**Welcome, Everyone!**

I am delighted to see so many of you interested in exploring topics that extend beyond the realm of pure physics.

I recognize that we all come from different backgrounds in terms of philosophical knowledge. Some of you have a strong foundation in philosophy, others have read a few books, while some are relatively new to the field. This diversity makes it challenging to balance the course to suit everyone’s level, but I will do my best to engage all of you.

This course does not aim to be an exhaustive or fully inclusive philosophical exploration. Rather, it serves as an introduction. The structure will be as follows:

* **Lecture 1:** We will begin with an introduction to the fundamental philosophical questions related to scientific work, along with a brief historical overview of ancient and medieval philosophy.
* **Lecture 2:** We will shift our focus to modern science, particularly the works of Galileo and Newton, examining their contributions from a philosophical perspective.
* **Lecture 3:** We will delve into the philosophy of science, addressing key questions such as: What is science? What does it mean for our work to be based on facts? How should we interpret scientific theories? This discussion will primarily focus on the 19th and 20th centuries, covering movements like Positivism and Neo-Positivism, the Vienna Circle, and influential thinkers such as Popper, Kuhn, Lakatos, and Feyerabend.
* **Lecture 4:** We will analyze the philosophical concept of truth. What does it mean to say that a theory is true or real? Are scientific theories mere metaphors, or do they describe reality itself?
* **Lecture 5:** A guest speaker specializing in the Bohmian interpretation of Quantum Mechanics will conclude the course with a special lecture.

Each lecture will include a philosophical recap, ensuring that we not only understand the historical and sociological context but also engage with the key philosophical questions that arise.

**Where Do We Begin?**

We begin with a question. As scientists, how often do we ask ourselves: *What is science? Why is science so successful?*Unlike literature, law, or philosophy, where debates often revisit the same fundamental questions, science appears to progress continuously, uncovering deeper truths—or at least, that is the narrative we tell ourselves.

Another perspective considers the metaphysical and ontological aspects of science. What is the nature of reality? What are the fundamental principles underlying our world? These questions will emerge throughout the course, particularly when discussing the major scientific revolutions of the 18th and 19th centuries.

Science is built upon facts. As physicists, we observe phenomena and strive for an objective understanding of the physical world. But is science merely a collection of facts, or is there more to it? This skepticism is reflected in Richard Feynman’s famous remark that *the philosophy of science is as useful to scientists as ornithology is to birds.* A more critical perspective suggests that philosophers of science are simply physicists who were unsuccessful in their field and had to switch disciplines.

In his book *What Is This Thing Called Science?*, Alan Chalmers outlines key points that challenge the traditional view of science:

1. Scientists, as practitioners, are best equipped to conduct scientific work and do not need philosophical guidance.
2. However, scientists are often not skilled at stepping back and reflecting on the nature of their work.
3. Scientists excel at making progress but struggle to articulate what constitutes that progress.

**A Short Anecdote**

A scientist once asked a philosopher: *Why do you think philosophy is so important?* The philosopher replied: *Why do you think science is so important?* The scientist confidently listed several reasons. The philosopher interrupted: *Stop! You are now engaging in philosophy.* This story highlights that even when we believe we are detached from philosophy, we are inevitably engaged in it—whether we acknowledge it or not.

**The Role of Philosophy in Science**

Consider a simple example: We landed on the moon—an extraordinary scientific achievement. But we also built the atomic bomb. Is that progress? The answer is not purely scientific but requires philosophical reasoning.

Albert Einstein once observed:

*Many scientists today are like someone who has seen thousands of trees but never a forest. Knowledge of the historical and philosophical context grants independence from the prejudices of one’s own generation. This distinction separates a mere specialist from a true seeker of truth.*

Most of us pursued physics out of a desire to uncover deeper truths, not just to write code or assemble circuits. I am not here to convince you of anything, but rather to encourage an exchange of ideas. While we don’t need philosophy in the laboratory, maintaining a philosophical perspective can prevent us from becoming mere specialists.

**Objectivity in Science**

Science is often regarded as purely objective—based on what we see, hear, and measure, rather than personal opinions or speculative imagination. It is a fact that the Earth orbits the Sun. Science, in this view, is a structure built upon indisputable facts.

However, history shows that even fundamental scientific principles are subject to upheaval. The 17th-century mathematical revolution—marked by Frege’s and Hilbert’s failed attempts to establish absolute foundations for mathematics—illustrates this instability.

As H. D. Anthony noted:

*Galileo’s break with tradition was not just due to his observations and experiments, but his approach to them. He accepted facts as they were, rather than conforming them to preconceived ideas. Theories were built to fit the facts, not the other way around.*

This presents a naïve view of science: that Galileo simply observed the world and formulated theories based on his observations. But do we truly believe science works this way? Perhaps we don’t often reflect on such questions, but they are worth considering.

**Thought Experiments and Philosophical Inquiry**

Philosophers and scientists both engage in thought experiments. Consider:

1. **Einstein’s Elevator** and **Schrödinger’s Cat**—scientific thought experiments that challenge our understanding of reality.
2. **The Brain in a Vat**—a philosophical thought experiment questioning the necessity of an external physical world.
3. **The Trolley Problem**—a moral dilemma that illustrates the complexity of ethical decision-making.

**Epistemology: How Do We Know What We Know?**

Epistemology—the study of knowledge—has been a central philosophical concern since Aristotle. It remains a critical area of inquiry today.

**The Historical and Social Context of Science**

In particle physics, we gather data from experiments such as those conducted at the LHC. Philosophers, in turn, analyze historical data, recognizing that history is often written by the victors. In physics, do we also only focus on the “winning” theories? Examining the historical evolution of scientific ideas provides valuable insights into our understanding of science itself.

**Conclusion**

My goal is not to argue that physicists must become philosophers or that our scientific methods are flawed. Rather, I invite you to keep an open mind and consider how a philosophical perspective might enrich our understanding of natural science. Throughout this course, we will explore these questions step by step, aiming to foster critical thinking and intellectual curiosity.

**History of Ancient Philosophy**

To understand the origins of scientific thought, we must begin with the basics: the history of philosophy, tracing its roots from ancient Greek and medieval traditions.

Roughly seven million years ago—assuming we accept the biological evolution model—our ancestors diverged from chimpanzees. At some point, mysteriously, humans began developing language, a pivotal step in the evolution of our species. The genus *Homo* emerged around three million years ago, crafting tools, forming societies, and laying the groundwork for civilization.

The first major scientific revolution occurred approximately 50,000 to 100,000 years ago with the advent of symbolic and abstract reasoning, as evidenced by the cave paintings in Altamira. Religion emerged as an attempt to explain natural phenomena through mythological narratives, attributing them to gods and spirits. Writing, mathematics, geometry, and astronomical observations followed, shaping the intellectual landscape.

A civilization without access to the stars and the sun would not develop religion. As Plato and Cixin Liu suggest, astronomical observation, natural inquiry, and religion were deeply interconnected. However, during this early period, knowledge primarily served utilitarian purposes—governing, constructing, and consolidating power—rather than seeking objective understanding. Consequently, this era cannot be considered a scientific epoch, as explanations of natural phenomena remained rooted in myths and religious doctrines.

**The Birth of Philosophy**

A significant shift occurred in the sixth century BCE with the emergence of a new intellectual discipline: philosophy. The term, likely introduced by Pythagoras of Samos, originates from the Greek words *philos* (love or passion) and *sophia*(knowledge), signifying a love for wisdom. Unlike today, where philosophy is sometimes seen as impractical, in antiquity, it represented the highest form of intellectual pursuit—a method of seeking rational explanations rather than relying on myths.

The first known philosopher, according to Aristotle, was Thales of Miletus, from what is now Turkey. The rise of philosophy was facilitated by two critical factors: political freedom and economic prosperity. Greek city-states, each with their own government, fostered intellectual freedom by preventing the imposition of a centralized authority that dictated dogmatic truths. Additionally, economic and cultural exchanges provided a fertile environment for philosophical inquiry.

Another factor—perhaps less serious but intriguing—is the Mediterranean climate. As a joke (or maybe not), pleasant weather might have encouraged free thinking.

**Early Greek Philosophy: Physis and Arché**

The early Greek philosophers, particularly the pre-Socratics, were primarily concerned with *physis*—a term referring to nature in its constant state of becoming. Unlike modern physics, *physis* emphasized growth, transformation, and underlying principles of existence.

A central concept in their inquiries was *arché*—the fundamental principle or origin of all things. Thales proposed that water was the *arché*, though not in the modern sense of H₂O, but rather as an abstract, primordial substance. Pythagoras introduced a mystical interpretation of mathematics and music, while Empedocles proposed the four classical elements—earth, fire, water, and air—a framework that persisted until the early modern period. Plato later added *ether*, a concept that remained unresolved until the 20th century.

Democritus' atomic theory came closest to our contemporary understanding of matter, positing that the universe consists of indivisible atoms moving through empty space—a profoundly materialistic view.

**The Socratic Revolution**

With Socrates, the focus of philosophy shifted from nature to human existence and ethics. His methodological approach—asking relentless questions—challenged conventional wisdom and sought deeper truths.

Then came the giants: Plato and Aristotle.

**Plato**, a student of Socrates and teacher of Aristotle, distinguished between the physical world and the world of eternal, immutable Forms. For him, true knowledge derived from rational thought rather than sensory experience. Mathematics and geometry, with their certainty independent of perception, held a privileged position in his epistemology. Plato's allegory of the cave illustrates the philosopher's struggle to perceive ultimate reality. The wise man who leaves the cave, sees the sun (truth), and returns to enlighten others is met with disbelief—an idea that resonates with Kant's notion of the unknowable *noumenon*.

**Aristotle**, in contrast, grounded knowledge in empirical observation and systematic classification. He organized his studies into distinct fields and structured a comprehensive view of the cosmos, placing Earth at the center. Unlike Plato, Aristotle did not emphasize mathematics but instead focused on qualitative descriptions. His work laid the foundation for natural philosophy, though his geocentric model was later challenged by Galileo’s telescopic discoveries.

However, Aristotle’s thought became dogmatized over time, particularly within the Roman Catholic Church. The crystallization of his ideas into doctrine was not his fault, nor that of Thomas Aquinas, but rather the result of institutional power seeking to maintain control.

**The Decline of Greek Philosophy**

By the 5th century CE, Greek philosophy had largely faded. Skepticism and superstition took hold, and Christianity, with its emphasis on revealed truth, replaced philosophical inquiry as the dominant intellectual force. The Roman Empire split in 395 CE, with the Western half collapsing in 476 CE, while the Eastern Byzantine Empire persisted until 1453. Though Platonic and Aristotelian traditions survived in the East, they were largely reconciled with Christian doctrine rather than pursued as independent inquiries.

**Islamic Contributions to Philosophy and Science**

During the Islamic Golden Age (roughly 600–1258 CE), scholars preserved and expanded upon Greek philosophy. The Qur’an itself encourages the study of nature, as seen in verses such as 2:164, 3:189-191, and 24:44. Islamic scholars translated Greek texts into Arabic and later Latin, making them accessible to medieval Europe. Figures such as Avicenna (who explored physics and consciousness through thought experiments like the *Flying Man*) and Averroes (who reintroduced Aristotle to Europe) played crucial roles in this intellectual transmission.

However, by the mid-13th century, Islamic thought grew increasingly conservative, limiting philosophical exploration.

**The 12th-Century Renaissance and Medieval Thought**

The translation of Greek texts into Latin sparked a European intellectual revival, leading to the foundation of universities such as Bologna, Paris, Oxford, and Cambridge. Scholastic thinkers like **William of Ockham**, known for *Ockham’s Razor*(though similar principles existed in Aristotle’s work), emphasized simplicity in explanations—an idea seemingly contradicted by modern theories such as the multiverse.

Albertus Magnus and **Thomas Aquinas** synthesized Aristotelian philosophy with Christian theology, a process culminating in Aquinas’ *Summa Theologiae*. His structured approach to reasoning remains influential, particularly in contemporary analytical philosophy.

One of the central tensions in medieval thought was reconciling Aristotle’s eternal universe with the Christian doctrine of creation. Ultimately, the Catholic Church entrenched Aristotelian cosmology as official doctrine—a position that would later be challenged by the Scientific Revolution.

**Conclusion**

The evolution of philosophy from its mythological origins to rational inquiry set the stage for modern science. While ancient and medieval thinkers lacked our empirical methodologies, their quest for knowledge laid the foundation for future breakthroughs. The history of philosophy reveals not just intellectual progress but also the constraints imposed by religious and political structures—lessons that remain relevant in today's pursuit of truth.

**Recap of Key Concepts**

* **The Philosophy of Physis** is broader and more profound than modern physics. Its goal is to understand the true nature of the world: What is reality? What is truth?
* **Pre-Socratic Philosophers** focused on origins, first principles, and causality—seeking to determine what causes what.
* One of their main challenges was explaining **reality and movement**: Why does the world change? Why do different things exist? (A concept we might now explain through symmetry breaking.)

**Perspectives on Change and Reality**

* **Heraclitus** believed that everything is in flux: "You cannot step into the same river twice" because everything constantly changes.
* **Parmenides**, in contrast, argued that "being is"—it is immutable, and movement is an illusion.
* **Plato** asserted that true reality is eternal and unchanging, consisting of ideal Forms existing in a metaphysical realm.
* **Aristotle** introduced a resolution: reality consists of both **actuality** (energy) and **potentiality** (essence). Things possess the potential to become something else, and this transformation is governed by their intrinsic essence. Unlike Plato, Aristotle located these realities within objects themselves rather than in a separate metaphysical world.
* Aristotle also emphasized the importance of **causality**, exploring the different causes that explain why things are the way they are.

**Epistemology: Understanding Knowledge**

Epistemology examines how we acquire knowledge and what constitutes true knowledge.

* In Raphael’s *The School of Athens* (~1510, Vatican Museum), **Plato** is depicted pointing upward, symbolizing his belief that reality consists of eternal ideas grasped through reason. This reflects **rationalism**, which later influenced **Idealism** in the 19th century—a view claiming that external reality doesn’t exist independently but is constructed by the mind.
* **Aristotle**, in contrast, points downward, emphasizing that knowledge comes through sensory experience and observation. His approach laid the foundation for **Realism**, the idea that an external reality exists independently of our minds. This perspective influenced figures like Einstein.
* These two contrasting views raise profound questions about the nature of **facts**, the **laws of physics**, and scientific **theories**.

**Science: Facts and Theories**

Science is often seen as being derived from facts, but this relationship is more complex than it seems.

1. **Empiricism (17th-18th Century British Philosophers)**
   * Thinkers like **Locke, Berkeley, and Hume** emphasized that knowledge is based on sensory experience and observation. This led to concerns about **inductive reasoning**—how we derive general principles from specific observations.
2. **Positivism and Logical Positivism (Vienna Circle, Early 20th Century)**
   * These movements sought to establish precise logical relationships between scientific knowledge and facts. They were responding to foundational crises in mathematics in the late 19th century.

**The Interplay Between Facts and Theories**

Are facts truly independent of theory, with theories simply derived from them? Or do theories shape how we perceive and interpret facts? This ongoing debate continues to shape the philosophy of science.

More questions to explore—and perhaps, some answers to uncover.