Evolving Views of Physics: Theological Implications?

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“By their fruits you shall know them” -- Mathew 7

“No one really understands quantum mechanics”
-- Richard Feynman

“Something’s out there”
-- Mulder and Skully, the X-Files

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Why Physics?

• “Physics, its practitioners will proudly tell you, is the most fundamental of sciences.

• Its theories and laws distil the workings of the real world - of particles and planets, heat and light - into stark, sweeping statements of universal validity.
  – Think Newton's law of gravity, which describes with equal assurance how an apple falls and Earth orbits the sun, or the laws of thermodynamics that govern how energy flows.

• These physical laws are generally couched in the language of mathematics, which can be obscure.
  – But this is merely a convenient shorthand.
  – The mathematical quantities are symbols for the tangible objects of the real, physical world and their measurable properties. “
  – At least until Quantum Mechanics. [More later]

Richard Webb, “Is quantum theory weird enough for the real world?”

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Classical (Ancient) Views

• Earth was the center of the universe
  – The sun rose and set over it.
  – Humans were in a privileged cosmological position.

• Democritus in ~400 BC: “Atomos” (tiny particles) are the fundamental building blocks of nature

• Aristotle: Matter continuous, not particles
  – Criticized “atomists,” largely due to question of accounting for extra space beyond the small particles of matter

• Is matter more like peas (particles) or mashed potatoes (continuous)?
  • A theme of today’s discussion and of 20th century physics

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Modern Classical Mechanics
(Movement and Interaction)

• Copernicus and Galileo put the sun at the center of the solar system
  – Humans no longer in especially privileged position

• Sir Isaac Newton expressed classical mechanics in the 17th century with the very influential Laws of Motion. Thermodynamics.
  – E.g., Bodies in motion tend to remain in motion; there is Increasing Entropy (Disorder); equal and opposite reactions; gravity.
  – Described change and motions clearly. Predicted future positions
  – Knowing all the starting conditions, one could predict outcomes
  – Entropy increases and the world becomes more disordered
  – Very deterministic and pessimistic (Universe ends as fuel runs out)

• Possible Theological Implication:
  – God as Great Watchmaker who set the world in motion and then largely withdrew while it plays itself out
  – Theological tension: Free will or God’s will? (Calvin and predestination)
Later Progress and “Loose Ends”

- 19h C: Michael Faraday: Electricity and Magnetism are related.
  - Rotating magnetic fields create electricity, and electricity can magnetize.

- James Clerk Maxwell 1873: Light is electromagnetic waves
  - Considered to be oscillations on the “ether”
  - Could be described mathematically
  - Newton had thought light was made of particles

- Electromagnetism is one basic force

- Lord Kelvin at end of 19th century: Physics is a solved problem. Just needs a few more precise calculations
  - Several loose ends, like “black body radiation” discrepancies
    - “Ultraviolet Catastrophe” and Photoelectric Effect
Upsetting the Apple Cart: Quantum Effects
Planck and Einstein circa 1900

• “Ultraviolet Catastrophe”
  – Invisible light radiating from Black Bodies (ideal collectors) has an unexpected range of wavelengths

• Photoelectric Effect: light shone on metal creates electricity
  – However, the amount of electricity is not related to how bright the light is, but the color of the light

• Max Planck: Radiation transfers as persistent quanta of energy, not continuous. (Waves should be continuous.)

• Einstein applied Planck’s idea to the photoelectric effect and found that it also explains the results there.
  – (Electricity is proportional to frequency, not brightness)
  – Quantum Mechanics is born
  – (Pass the peas, hold the mashed potatoes!)
Further Progress: Relativity
Physics of the Very Fast, and Gravity

• Michelson Morley Experiment in 1880s.
  – Interferometer can measure light precisely
    • Light going with Earth’s rotation is same speed going against
  – Light goes at a constant speed
    • Imagine a moving car turning on its headlights
• Einstein’s 1905 theory of Special Relativity relates time, speed
  • Mass increases and time slows so c will not be exceeded
• Einstein theory shows that matter and energy are related
  \( e = mc^2 \)
  – Matter might be seen as a great deal of congealed energy
  – Time, mass, energy relative, but light speed is constant upper limit
• Einstein’s General Relativity re-describes gravity as curvature of space-time. (Think bowling ball on a mattress).
Einstein pointed to certainty in the **absolute** speed of light

Quantum Mechanics held that fundamental entities were both waves and particles, with **probabilistic** properties
  - Uncertainty Principle

Einstein challenged Quantum Mechanics as an *unfinished* theory.
  - “God does not play dice.”

Physicists performed experiments to determine the truth

[Dr Quantum - Double Slit Experiment](https://www.youtube.com/watch?v=05:03 - 2008)

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Particles created together may be “entangled”
- Possess a single quantum state?

When one observes one entangled particle, it affects the state of the other. Einstein Podolsky Rosen (EPR) experiment.
- This happens even if the observed particle is “beyond the light cone” of the affected particle
  - It appears that information is transferred from one particle to the other faster than the speed of light. Violates Special Relativity.
  - Follows quantum theory mathematical prediction. Bell’s Theorem.
  - May show non-locality: “Spooky actions at a distance”. --Einstein
Seven Essential Elements of Quantum Physics, by Chad Orzel (1)

1) **Particles are waves, and vice versa.** Quantum physics tells us that every object in the universe has both particle-like and wave-like properties. It's not that everything is really waves, and just sometimes looks like particles, or that everything is made of particles that sometimes fool us into thinking they're waves. They’re both, and neither.

2) **Quantum states are discrete.** The "quantum" in quantum physics refers to the fact that everything in quantum physics comes in discrete amounts. A beam of light can only contain integer numbers of photons—1, 2, 3, 137, but never 1.5 or 22.7.

3) **Probability is all we ever know.** When physicists use quantum mechanics to predict the results of an experiment, the only thing they can predict is the probability of detecting each of the possible outcomes (even though the overall calculations are deterministic).
Seven Essential Elements of Quantum Physics, by Chad Orzel (2)

4) **Measurement determines reality.** Until the moment that the exact state of a quantum particle is measured, that state is indeterminate, and in fact can be thought of as spread out over all the possible outcomes. After a measurement is made, all subsequent measurements on that particle will produce the same outcome.

5) **Quantum correlations are non-local.** One of the strangest and most important consequences of quantum mechanics is the idea of "entanglement." When two quantum particles interact in the right way, their states will depend on one another.

6) **Everything not forbidden is mandatory.** A quantum particle moving from point A to point B will take absolutely every possible path from A to B, *at the same time.*
Seven Essential Elements of Quantum Physics, 
by Chad Orzel (3)

7) **Quantum physics is not magic.** As strange as quantum physics is, it does not suspend all the rules of common sense. The bedrock principles of physics are still intact: energy is still conserved, entropy still increases, nothing can move faster than the speed of light. You cannot exploit quantum effects to build a perpetual motion machine, or to create telepathy or clairvoyance.

Quantum mechanics has lots of features that defy our classical intuition-- indeterminate states, probabilistic measurements, non-local effects-- but it is still subject to the most important rule at all:

If something sounds too good to be true, it probably is. Anybody trying to peddle a perpetual motion machine or a mystic cure using quantum buzzwords is deluded at best, or a scam artist at worst.
Summary and Questions (1)

• So the one thing we thought we could count on, the speed limit based on light, is called into question with nonlocality.

• Photons and Electrons behave as both waves and particles.
  – Tend to travel as waves, interact as particles. “Wavicles.”
  
  • A moving disturbance in a quantum field.

  – EPR experiment shows “there’s something out there.”

  – Our “Ultraviolet Catastrophe” and Photoelectric Effect?
    • Will this discrepancy lead to a new departure in physics like QM?

  – Doesn’t mean “New Ageism” is right.
    • Consciousness is not linked across the universe.
Summary and Questions (2)

• The Quantum world is quite weird, but has predictable elements with Quantum Mechanics theory
  – Quantum Theory makes probabilistic predictions that generate reliable statistics. Transistors work due to QM. (Waves in crystals)
  – Individual particle is “free;” but collective behavior is predictable

• Analogous to free will in an ordered universe?
  – “God doesn’t play dice with the universe” Einstein
  – “Quit telling God what to do, Einstein.” Neils Bohr

• Romans 1:20. We can see God’s invisible powers and divinity in His creation. Discuss.

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