Quantum Openness and the Sovereignty of God

by

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Outline

Some Preliminary Remarks — What motivates the talk
Assumptions for the talk
Evidence for Openness
  - Openness in Quantum Mechanics
  - Openness in Other Areas
A Teleological Argument for Openness in Creation
Implications of Openness
Concluding Theological Reflections
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  - Mind/Body dualism as a problem
- Empirical arguments
- Intuition
  - (sometimes we should trust our gut-feelings)
- Ongoing interest in openness in connection with divine action
- Christian theology suggests non-reductionist ontology

⇒ Why let the perceived implications of the science of today dictate our interpretation of ontology when they may be wrong tomorrow?
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  - God interacts with the world through his Spirit-presence
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Why assume a non-reductionist ontology?

Arguments concerning emergence (closet reductionism?)

"The whole is greater than the parts" physical science, e.g. "collective phenomena"

biological science in relation to design arguments

psychology and the mind/body problem

⇒ top-down causality

empirical arguments

intelligent design arguments may be related

non-reductionism of Dutch-Reformed Philosophy (Dooyeweerd)

⇒ Antinomies arise if a reduction is attempted

Gut-feelings . . .
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“Neurobiological reductionism has to be false. If not, then what may appear to be a product of rational processes must instead be the consequence of causal processes in the brain. If this is the case, ‘arguments’ for neurobiological reductionism are not in fact arguments but mere noises. And while we did not judge there to be a fully adequate response to this problem at the time we began our project (in the fall of 1998) we recognized a growing body of helpful resources in the literature.” — *Did My Neurons Make Me Do It?*, Nancey Murphy and Warren S. Brown
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- Gut-feelings . . .
- No need for reductionism from a Christian perspective
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No need for reductionism from a Christian perspective
⇒ we have greater freedom in metaphysical/theological speculation than a materialist like Richard Dawkins
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    ⇒ the end is not “built-in” to the beginning
The Strangeness of Quantum Mechanics

“[T]he structure of nature may eventually be such that our processes of thought do not correspond to it sufficiently to permit us to think about it at all. . . . The world fades out and eludes us, . . . we are confronted with something truly ineffable. . . . We have reached the limit of the vision of the great pioneers of science, the vision, namely that we live in a sympathetic world in that it is comprehensible to our minds.”

— Percy Williams Bridgman

(1882–1961, Noble Laureate Physicist and Philosopher)
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- “Particles” behave with both wave-like and particle-like properties
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- Entanglement – particles affect each other instantaneously even though widely separated
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- Uncertainty Principle
  \[ \Rightarrow \text{Cannot measure both position and momentum of a particle at the same time, indeed, both quantities appear not to exist at the same time.} \]
- “Particles” behave with both wave-like and particle-like properties – double slit experiment – no time to discuss
- Entanglement – particles affect each other \textit{instantaneously} even though widely separated – spooky action at a distance
Uncertainty Principle

Given a particle with mass $m$ and speed $v$, its momentum is the product of these: $p = mv$. 

According to quantum theory, every particle has wave properties associated with it, and the momentum is associated with the wavelength of the particle $\lambda$ through $p = \frac{h}{\lambda}$. ($h$ is a very small number known as 'Planck's constant', after Max Planck who discovered it.)
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$$p = \frac{h}{\lambda}.$$

($h$ is a very small number known as ‘Planck’s constant’, after Max Planck who discovered it.)
If $\Delta x$ is the uncertainty within which you can measure the position, and $\Delta p$ is the uncertainty with which you can measure the momentum (think, standard deviations or the width of a bell curve), then the uncertainty principle states:

$$\Delta x \Delta p \geq \frac{h}{4\pi}.$$
Uncertainty Principle

\[ \Delta x \Delta p \geq \frac{h}{4\pi}. \]

Various Bell curves representing data.
Entanglement (Spooky Action at a Distance)

What follows are some arguments that generally lead to the conclusion that two particles which are formerly intertwined, remain so, and can affect each other instantaneously, even if they are very far apart.
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- Quantum particles do not behave like the ‘classical’ particles of everyday life (as we have seen in the uncertainty principle)
What follows are some arguments that generally lead to the conclusion that two particles which are formerly intertwined, remain so, and can affect each other instantaneously, even if they are very far apart. This phenomenon is known as *entanglement*. Reasons:

- Quantum particles do not behave like the ‘classical’ particles of everyday life (as we have seen in the uncertainty principle)
- Quantum mechanics works very well in describing experiments
Measuring a Classical Spin in Inhomogeneous Magnetic Field

Measuring Spin
Measuring a Classical Spin in Inhomogeneous Magnetic Field

classical behavior
Classical and Quantum Behavior - electron (spin $\frac{1}{2}$)

classical - a range of scatter depending on the angle

quantum - "up" or "down" (relative to the magnet)
Einstein-Podolski-Rosen Thought Experiment

- zero spin particle decays into spin up and spin down
- total spin is still zero $\iff$ spin is conserved
spins are deflected, up or down
if the magnetic fields are lined up the results are correlated — when one goes up, the other goes down
Einstein-Podolski-Rosen Paradox

Einstein’s argument:

in quantum mechanics, measuring spin on the $x$-axis and measuring spin on the $y$-axis (i.e. two perpendicular axes) is rather like measuring position and momentum. You cannot measure both precisely. (uncertainty principle)

but if we measure one spin along the $x$-axis, we know in principle that the other must be of opposite spin along the $x$-axis.

therefore we just measure the spin of the second along the $y$-axis and we know both precisely!

$\Rightarrow$

something must be wrong with quantum mechanics (it is not 'complete')
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⇒ something must be wrong with quantum mechanics (it is not ‘complete’)}
Bell's Inequality

It turns out that Einstein's assumption leads to a conclusion that is not in agreement with quantum mechanics. In 1964, John Bell derived an inequality using a rather weak assumption, just that after the particles separate, measuring a particle on one side does not affect the measurement of the particle on the other. The inequality therefore represents a statement that follows from a "complete" theory, as Einstein put it. Quantum mechanics predicts a violation of the inequality. Therefore the issue could be decided experimentally: and quantum mechanics wins every time.
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- Therefore the issue could be decided experimentally: and quantum mechanics wins every time.
Example: rotating one magnet by 20°

(Einstein’s case would be 90°)

Note: “up” and “down” for rotated magnet are different
One way to look at it...
Choose three possible axis directions: $20^\circ$, $0^\circ$, and $-20^\circ$. Each magnet can measure either ‘up’ or ‘down’ relative to its axis.
One way to look at it.

- Choose three possible axis directions: $20^\circ$, $0^\circ$, and $-20^\circ$. Each magnet can measure either ‘up’ or ‘down’ relative to its axis.

- So for each particle, there are eight possible measurements, depending on the direction we choose for each magnet; two for each of three directions:
  
  ▲▲▲▲ ▲▲▲▼ ▲▼▲▲ ▼▲▲▲ ▲▼▼▼ ▼▲▲▼ ▲▼▼▼ ▼▼▼▼
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  - $\uparrow\uparrow\uparrow$ $\uparrow\uparrow\downarrow$ $\uparrow\downarrow\uparrow$ $\downarrow\uparrow\uparrow$ $\uparrow\downarrow\downarrow$ $\downarrow\uparrow\downarrow$ $\downarrow\downarrow\uparrow$ $\downarrow\downarrow\downarrow$

- An identical problem probabilistically is group of people, considering their eye color, handedness, and sex.
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We can show in terms of probabilities:

$$P(\text{male and not left handed}) + P(\text{left handed and not brown eyes}) \geq P(\text{male and not brown eyes})$$
One way to look at it...
One way to look at it... 

P(male, not left handed) + P(left handed, not brown eyes) \geq P(male, not brown eyes)
One way to look at it...

\[
P(\text{male, not left handed}) + P(\text{left handed, not brown eyes}) = P(\text{male, not brown eyes})
\]
Similarly $P(\text{up at } 20^\circ, \text{not up at } 0^\circ) + P(\text{up at } 0^\circ, \text{not up at } -20^\circ) \geq P(\text{up at } 20^\circ, \text{not up at } -20^\circ)$

Of course, we cannot make two measurements on the same particle, but we CAN use Einstein’s trick that because of conservation of spin, if a particle were measured up on the left, at the same angle its partner would always be measured down on the right.
Summary

If the measurement on one side does not affect the measurement on the other (each is already set once the decay occurs, given the axes chosen):

\[ P(\text{up at } 20^\circ, \text{not up at } 0^\circ) + P(\text{up at } 0^\circ, \text{not up at } -20^\circ) \geq P(\text{up at } 20^\circ, \text{not up at } -20^\circ) \]

But...

Quantum theory predicts

\[ P(\text{up at } \theta_1, \text{not up at } \theta_2) = \frac{1}{2} \left( \sin^2 \left( \frac{\theta_1 - \theta_2}{2} \right) \right) \]

That is:

\[ P(\text{up at } 20^\circ, \text{not up at } 0^\circ) = P(\text{up at } 0^\circ, \text{not up at } -20^\circ) = \frac{1}{2} \sin^2(10^\circ) \]

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\frac{1}{2} \sin^2 (20^\circ) = 0.058
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\frac{1}{2} \sin^2 (10^\circ) = 0.015
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We would need \(0.015 + 0.015 = 0.030\) \(\geq 0.058\)

but not true!!!

so quantum mechanics violates Bell's inequality

Experiments agree with quantum mechanics every time!
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Entanglement (Spooky Action at a Distance)

Conclusion:

somehow the measurement of a particle on one side affects the measurement on the other ⇒ "entanglement"

We must conclude that the quantity 'spin' is not specified before measurement, so Einstein was wrong.
Likewise, the properties 'position' and 'momentum' cannot be said to exist in any real sense without a measurement.
⇒ some aspects of physical reality have no complete causal nexus in the past ⇒ "openness" → the end is not built in to the beginning
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Assumptions for the talk
Evidence for Openness
  - Openness in Quantum Mechanics
  - Openness in Other Areas
A Teleological Argument for Openness in Creation
Implications of Openness
Concluding Theological Reflections
Consider the following quote from a recent paper arguing for psychological determinism:

“According to some incompatibilists, morally significant freedom requires ultimate indeterminacy of the act (or according to some compatibilists, indeterminacy of some relevant prior act) by antecedent events and/or states of affairs. The problem is that a causally underdetermined event, such as an act of choice that is free in the sense required by the incompatibilist, would ultimately be inexplicable.” (Wingard, 6)
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Openness in Other Areas

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Without further evidence, why presume the states of affairs for psychological phenomena to be settled (i.e. “explicable”) any more than are the states of the quantum world?
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Without further evidence, why presume the states of affairs for psychological phenomena to be settled (i.e. “explicable”) any more than are the states of the quantum world? One answer might be that it follows from the assumption of a mechanistic ontology . . .
Openness in Other Areas

Psychological decision making ⇒ Social phenomena, economic phenomena, etc.

Animal behavior ⇒ a "doggy" example from Nova

Natural selection ⇒ consider niche animals in North America and Australia...
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- Implications of Openness
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A Teleological Argument for Openness in Creation

God's purposes are not primarily material.

⇒ The material world is not all that determines the future.

⇒ The end is not built (materially) into the beginning.

→ The quantum world makes perfect sense from this standpoint.

Recall the assumption that the biological, psychological, etc. are not reducible one to the other.

⇒ Each has its own commensurate laws, analogous to, but not derivable from, physical laws.

God's purposes are not primarily psychological (or economic or linguistic, etc.)

⇒ In each aspect of creation, we should similarly expect that the end is not built into the beginning.

⇒ “Openness” in an analogous way to the quantum world.
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The end (goal or purpose) of the universe is not built into the beginning. Openness is creational (or "creaturely"). ⇒ It says nothing about how God brings about his own purposes. In other words, from the standpoint of creation, i.e. what we might call laws of nature, the future is underdetermined. God is free to interact at all levels of openness, through his Spirit-presence in the world.
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Concluding Theological Reflections

What does this have to do with your view of God?

Nothing, really.

It comports well with

A “Hyper-Calvinist” God-does-everything view

Open-Theism:

God-waits-to-see-what-creation-does-and-reacts view

Anything in between

⇒

My own view is a Calvinist view in which God brings about all of his intended purposes, but there is genuine creaturely freedom in his creation.
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- ‘New’ laws at every level
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