Recent Developments in Physics

Some Implications for Theology

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Introduction

Want to look at several phenomena discovered in the 20th century:

- The Quantum World
- Relativity Theory
- Open vs Closed Universe
- Chaos Theory

The Quantum World

The Quantum World

A quick tour of quantum phenomena:

- Photoelectric effect
- Discrete energy levels in atoms, nuclei
- Wave-particle duality

Photelectric Effect

- Photoelectric effect: shining light on surface of a metal causes metal to give off electrons.
- For particular metal, electrons only given off if frequency of light is above some minimum threshhold.
- If above threshhold, electrons come off even with very weak beam of light.
- Metals apparently absorb light in packets, or quanta.

Discrete Energy Levels

- Atoms and nuclei do not absorb or emit light in just any frequencies/wavelengths.
- Rather, a particular atom or nucleus absorbs or emits a discrete series of frequencies.
- Apparently the atoms or nuclei exist in a series of energy levels or steps.

Wave-Particle Duality

- It now appears that light does not exist just as waves, as was earlier thought. Rather it behaves sometimes as a wave and sometimes as a particle.
- The same appears to be true for objects that were traditionally thought of as particles, e.g., electrons, protons, etc. They sometimes seem to be waves, sometimes particles.

Quantum Theory

- The theory that has been developed in the 20th century to explain these phenomena.
- Quantum objects are described by means of a wave function (a wave of probability or potentiality) which tells where the object is likely to be.
- When the object interacts with another object, the wave function collapses.

How realistic is quantum theory?

- It is partly an epistemological effect:
  - We are investigating size-scales where observational tools disrupt the structure we are looking at.
- It is more than an epistemological effect:
  - The light really is in quanta.
  - The peculiar two-slit experiment
  - The EPR paradox

The Two-Slit Experiment

- Shining light on a screen produces basically uniform illumination.
- Shining light which has passed thru a pair of slits onto a screen produces an interference pattern.
- If we turn down the intensity of the light so that only one quantum is passing from source to screen at a time, we still get the pattern!
- Which slit did the quantum go through?
- Closing either slit destroys the pattern!
- How does the quantum know about both slits?

The EPR Paradox

- If two particles have interacted, then their quantum states are correlated to each other.
- If an observer measures the state of one particle, somehow the other particle knows what the measurement was, even if they are so far apart that a signal could not have gotten there yet!
- Are these instantaneous effects at a distance? Is there something non-local about nature?

Diverse Models to Explain Quantum Phenomena

- Copenhagen Interpretation
- Mind Over Matter Interpretation
- Many Worlds Interpretation
- Neorealist Interpretation
- Undivided Wholeness Interpretation

Copenhagen Interpretation

- View of Bohr and Heisenberg
- Prevailing view in physics today
- There is no deep reality in the absence of measurement, only potentialities.
- Measurement collapses the wave function, so that potentialities become actual.
- Huge problem of how micro-world transitions to macro-world.

Mind Over Matter Interpretation

- View of Wigner, von Neumann
- A conscious observer collapses the wave function.
- Consciousness is necessary for the universe to exist.
- Problem of transition to consciousness:
  - Humans are conscious; are animals, bugs, plants?
- Schrödinger's Cat

Many Worlds Interpretation

- View of Everett, Davies
- No collapse of wave function, instead a multiplication of universes!
- Each alternative is manifested in some universe.
- Problem of conservation laws:
  - If nothing is conserved between universes, why anything conserved within them?

Neorealist Interpretation

- View of Einstein, Planck, Schrödinger, Bohm
- The world is made of objects that actually possess attributes, whether we observe them or not.
- Problem: these attributes are going to have to be rather strange ones!

Undivided Wholeness Interpretation

- View of Bohm, Capra
- The world is a seamless whole.
- The various variables have real values.
- But "locality" is abandoned.
- "Togetherness" is undiminished by distance.

Summary on Quantum World

- Strange!
- We now see that the old ideas of "particle-contact" and of "fields and waves" were research programs rather than "the way things are."
- They have now encountered contradictory evidence.
- But it is not at all obvious what the deep reality is like.

Relativity

Relativity

- Like quantum phenomena, relativistic phenomena seem to mock at common sense.
- Discussion of relativity is usually subdivided into:
  - Special Relativity
  - General Relativity

Special Relativity

- The main phenomena:
  - Absolute speed limit = that of light
  - Length contraction → zero length as velocity → that of light (c)
  - Mass increase → infinity as velocity → c
  - Time dilation → infinity as velocity → c
    - i.e., time slows down
- The results:
  - Inability to specify absolute frame of reference
  - Relativity of space & time intervals

Special Relativity

- Relativity of space & time intervals follows logically from absolute value of speed of light (in vacuum) for all observers.
- Relativity actually unpacks a contradiction between Newton's equations of motion and Maxwell's equations for electromagnetism.

General Relativity

- Attempt to generalize the results of special relativity by including acceleration.
- Both special and general relativity theory were worked out by Albert Einstein.
- General relativity discovers a link between mass and space curvature.
- It leads to the concepts of black holes and the twin paradox.

Black Holes

- The popular name for a peculiar phenomenon that arises from general relativity.
- As the amount of mass in a given volume is increased, light passing near the mass begins to be more and more bent, and light coming out from the mass more reddened.
- At a certain crucial mass per volume, light cannot escape from the mass, which then becomes a black hole.

Twin Paradox

- Imagine two twins, one of whom stays at home, and the other travels out into space and back, reaching speeds close to the speed of light.
- Depending on how close to the speed of light the traveling twin comes, less time will have passed for him on his trip than for the twin who stayed at home.
- The effect is not symmetrical, and all observers can distinguish between the twin who traveled and the one who didn't.

Summary on Relativity

- Relativity theory has often been misused by unwarranted generalization.
- It does not teach that all ideas or worldviews are relative and of equal weight.
- It does teach that our ideas of simultaneity and passage of time are relative.
- General relativity does reinstate a possible preferred observation frame, and both theories have an absolute speed of light.

The Universe: Open or Closed?

What does "open" mean?

- Two distinct uses of "open" and "closed" with reference to the nature of the universe:
  - Whether anything outside the universe can penetrate it (open) or not (closed)
  - Whether the universe will expand forever (open) or eventually collapse (closed)
- The former is more common in theological discussions, the latter in scientific.

What does "open" mean?

- We looked at the former in our PP talk “The Biblical View of Nature."
- Here we look at the latter.
- Some form of the Big Bang cosmology has now driven out its competitors.
- One way of classifying big bang models:
  - Oscillating: closed
  - One-bounce: closed
  - No-bounce: open

Universe open or closed?

- The oscillating model was popular until the early 1990s, but it now looks like the universe is expanding at an ever-increasing rate.
- Both the oscillating and one-bounce models require a bounce at the big-bang, but it looks like a collapsing universe would disappear into a black hole.

Universe open or closed?

- Stephen Hawking has pointed out that the entropy of the universe appears too low for it to have been through a bounce.
- Thus a no-bounce version of the big-bang currently fits the data best, an open universe.
- Current attempts to avoid a beginning seek to have our universe be one bubble in a whole sea of bubbles, but our universe at least is still an open universe.

Summary on Universe

- The universe appears to have begun at the big bang.
- Being finite and inside our universe, we cannot rule out multiple universes, but we have no evidence for this.
- The evidence we do have points strongly toward a creation event, a Creator and Designer.

Chaos Theory

What is it?

- Chaos has been observed in the flow of fluids (when they become turbulent) for many years. The differential equations for fluid flow are a mess to solve!
- The "butterfly effect": work with equations of meteorology (fluid flow) show that long-term prediction is impossible due to the non-linear nature of the equations.
- Recent interest has been sparked by finding chaotic phenomena in numerous simple systems, including planetary motion.

Chaotic Systems

- These are physical systems in which solutions with arbitrarily close initial conditions eventually diverge drastically, so that no matter how accurately one measures initial conditions, we can know virtually nothing about the state of the system once a significant period of time has passed.
- For example, it looks like weather prediction may be permanently limited to just a week or so.

Summary on Chaotic Systems

- The clearest message here is that humans are strongly limited in their ability to predict the future.
- This makes the evidence of fulfilled prophecy in Scripture very powerful.
- Some are hoping that chaotic systems will produce arbitrarily large levels of order without a designer. This appears to be whistling in the dark.

Conclusions on Recent Physics

- The 20th century produced a number of real surprises. We may very well see more of these in the 21st century.
- Reality is nowhere near so simple as we once thought it was.
- If Christianity is true, we should not fear that the Bible will somehow be outdated. We may still have to revise some of our interpretations, however.

The End

…of this talk. I doubt that we are near the end of discoveries in physics.

For Further Reading

- Davies & Brown, *Ghost in the Atom* (1986).
- Gamow, G., *Mr. Tompkins* (1940).
- Gleick, J., *Chaos: Making a New Science* (1997).
- Hawking, S., *Brief History of Time* (1988).
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- Polkinghorne, J.C., *Quantum World* (1984).
- Ross, H., *Fingerprint of God* (1991).