Why Causal Correlations are Applicable to Quantum Mechanics

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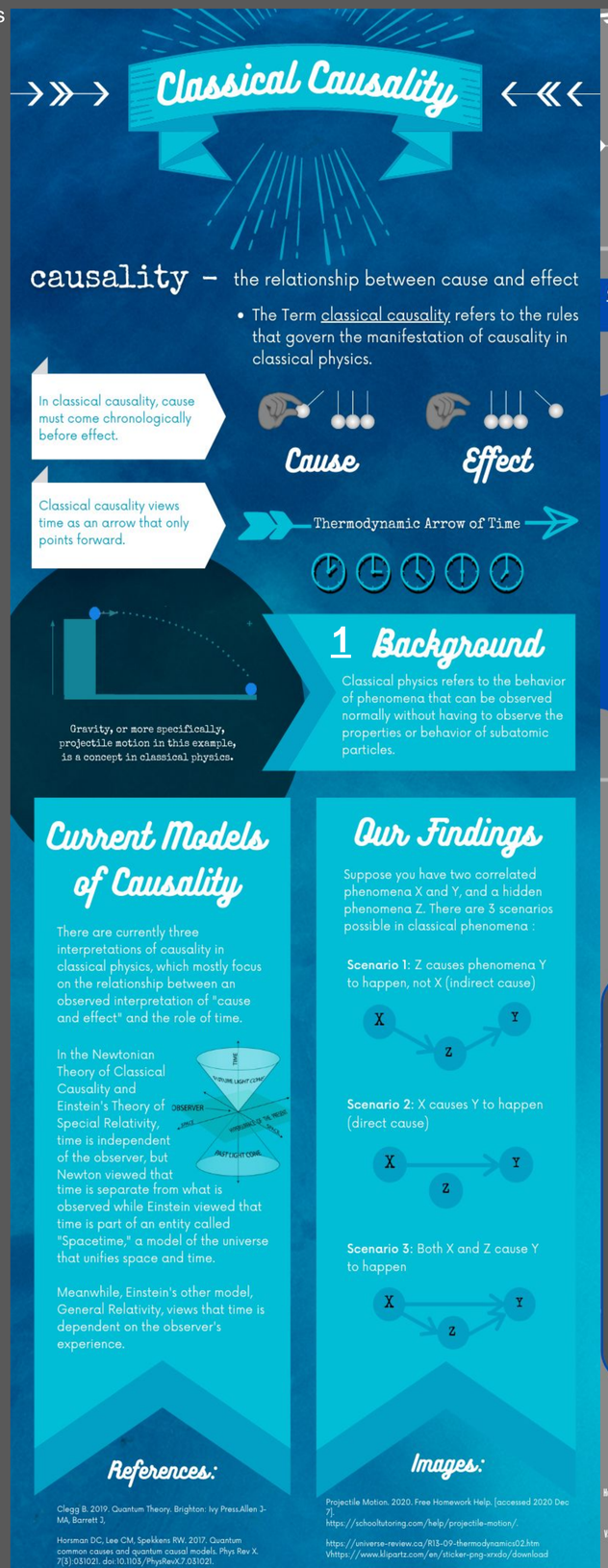
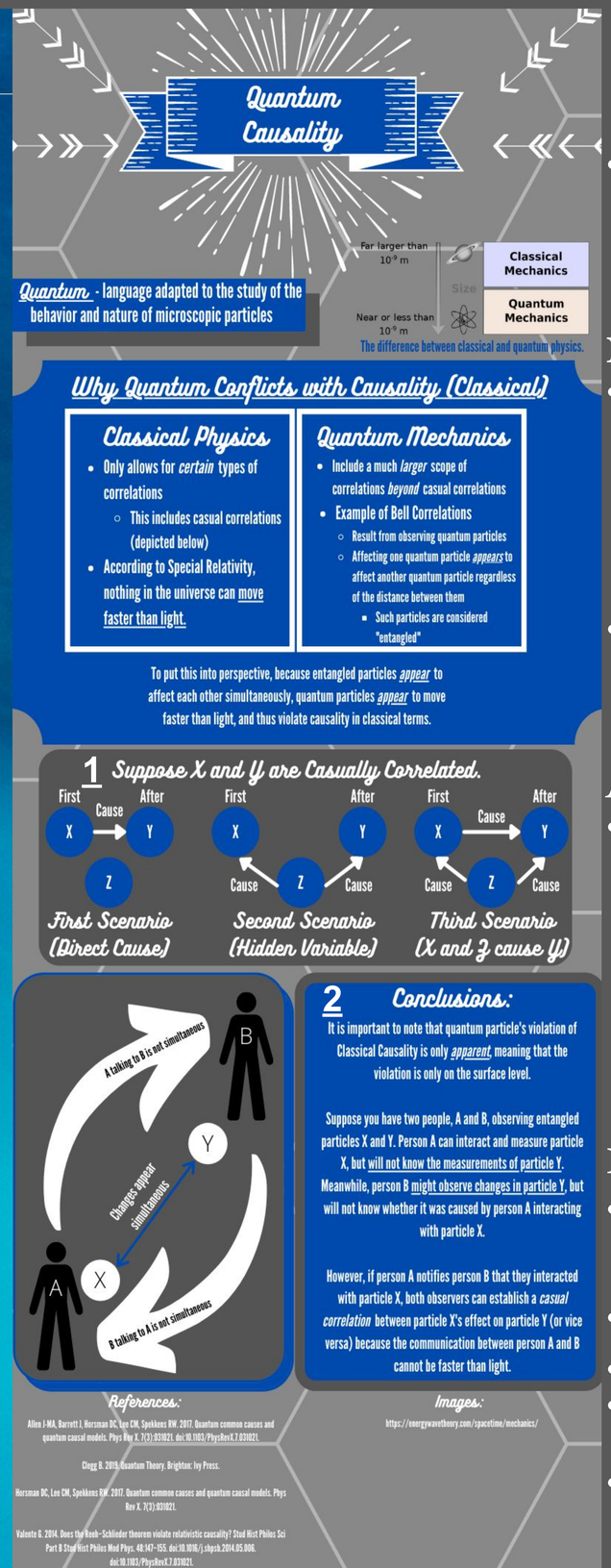
Grand Challenge:

- Quantum physics refers to the study of the behavior and nature of microscopic particles (Clegg 2019)
- Gravity is a force that is well-defined in terms of classical physics, or the behavior and interaction between groups of particles on the macro scale
- A model for causality in terms of quantum physics currently does not exist (Ball 2017)
  - Causality is generally presented through the concepts of "cause" and "effect"
    - In terms of classical physics, this definition and how causality is modelled is much more complex (Allen et al. 2017)
  - Our group decided to focus on researching how quantum mechanics can abide by a definition of causality

What We Did:

- **SCI 150:**
  - Research into a history of Quantum Gravity (roots, experimentation, etc.) (Clegg 2019)
  - Creation of concept maps based on research
  - Meeting with Dr. Silva, an expert in quantum physics, specifically researching quantum causality
    - 1. Define causality in terms of classical physics
    - 2. Identify why classical causality comes into conflict with quantum mechanics
    - 3. Define causality in terms of quantum physics, accounting for the conflict(s) found in previous step
- **SCI 200:**
  - How causality is normally perceived/defined in a non-physics context
  - The concept of causality in terms of classical physics
    - Casual correlations (Allen et al. 2017)
      - "Cause", "Effect", and "Hidden Variable" correlations
  - Meet with Dr. Silva for feedback
  - GOAL: Creation of an Infographic explaining Classical Causality
- **SCI 250:**
  - Research into quantum mechanics' conflict with classical causality
    - Entangled Particles (quantum) vs Theory of Special Relativity (classical) (Valente 2014)
  - Meeting with Dr. Silva
    - Discussion about how to tackle handling the apparent conflict (Oreshkov et al. 2011)
  - GOAL: Creation of an Infographic explaining Quantum Causality





Conclusions:

- Causality in classical physics relates to casual relations
  - Correlations between a perceived cause, perceived effect, and a hidden variable
  - 3 Scenarios within causal correlations **1**
    - Perceived cause results in the perceived effect (direct cause)
    - A hidden variable is responsible for the perceived effect while the perceived cause is unrelated (indirect cause)
    - Both a perceived cause and a hidden variable are responsible for the perceived effect (Both)
- Quantum Causality (Quantum Physics)
  - Main Conclusion: The scope of quantum causality goes beyond causal correlations, but *can* include causal correlations **2**

Next Steps:

- Get into contact with Dr. Silva and additional Quantum Causality experts
  - Discuss potential avenues we can take in regards to refining our definitions of quantum causality
    - Based on such definitions, create a representation (conceptual or mathematical model) of quantum causality
  - Discuss avenues to take in order to spread awareness of our conclusions within the field of quantum physics
- Return to our original Grand Challenge of modelling Quantum Gravity based on our conclusions about quantum causality

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