CPR itself, Kant's *Prolegomena*, Scruton (2001), Steinbauer (2024) and Robinson (2012)

# Our *Structures of Understanding* the World

Kant argues that we project *Structures of Understanding* onto the World such that the features we perceive in the World are an admixture of our own concepts and of incoming sense-data.

***'Appearances' – Phenomena*** – are not the ***'Things in Themselves' ('Dinge an sich')***

*'... without sensibility no object would be given to us; and without understanding no object would be thought. Thoughts without content are empty; intuitions without concepts are blind'*. CPR B75.

For Kant what structured the *'Appearances' (Phenomena)* were:

- His ***Categories***     See CPR A80/B106
- The ***Forms of Intuition: Space*** and ***Time***, which are ***Ideal***, i.e. conceived solely by us – they are not entailed in the ***'Dinge an sich'***

See CPR A19/B33ff for Kant's *'Transcendental Aesthetic'*, A22/B31ff on Space and A30/B46ff on Time esp. A36/B53

# Kant's *Categories* - his '*Synthetic a priori*'

See CPR A80/B106

## 1. Of Quality

Reality  
Negation  
Imitation

## 2. Of Quantity

Unity  
Plurality  
Totality

## 3. Of Relation

Inherence & Subsistence  
Causality and Dependence  
Community

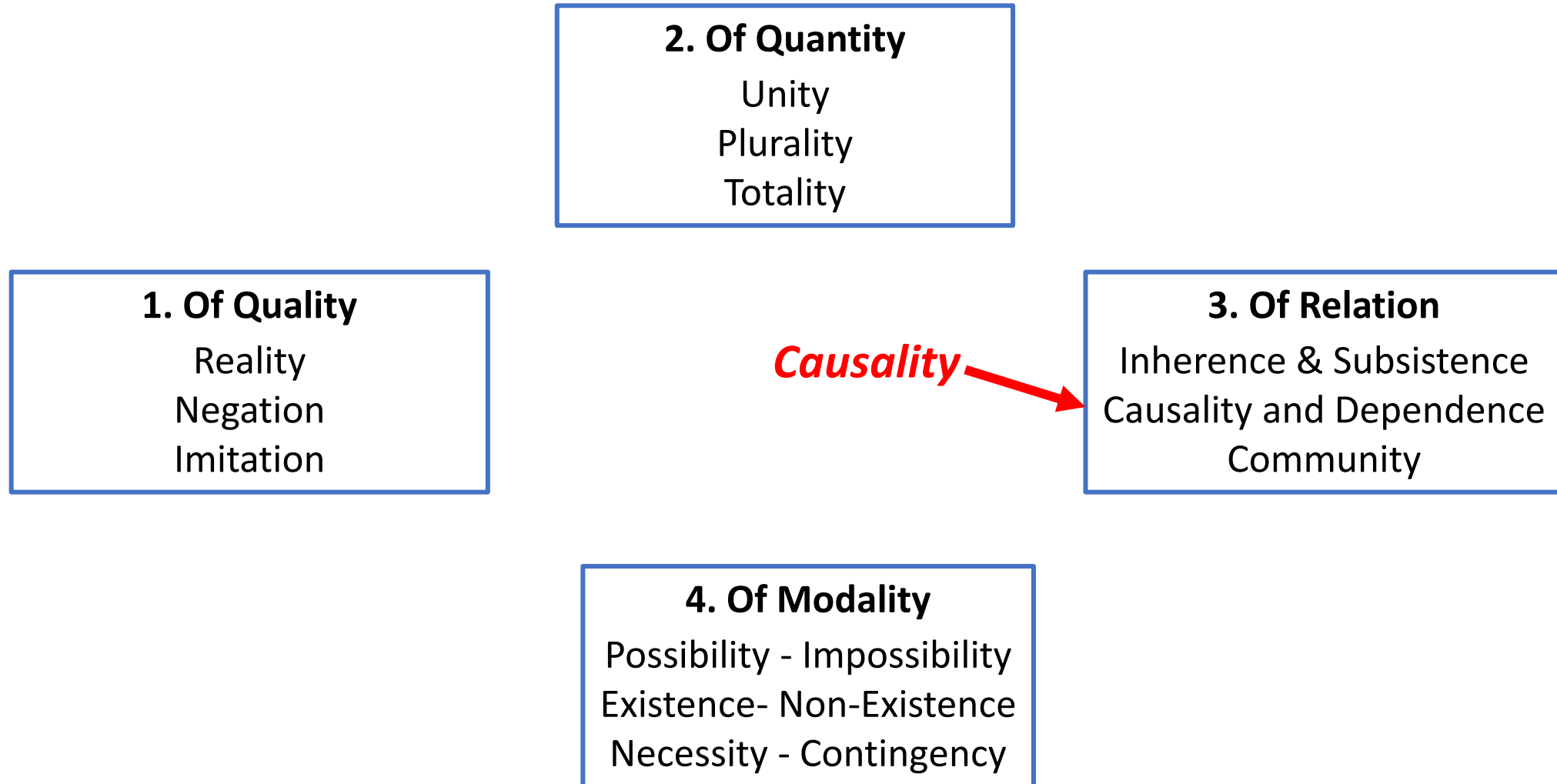
## 4. Of Modality

Possibility - Impossibility  
Existence- Non-Existence  
Necessity - Contingency



# Kant's *Categories* - his 'Synthetic a priori'

See CPR A80/B106



## 2. Updating Kant's Metaphysics

Kant was writing over 200 years ago  
Science & Philosophy have progressed since then.

We must update Kant regarding  
the Ordering Principles of our Human Understanding  
... his very rational 'Categories' can no longer be seen as "fundamental",  
but rather as Derivative of more Organic Human Structures of Understanding.

At the very least, I propose that we must take into account  
**Darwin's *Theory of Evolution*** and our ***Embodied Mind***

i.e. our *Evolution* and our *Experience of living in the world* have given us the Structures of Understanding that condition our *psyche* (both Conscious and Unconscious) ...

# Kantian ‘*Critical*’ Metaphysics: *What needs to Go?*

The *A-priority* and ‘*Certainty*’:

- The Categories as *fundamental*
  - Newton’s Physics as *fundamental*
  - Euclidean Geometry as *fundamental*
- Kant put an enormous amount of intellectual effort (and writing!) into attempting to demonstrate the ‘*certain*’ *a-priority* of his doctrines – but that has to go!
  - There are some who would say that if we abandon these principles we cannot be called ‘Kantians’
  - *I disagree*: we can replace supposedly ‘*certain*’ *a-priority* with *other concepts* that were *promoted by Kant himself!*

# How do we Update Kant?

We replace *a-priority* and ‘*certainty*’ with:

- (1) Our *Human Innate Embodied* Understandings of the World ... *and* ...
- (2) ... extensions of our Understandings via *Consciously Constructed Models and Perspectives on the World*, e.g. *Scientific Theories*,
  - After all, we now know that *Newton’s Physics*, which Kant took to be *a-priori*, is just a scientific theory – a human *model* of certain aspects of the world that can be pragmatically useful to us in certain circumstances.
  - Likewise: *Euclidean Geometry*.
  - Likewise: *The Categories* should now be seen as *Derivative* of more *Organic Embodied* Human *Structures of Understanding*.
- (3) A *Healthy Scepticism* about any claims of *a-priority* and *certainty* .

On Organicism and Embodiment see Kant, ‘*Critique of Judgement*’ (1790), §61-67, §77, Thompson (2007), p. 133-4, Weber & Varela (2002), esp. p. 106, Johnson (1987), Mensch (2015), Watkins & Stan (2003 & 2023), Section 5.

# Kantian '*Critical*' Metaphysics: What needs to Stay in our Neo-Kantian Philosophy?

*Key Features* of Kant's Critical Metaphysics:

- Kant's '*Copernican Revolution*'
- Kant's *Realism* regarding the '*Dinge an sich*'
- Kant's *Distrust* of '*Pure*' Reason

*Where 'Pure' Reason is reasoning unsupported  
by well-attested Empirical Evidence*



## **3. Kant's Realism** - Kant is a Realist

Positions available to us regarding Realism  
with respect to the '*Dinge an sich*'

1. Naïve Realism
2. Kantian Realism
3. Anti-Realism
4. Strict Idealism

*See Kant: Prolegomena* at 4:289 for a clear exposition of his position

- He is not a (Berkelian) Idealist.
- He is a Realist regarding the '*Dinge an sich*'

# Kant's Realism

## - Kant is a Realist

**Kant: Prolegomena** at 4:289 in the Cambridge edition edited by Gary Hatfield:

*'Idealism consists in the claim that there are none other than thinking beings; the other things that we believe we perceive in intuition (**Anschauung**) are only representations in thinking beings, to which in fact no object existing outside these beings corresponds. I say in opposition: There are things given to us as objects of our senses existing outside us, yet we know (**wissen**) nothing of them as they may be in themselves, but are acquainted only (**kennen**) with their appearances, that is, with the representations that they produce in us because they affect our senses. Accordingly, I by all means avow that there are bodies outside us, that is, things which, though completely unknown (**unbekannt**) to us as to what they may be in themselves, we know (**kennen**) through the representations which their influence on our sensibility provides for us, and to which we give the name of a body – which word therefore merely signifies the appearance of this object that is unknown to us but is nonetheless real (**wirklich**). Can this be called idealism? It is the very opposite of it.'*

# Positions available to us regarding Realism

1. **Naïve Realism**: What you perceive in the World is what is actually there: we have direct perception of the *Dinge an sich* .... **Wrong!** - ***all the evidence is against this!***
2. **Kantian Realism**: what you perceive are *phenomena*: they are what our ***Structures of Understanding*** impose on our World under the influence of the *Dinge an sich* – we can only be acquainted with *phenomena* and ***not*** with the *Dinge an sich*.  
***This is what Kant says – I believe all the evidence supports him! Correct!***
3. **Anti-Realism**: Forget about the *Dinge an sich*: Science is, and ought only to be, a discipline that ***Describes*** the *Phenomena*.  
***This was the Zeitgeist (1920's) of early QM – The Copenhagen Interpretation of QM was influenced by Logical Positivism and Ernst Mach: Reject Metaphysics!***  
***... Wrong! – a council of despair! – Science should predict as well as describe!***
4. **Strict Idealism**: There ***are*** no *Dinge an sich* outside of us - all there is in the World is ***Thinking Minds***. .... **Wrong!** - ***all the evidence is against this!***

# ***Why do we need Kant's Realism? ...*** ***... and the Dinge an sich?***

Here's one reason:

- The unexpected (non-intuitive) discovery of QM. See Rovelli (2022)
- No-one in their right mind in 1880 would have wanted QM to be thrust on them. See e.g. Philip Ball (2013)
- Here we are - all these years later - and we still can't assimilate QM: it is alien to our human ways of thinking!

***'If you think you understand QM ... ' etc.***

***The only reason we have QM is because the Dinge an sich 'out there' constrain the Phenomena that we perceive in ways that are not easy for us to get our minds around !!***

## 4. QM as a Theory of Phenomena

QM in its most advanced form - Quantum Field Theory (QFT) - predicts happenings in the world phenomenally accurately – the best theory we've ever had!! ...

... but we Human Beings cannot help wanting to understand the 'Ontological Reality' behind the *Phenomena*!

*Per impossibile* we want to know what the '*Dinge an sich*' are and how they behave!

*Look at this in the light of*

**Kant's '*Transcendental Dialectic*'**

i.e. Compare the lessons we learn from Kant's '*Antinomies*' with our predilections for *Ontological 'Interpretations' of QM.*



# Kant's *Antinomies* in his *Dialectic of Pure Reason*

*Competing Ontologies:*

Table of Antinomies

CPR A405/B432 ff

|            | <i>Thesis</i>   | <i>Antithesis</i>   | <i>Where in CPR?</i> |
|------------|---|---|----------------------|
| <b>1st</b> | The World has a Beginning in Time   | The World had no Beginning  | A416/B454 ff         |
| <b>2nd</b> | Every composite substance consists of simple parts                                      | No composite substance consists of simple parts, and nowhere does there exist anything simple | A434/B462 ff         |
| <b>3rd</b> | There is <u>both</u> Causality according to Natural Law <u>and</u> according to Freedom | There is <u>only</u> Causality according to Natural Law and <u>no</u> Freedom                 | A444/B472 ff         |
| <b>4th</b> | There is an Absolutely Necessary Being  | There is <u>no</u> Absolutely Necessary Being   | A454/B482 ff         |

***These disagreements arise from the application of 'Pure' Reason:  
reasoning unsupported by well-attested Empirical Evidence***

# 'Interpretations of QM' - 1

*QM is an amazingly effective theory  
it can make extremely accurate predictions*

- But it is a theory about Phenomena – the Appearances
- But as Human Beings, we cannot help wanting to know the Ontology behind the *phenomena* – what are the '*Dinge an sich*' behind the appearances?
- Speculative scientific attempts to posit the **Ontological Reality** behind **QM** Phenomenology are called:

## *'Interpretations of QM'*

Not all Interpretations of QM are Ontological, some are Epistemological, e.g. 'QBism'. The original 'Copenhagen Interpretation' was a bit of both!

See '*Interpretations of Quantum Mechanics*' - Wikipedia

# Competing Ontologies: 'Interpretations of QM' – 2

## Ontological Interpretations:

See 'Interpretations of Quantum Mechanics' - Wikipedia

De Broglie-Bohm

Many Worlds

Many Minds

Transactional

Consciousness Causes Collapse

Objective Collapse

See John Gribbin, (1984)

See Kastner, (2012),  
Cramer (2016)

- They all make ontic claims about the '*Dinge an sich*' behind QM Phenomena:
- They are ontologically incompatible with each other
- They are exercises in 'Pure' Reason in the Kantian Sense
- They cannot be established as '*ontologically factual*' because they deliberately predict exactly the same phenomenology!

*Phenomenology always underdetermines Ontology  
in the absence of Empirical Evidence that can resolve issues*

They should not be presented as **factual** – they should be recognised as **speculations** of 'Pure Reason'

# 'Interpretations of QM' - 3 *Competing Ontologies:*

*From Wikipedia:*

| Interpre-<br>tation           | Year<br>pub-<br>lished | Author(s)  | Determ-<br>inistic? | Ontic<br>wave-<br>function? | Unique<br>history? | Hidden<br>variables? | Collapsing<br>wave-<br>functions? | Observer<br>role?               | Local<br>dyna-<br>mics? | Counter-<br>factually<br>definite? | Extant<br>universal<br>wave-<br>function? |
|-------------------------------|------------------------|--|---------------------|-----------------------------|--------------------|----------------------|-----------------------------------|---------------------------------|-------------------------|------------------------------------|---|
| Ensemble interpretation       | 1926                   | Max Born   | Agnostic            | No                          | Yes                | Agnostic             | No                                | No                              | No                      | No                                 | No  |
| Copenhagen interpretation     | 1927                   | Niels Bohr,<br>Werner Heisenberg                   | No                  | Some <sup>[58]</sup>        | Yes                | No                   | Some <sup>[59]</sup>              | No <sup>[60][61]</sup>          | Yes                     | No                                 | No  |
| De Broglie–Bohm theory        | 1927–1952              | Louis de Broglie,<br>David Bohm                    | Yes                 | Yes <sup>[a]</sup>          | Yes <sup>[b]</sup> | Yes                  | Phenomenological                  | No                              | No                      | Yes                                | Yes                                       |
| Quantum logic                 | 1936                   | Garrett Birkhoff                                   | Agnostic            | Agnostic                    | Yes <sup>[c]</sup> | No                   | No                                | Interpretational <sup>[d]</sup> | Agnostic                | No                                 | No  |
| Time-symmetric theories       | 1955                   | Satosi Watanabe                                    | Yes                 | No                          | Yes                | Yes                  | No                                | No                              | No <sup>[62]</sup>      | No                                 | Yes                                       |
| Many-worlds interpretation    | 1957                   | Hugh Everett                                       | Yes                 | Yes                         | No                 | No                   | No                                | No                              | Yes                     | Ill-posed                          | Yes                                       |
| Consciousness causes collapse | 1961–1993              | John von Neumann,<br>Eugene Wigner,<br>Henry Stapp | No                  | Yes                         | Yes                | No                   | Yes                               | Causal                          | No                      | No                                 | Yes                                       |

**Analogous to Kant's tabulation of Antinomies! Revelation of incompatibility of Ontological models!**

## 5. Time in Kant, Relativity and QM

# Is Time Fundamental?

Is it a Fundamental Real Feature of the Universe?

In his '*Critical Period*' Kant said 'No'  
– both *Time* and *Space* are Ideal

*i.e. Imposed upon the World by Our Understanding*

*Was he Right ?*

***For many years I thought he was wrong ...***

After all, it is a simple fact that **Time**, symbol '**t**', appears as an essential parameter in all of the mathematical expressions of the “*Laws of Physics*” that we apply practically and pragmatically in the world every day.

This is true of:

- Newtonian Physics (from 17th C)
- Special Relativity (1905)
- General Relativity (1915)
- ‘Elementary’ Quantum Mechanics (1920’s)

**Also: Time** and its inverse, **Frequency**, are the two physical quantities that we can measure far, far more accurately than any others – better than parts in  $10^{16}$  in specialist labs and to parts in  $10^{11}$  routinely!

***Surely Time must be Real!***

***Well! ...***

# Is Time Fundamental?

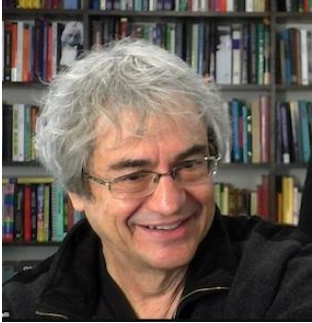
# What are the Options?

↑  
Increasing Idealism  
↓

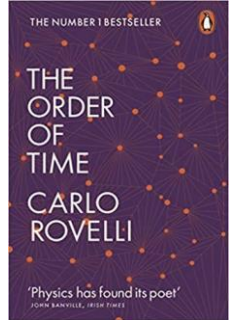
- (1) Time is real and is a fundamental feature of the Universe.
- (2) Time is not fundamental but is a real emergent feature of the Universe, i.e. reducible to other real and fundamental features of the Universe.
- (3) Time is one of our important human perspectives on the Universe which nevertheless correlates with some important real features of the Universe.
- (4) Time is 'Ideal' *à la Kant* – i.e. wholly part of our Understanding that we impose in our 'take' on the Universe (*arguably 'psychological' but not for Kant!*).



# Starting from Newton's Absolute Conception of Time and Space:



We follow Carlo Rovelli, '*The Crumbling of Time*'  
in his book '*The Order of Time*' (2018) pp. 167-170.



***Even before we embark upon Quantum Mechanics***

***we have experienced the gradual erosion of many dearly held beliefs about Time:***

- (1) 'Loss of Direction': there is no difference between 'Past' and 'Future' in microscopic physics. No '*Arrow of Time*' (already true in Newton's Physics!)
- (2) 'The End of the Present': A Universal 'Present' does not exist. (No 'Simultaneity') (SR)
- (3) 'No Fundamental Duration': There is no single duration between two events (SR, GR)
- (4) 'No Flow of Time': Determinism: The Block Universe (SR, GR) see Lockwood (2005)
- (5) 'Gravitational Dependence': Time passes differently in different gravitational fields (GR)

***Time has lost its independence from the rest of the world*** (p. 70).

***We are already bidding 'Goodbye' to some of our prejudices regarding Time!***



# Quantum Gravity - 1

- But matters get far worse for '**Time**' when we turn to **Quantum Gravity** – which is the attempt by today's fundamental physicists to unify **QFT** with Einstein's **General Theory of Relativity** – and which are conceptually incompatible with each other!
- 60 years of trying have not yielded an acceptable new theory – but they have generated many problems for '**Time**' !
  - In elementary **QM**, Schrödinger's Equation tells us how physical states of affairs in the world evolve with '**Time**'.
  - In 1967 **John Wheeler** and **Bryce DeWitt** attempted to apply this approach to the **Whole Universe** – they came up with the Wheeler-DeWitt Equation which effectively says 'The Universe never changes'!
  - **Quantum Gravity** produces many other problems for '**Time**' ...

*Deep problems for Time arise when combining **Quantum Field Theory (QFT)** with **Quantum Gravity**: the attempt to assimilate QFT with General Relativity*

John Archibald Wheeler (1911 - 2008)

One problem that this attempt gives us is:

Bryce DeWitt (1923 - 2004)

*Start with:*

**The Wheeler-DeWitt Equation** (1967)

The Time-Dependent Schrödinger Equation in 'elementary' quantum mechanics:

$$H\psi = i\hbar \partial\psi / \partial t \quad \dots \text{we can work out how quickly a quantum state, } \psi \text{ changes.}$$

**DeWitt** attempted to apply this idea to the **Whole Universe**:  $\Psi$  now represents the state of the Whole Universe. He came up with the **Wheeler-DeWitt Equation**:

$$H\Psi = 0$$

... !! Does the Universe never change! Was Parmenides right?

see [Wheeler-DeWitt equation – Wikipedia](#)

***This has given fundamental physicists pause for thought for many years***

*(NB. I'm riding roughshod over all the details here)*

# Quantum Gravity - 2

Attempts to unify **QFT** with **General Relativity** appear to require us to relinquish our objective concept of **'Time'** as existing entirely in the **'Outside World'!**

**Julian Barbour**: the concept of **'Time'** is redundant:

- *'I think it is entirely possible – indeed likely – that time as such plays no role in the universe'*. See his book **'The End of Time'**, (1999).

*Perhaps Julian Barbour goes too far!*

In fact, there is no consensus among fundamental physicists as to the **'Fundamental'** Ontological Status of **'Time'**

But we can follow **Carlo Rovelli's 'The Order of Time'**, (2018) again, which is particularly interesting regarding **Kant**.

## Rovelli – *Time is Relational*

*It arises from our Particular Human Circumstances in the World*

- All apprehension of **'Time'** is **Relational** – when we 'measure' **'Time'**, we compare one physical process with another, e.g. with the position of the hands of a clock or the rotation of the Earth.
- All concepts relate to where we find ourselves in the Universe:
  - e.g. 'Up-Down' makes sense on the surface of the Earth but not up in space for astronauts in 'Free-Fall'.
- **'Time'** arises from our own particular human position in the Universe and our way of analysing it into separate entities: it is in their relationships that we discover **'Time'** ...
- This is close to Kant's Leibnizian **'Relational'** view of **'Time'** in his Pre-Critical days
- ... but was he right to go on from there to take **'Time'** to be wholly **'Ideal'** in his **'Critical'** works? ....

# Is Time Fundamental? **The Options:**

*My (current tentative) view:*

? (1) Time is real and is a fundamental feature of the Universe.

? (2) Time is not fundamental but is a real emergent feature of the Universe.

**Possibly the best position, based on the Empirical evidence lies in this region**

? (3) Time is one of our important human perspectives on the Universe which nevertheless correlates with some important real features of the Universe.

Valid for **Subjective** temporal experiences, but not for **Objective** philosophy

? (4) Time is 'Ideal' à la Kant – i.e. wholly part of our Understanding that we impose in our 'take' on the Universe.

***Is Time Fundamental?***

*Are we getting any closer to an answer to this question?*

## 6. Causality and Imagination

### Kant's approach and a Neo-Kantian approach

- Remember, for Kant **Causality** ('Cause and Effect') is an a priori Category.
- **Causality** cannot apply to the *Dinge an sich*, because they are *atemporal*, but the very idea of **Causality** is that Effects follow their Causes in Time, so for Kant **Causes** must be imposed upon the World by us.
- Here's a **Neo-Kantian** way of understanding this through a contemporary understanding of Causality: **The Counterfactual Theory of Causality**.
- We must abandon Kant's **a-prioristic** arguments, but this **Counterfactual** route is actually based in Kantian philosophy too ...
  - ... based on Kant's understanding of Human Imagination.

# Kant on Human Imagination:

- *'Imagination\* is the power of presenting an object in intuition even without the object's being present', CPR, B151.*
- *'Psychologists have hitherto failed to realize that imagination is a necessary ingredient to perception itself', CPR, A120, ftnt A, as trans. by P F Strawson (1970), p. 31.*
- *'... every appearance contains a manifold ... Hence there is in us a power to synthesize this manifold. This power we call the Imagination ...', CPR, A120*
- Kant is effectively claiming that we use the same Faculty of Imagination for Perceiving, Memorising and Imagining the world.
- Imagination is a core faculty of our human psyche that enables us to relate to the world ... See Stevenson (2003), Stuart (2014)

- ... now apply this to 'Cause and Effect' .....

\* Kant's word for 'Imagination' is 'Ein-Bildungs-Kraft': an 'In' - 'Picturing' - 'Ability'.

# Cause and Effect (Aristotle's 'Efficient Causality') - 1

- If we claim that '**A caused B**', we claim that '**B would not have happened if A had not happened**' - (paraphrase).
- Or, at least, that '**B would not have happened in the way that it did if A had not happened**'. Example:
  - '**The car crashed into the lamp-post because the driver was drunk**' - **implies:**
    - '**The car would not have crashed into the lamp-post if the driver were not drunk**' (note use of Subjunctive):
- We are *here* positing a **Counterfactual** – a state of affairs that does not correspond to the facts. So:
- We are comparing our **Factual World** with an imagined **Counterfactual World**.
- We are using our **Imagination!** (either *explicitly* or *implicitly*).

For Counterfactuals in the human world, see esp. Byrne (2016)



## Cause and Effect - 2

So ... the reason why **Hume** cannot find a '**Necessary Causal Connection**' in 'this' **Factual** 'Natural' Physical World is that **Causes** do not reside in 'this' **Factual**, 'Natural', Physical World ...

- They reside in a **Relationship** between the **Factual World** and our **Imaginary Counterfactual** worlds:
- On this account **Causes are manufactured by our Faculty of Imagination** - they are *inalienably Imaginary* – but, as **Kant** claimed, they are central to our 'take' on the World
- We may add that **Causes** exhibit other *humanly-biased* ways of accounting for what happens in the world!

In general see Lewis (1973 & 2000) & Pearl references He argues that *Statisticians* and *Epidemiologists* have a much better understanding of 'Cause' than do *Philosophers* & *Scientists*: they absolutely have to in order to be effective in their jobs! See also the other references to Counterfactuals & the Human *Psyche*.

# Cause and Effect - 3

## *A few points:*

- (1) This '**Counterfactual Theory of Causality**' is widely used by medical scientists & statisticians – it is not just an 'ivory-tower' 'philosophical' concept – see e.g. Höfler (2005)
- (2) Our most fundamental Physical Understandings are based on **Principles** – **Conservation of Energy** and **Momentum, The Principle of Least Action** – not '**Causes**'.
- (3) In what sense are **Random** Quantum events '**caused**'?

In general see Lewis (1973 & 2000) & Pearl references He argues that *Statisticians* and *Epidemiologists* have a much better understanding of 'Cause' than do *Philosophers* & *Scientists*: they absolutely have to in order to be effective in their jobs! See also the other references to Counterfactuals & the Human *Psyche*.

# The Ubiquity of Imagination in Quantum Science

See e.g. Stuart (2014)

- Note that we have to use Imagination when we try to understand **QM!**

*In fact, we have to stretch it to its limits!*

- Wave/Particle Duality !!!
- Mixed States !!!

*... 'If you think you understand QM ...*

*At a more technical level:*

- *Variational* mathematical approaches to **QM**
- *Conceptual 'Spaces'* in Physics – *Hilbert Space (QM)* – *Phase Space, etc.*

## **7. Overview**

# Kant revised by ... er! ... Kant

Even where we find we need to revise some of Kant's fundamental concepts, we can find our resources for revision in other parts of Kant's own work. e.g.

- Kant's ***Category of Causation*** is replaced by a ***Counterfactual Theory of Causation*** that relies upon the **Human Faculty of Imagination** and Kant was partly responsible for the growth in the recognition of Imagination as central to human perception and relationships with the world See refs above.
- ***A-priorism*** is replaced by ideas that Kant developed for our Understanding of ***Organisms***: Concepts that he originated in the ***Critique of Judgement*** and his ***Opus Postumum*** are recognised as inspiring today's concepts of ***The Embodied Mind, Autopoiesis, 4EA*** see Kant, 'Critique of Judgement' (1790), §61-67, §77, Thompson (2007), p. 133-4, Weber & Varela (2002), esp. p. 106, Johnson (1987), Mensch (2015), Watkins & Stan (2003 & 2023), Section 5.

# In General ...

*Engaging with Kant when we try to understand:*

**Quantum Mechanics**

**Time**

**Imagination**

**Causality**

*... is a very fruitful thing to do*

**End**

**Kant:** *'Out of the crooked timber of humanity no straight thing was ever made'*

Immanuel Kant, *'Idea for a Universal History with a Cosmopolitan Purpose'* (1784).