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PHYSICS AS A COGNITIVE BIAS: LIGHT, SPACETIME, AND BATS THE SCIENTISTS

Classically, physicists strived to assign some rigorous explanatory models to what happens in our phenomenal scope, and they surely succeeded. Nowadays, cognitive science tells us that our phenomenal representations, even being presumably structurally veridical, are made out of our inborn "mental paints" (Harman), such as light, colours, warmth, density, etc. According to professionally trained physics, the wave-particle duality is not at all paradoxical mathematically, only is it perceptually. Thus, one may conjecture that the rest of items of our physical ontologies may have been induced by our perceptual constitution, and if bats or robots did physics, their science, the set of its problems and their representations of facts could have substantially differed. Our physics uses categories (particles, waves) that feel natural to us because they're built from our "mental paints" and predictive habits. A robot's correlation-based science would skip these, suggesting our ontology isn't inevitable. If perception is an evolved interface (Hoffman) and knowledge is a data-trained predictive model (Friston), then bats or robots would indeed craft different sciences. Our "problems" (e.g., wave-particle duality) might not even register with them. Big Data science hints that theory itself – our need to explain with entities like "fields" – might be a human peculiarity. An AI could deal with the same reality without our conceptual baggage, echoing Hoffman's idea that we don't see the "real" code. In sum, this suggests that the ontology of physics isn't a direct window into reality but a human-constructed map, shaped by how evolution painted our interface and how our brains model the world. The mathematics might be universal (e.g., quantum equations), but the entities we project beyond – like waves or particles – are our own. Moreover, match or mismatch of an ontology and a theory can affect the latter's efficiency.

Keywords: physics; ontology; perception; theory; waves; particles; duality

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ФИЗИКА КАК КОГНИТИВНАЯ СКЛОННОСТЬ: СВЕТ, ПРОСТРАНСТВО-ВРЕМЯ И УЧЕНЫЕ ЛЕТУЧИЕ МЫШИ

Классически физики стремились предложить строгие объяснительные модели для того, что происходит в нашем феноменальном мире, и им это, безусловно, удалось. Сегодня когнитивная наука утверждает, что наши феноменальные представления, даже предположительно структурно достоверные, состоят из наших врожденных «ментальных красок» (Харман), таких как свет, цвета, тепло, плотность и т.д. Согласно профессиональным физикам, корпускулярно-волновой дуализм вовсе не парадоксален с математической точки зрения, он парадоксален только с точки зрения восприятия. Таким образом, можно предположить, что остальные элементы наших физических онтологий могли быть обусловлены нашей перцептивной конституцией, и если бы летучие мыши или роботы занимались физикой, их наука, ее проблемы и их представления о фактах могли бы существенно отличаться. Наша физика использует категории (частицы, волны), которые кажутся нам естественными, поскольку они построены на наших «ментальных красках» и предсказательных привычках. Наука роботов, основанная на корреляциях, обошлась бы без этих категорий, из чего следует, что наша онтология не является неизбежной. Если восприятие – это эволюционировавший интерфейс (Хоффман), а знание – предиктивная модель, обученная на данных (Фристон), то летучие мыши или роботы действительно создали бы разные науки. Наши «проблемы» (например, корпускулярно-волновой дуализм) могут даже не регистрироваться ими. Наука о больших данных намекает, что сама теория – наша потребность объяснять мир с помощью таких сущностей, как «поля», – может быть особенностью человека. ИИ мог бы работать с той же реальностью без нашего концептуального багажа, подтверждая идею Хоффмана, что мы не видим «реальный» код за интерфейсом. Все это вместе предполагает, что онтология физики – это не прямое окно в реальность, а созданная человеком карта на основе эволюционно сформированного интерфейса. Математика может быть универсальной (например, квантовые уравнения), но сущности, которые мы за ней предполагаем, например волны или частицы, – наши собственные. Более того, совпадение или несовпадение онтологии и теории может повлиять на эффективность последней.

Ключевые слова: физика; онтология; восприятие; теория; волны; частицы; дуальность

> *We have arranged for ourselves a world in which we can live – by the postulating of bodies, lines, surfaces, causes and effects, motion and rest, form and content: without these articles of faith no one could manage to live at present! But for all that they are still unproved. Life is no argument; error might be among the conditions of life.*
>
> *Friedrich Nietzsche, Die fröhliche Wissenschaft (1882)*

1. Introduction: The Human Lens and AI's Challenge

If bats were a civilization and had a kind of academia, they would have their own science of nature describing a set of invariant causes and laws responsible for the kaleidoscope of their perceptions. But, as Thomas Nagel reminds [27], qualities of their perceptions cannot be but crucially different from ours. Even having developed mathematics as good as ours, they would picture the ultimate reality behind sheer phenomena with metaphors borrowed from those very phenomena – much like we do. They would hardly have "fields" or "particles" among their explanantia, rather sticking to something like "echo fronts" or "temporal densities" or, more probable, something quite unimaginable by humans. I wonder if modern technologies afford for modelling a kind of "bat physics", but conceptually the question stands as this: would a science built over a structurally and qualitatively different ontology be mathematically equivalent to the human science? Obviously, this is a question of the influence of ontologies on the success of research.

To explain the phenomenal reality, physics had to project probable causes of the observed phenomena into, as it were, the Platonic world of forms, but aiming only at its lower levels where perceptual ideas dwelled, because explanations were meant to remain "physical", which means grounded in sensible "nature". Thus, the specific physical ontology appeared where perceptual *explananda* were partly transferred to the realm of *explanantia* to become metaphors[1] referred to by variables in physical equations. Metaphors like *mass* and *force* refer to magnitudes represented

[1] The Greek μεταφορά means *transfer*.

directly therein, while those like *particles* and *waves* are implied as carriers of such magnitudes.

This construction is founded on a paradox, which I will try to reveal using the concept of *mental paint*. In 1990, Gilbert Harman [15] used this metaphor to highlight the qualitative residue of sensual experience, which is not penetrated by functionalist explanations of mind, being as well transparent for a perceiving subject: we see the observed qualities not as properties of experience but as properties of an experienced entity. I would like to use this argument the other way round. By using sensual metaphors, physics, as it were, lays clots of mental paints in the fundament of its ontology, naïvely presenting them as a true picture of the objective world. At its face value, this composition is harmless: one might say that it makes no difference what is referred to by mathematical variables until a theory gives reliable predictions. But the history shows that the efficiency of a theory may depend on the choice of ontology.

In what follows, I will argue for two statements. First, using sensual metaphors as items of a physical ontology is aimed at accommodating physical theories to our everyday observations. But as it may be shown that the latter are shaped by the evolutionally constructed phenomenal interface and not by the world "as it is", such a construction causes a kind of cognitive cycle that is dubious as a way of making a theory efficient outside the human *Umwelt*. Second, an AI empowered with scientific research would not require ontologies grounded in a living organism's perceptions and thus might show an increased efficiency.

2. On Physical Ontologies

Classical physicists aimed to create rigorous explanatory models for phenomena within our sensory reach – things we could see, feel, or measure, like falling apples or planetary orbits. Newton's laws, thermodynamics, and electromagnetism were triumphs in mapping these experiences onto mathematical frameworks. These models were grounded in what we might call "phenomenal representations" – our direct encounters with the world, like the sensation of weight or the perception of motion. The success of classical physics suggests a structural alignment between our sensory experience and the underlying reality, even if the details of that reality (e.g., atoms) weren't directly observable at the time. So, physics couldn't avoid postulating unbservable entities to explain observable facts, but those former were mainly invoked from physicists' perceiving minds and, therefore, imagined with the same shapes and behaviors as things given in their everyday experiences. A specific system of such entities projected from the realm of phenomena to the realm of their causes forms a specific ontology of a certain physical theory.

Conventionally, ontology refers to beliefs of what exists. In the context of physics, it encompasses the fundamental entities and their ruling principles that physical theories propose to describe the world. These include concepts like particles, waves, fields, forces, space, and time. So, a question may arise, whether these categories stem from the human cognitive constitution, which includes how humans sense and perceive the world (e.g., feeling density, seeing particles as discrete objects, or observing waves in water).

Human cognitive constitution – our sensory experiences and mental frameworks – undoubtedly influences how we begin to conceptualize the physical world. In the case of density, we perceive some objects as solid or heavy, which may inspire the idea of mass or matter as fundamental. In turn, concepts like particles and waves are derived from our everyday observations of discrete objects (like grains of sand) that might lead us to the stable representation of particle-like entities, while watching ripples on water might suggest the idea of waves. These sensory experiences provide a foundation for early physical concepts. Historically, our intuitive understanding of the world shaped basic notions in physics, such as the idea of objects moving due to pushes or pulls, which induced the notion of force. Electric or gravitational fields are not tangible in the way objects are, but they are obvious sensual metaphors derived from perceiving continuous surfaces in multiple experiential situations.

Obviously, the ontology of physics is not fully determined by our sensations and perceptions. Modern physics often deals with phenomena that transcend or even contradict our everyday experiences. For instance, in quantum mechanics particles are seen not as tiny, solid objects; they can exist in superpositions or exhibit wave-like properties. The concept of a wave function is a mathematical abstraction, not something we directly sense. In Relativity, space and time are intertwined in ways that defy our intuitive sense of them as separate and absolute, challenging the way we naturally perceive the world.

Nevertheless, our cognitive constitution might subtly influence how we construct these theories. Philosophers like Immanuel Kant argued that concepts like space and time are innate frameworks of the human mind, structuring our experiences [19]. He is also known for claiming that a "science proper" can't do without perceptual schemata attached to pure concepts [20]. Nowadays, embodied cognition theorisis suggest our thinking is grounded in bodily interactions. Thus, Lakoff and Johnson argue that cognition is not solely a function of the brain, but is deeply intertwined with our physical bodies and interactions with the environment. This perspective suggests that our understanding of the world, including abstract concepts, is built upon sensory and motor experiences [22]. Their work specifically explores how abstract concepts are understood through metaphorical mappings of our bodily experiences. Lawrence Barsalou even developed the concept of "perceptual symbol systems," suggesting that our thinking relies on simulations of past sensory and motor experiences [2]. From this point of view, we might schematize forces as "pushes" or "pulls" because that's how we experience the world physically. Even some more abstract ideas in physics (e.g., "fields" exerting influence) may extend from sensory metaphors, while their formal definitions are mathematical. Although the laws of physics are said to hold universally[2], yet, because we formulate these laws, our cognitive lens shapes how we express and interpret them.

Our sensations (e.g., density) and perceptions (e.g., particles vs. waves) provide an initial framework and intuitive analogies for understanding the physical world. However, the ultimate ontology emerges from a combination of these cognitive influences and the objective demands of scientific inquiry – experimentation, mathematical rigor, and the need to account for phenomena that often defy our intuitive grasp. While human cognition shapes the starting point and the way we think about physics, the ontology itself is also determined by responses of reality registered with rigorous scientific methods. Thus, my aim in the present paper is not to prove "subjectivity" of physics, but to identify a part of it that is not of a great help in unveiling the "thing-in-itself".

For instance, one may ask if wave-particle duality is grounded in the mathematics or in our learned perceptual frames, and eventually lean

[2] Although there are well-known doubts in their reliability (see [3]).

toward the latter, noting no contradictions in the math itself. In quantum mechanics, the Schrödinger equation or Dirac equation describes a wave function – a unified mathematical object. There's no inherent duality or contradiction in the formalism; it's a smooth, consistent framework. Yet, we interpret this as "wave-particle duality" because our perceptual experience splits the world into discrete objects (particles, like grains of sand) and continuous flows (waves, like ripples). Experiments reinforce this: a photon acts "particle-like" in a detector click, "wave-like" in an interference pattern. The "duality" isn't a mathematical necessity but a cognitive artifact – a way we parse quantum behavior through familiar perceptual lenses. If the math doesn't demand the split, then our ontology (waves vs. particles) might indeed stem from how our minds carve up reality.

And this may imply that other items in our physical ontology – like forces, fields, or even space and time – could be induced by our perceptual constitution. We experience pushes and pulls bodily, so we conceptualize interactions as "forces" acting between objects. Fields as a concept are less intuitive, they are a metaphorical way to represent how forces act at a distance through space. Particles are conceptual tools that physicists use to make sense of complex quantum phenomena. Historically, physicists like Maxwell used mechanical metaphors (e.g., vortices and ball-bearings in a fluid) to visualize electromagnetic fields, knowing these models were not literally true but useful for understanding and predicting phenomena.

3. Duhem on Saving the Phenomena

Pierre Duhem, in his seminal work "To Save the Phenomena" [8], argued for a philosophy of science that emphasizes empirical adequacy over metaphysical truth. His key idea is that physical theories are tools to "save the phenomena" – to account for observable data – rather than to reveal the ultimate nature of reality. He was skeptical of claims that theories directly describe the world's true ontology (e.g., whether light is "really" waves or particles). Instead, he saw theories as convenient mathematical frameworks that organize sensory experience, shaped by human reasoning and observation.

Duhem also argued that theories are underdetermined by data – multiple models can fit the same observations. For instance, both wave and particle theories of light could "save" 19th-century optical phenomena, as seen in Young's experiments or Newton's corpuscles. This flexibility implies that our choice of ontology (waves vs. particles) reflects cognitive preferences or biases, not an absolute truth. Our brains, wired to categorize and simplify, pick frameworks that feel intuitive.

On the contrary, Planck's quanta and Einstein's photons were initially counterintuitive because they clashed with the continuous, wave-like models our senses favor. Duhem's view would frame these as new tools to save new phenomena (blackbody radiation, photoelectric effect), not as discoveries of reality's true nature.

Duhem introduces a historical and methodological layer: his underdetermination thesis implies that multiple ontologies can fit the same data, raising the question of why we settle on one. Could this be because our cognitive constitution – our "mental paints" or Bayesian priors – makes certain ontologies (like waves over ether) more natural for us? And can modern physics (e.g., quantum fields) still carry human fingerprints despite its abstraction?

The critical line towards straightforward naïve realism has been continued by Bas C. van Fraasen [12, p. 6–40]. His "constructive empiricism" posits that the aim of scientific activity is not to find true descriptions of the world, but rather to develop theories that are empirically adequate. This means that a scientific theory is considered successful if it accurately describes observable phenomena, without necessarily making claims about unobservable entities. He openly refers to Duhem, as chapter 3 of the book is titled "To Save the Phenomena."

3.1. Ether as a waving medium

In Treatise on Light of 1690 [18], Christiaan Huygens proposed light as a wave, implicitly requiring a medium, contrasting Newton's particle-based view. The ether fit the cognitive need for a tangible substrate. Thomas Young's double-slit experiment (1801) [34] demonstrated light's interference, solidifying the wave model and the need for ether to "carry" these waves. In A Dynamical Theory of the Electromagnetic Field [24], James Clerk Maxwell showed light as an electromagnetic wave, further entrenching ether as the medium for these vibrations. Maxwell's equations unified electricity and magnetism, implying light as an electromagnetic wave needing an "ether" medium – born from the human need for a tangible substrate, like air for sound.

The famous Michelson-Morley Experiment of 1887 [26] showed no evidence of Earth moving through the ether, undermining its necessity. The experiment's precision clashed with the ether's expected "drag" on light. Their null result debunked the ether, showing how a perceptually grounded concept (a medium for waves) was overturned by experiment and making a pivotal shift in ontology. More to it, by the late 19th century, attempts to salvage ether (e.g., FitzGerald-Lorentz's contraction hypothesis [11; 14]) grew increasingly ad hoc, straining its plausibility. The ether was abandoned because it no longer "saved the phenomena". Einstein's special relativity of 1905 eliminated the need for a medium by treating light's speed as constant in all frames, shifting the ontology from a material ether to a relativistic spacetime framework [9]. This move reflected a departure from sensory intuition (needing a "stuff" for waves) toward abstract mathematics.

Interestigly, in the lecture referred above Einstein says: "How does it come about that alongside of the idea of ponderable matter, which is derived by abstraction from everyday life, the physicists set the idea of the existence of another kind of matter, the ether? The explanation is probably to be sought in those phenomena which have given rise to the theory of action at a distance, and in the properties of light which have led to the undulatory theory." [9, p. 3] On the further pages, he elegantly traces some interconnected sensual ideas that eventually brought about this mysterious medium of radiating hesitations.

3.2. Particles: A Return to Discrete Entities

The particle concept predates ether, originating with Isaac Newton's corpuscular theory of light [28], where light was seen as streams of tiny, discrete "corpuscles." As Einstein puts it in his foreword to the 1952 edition of Newton's tractatus, "The conceptions which he used to reduce the material of experience to order seemed to flow spontaneously from experience itself, from the beautiful experiments which he ranged in order like playthings and describes with an affectionate wealth of detail." [28, p. lix]

Einstein's own explanation of the photoelectric effect [10] reintroduced particles as "light quanta" (later called photons). He proposed that light behaves as discrete packets of energy to explain why electrons are ejected from a metal surface only above a certain frequency threshold, not intensity – a phenomenon wave theory couldn't fully account for. Observations like the photoelectric effect, Compton scattering [4], and later quantum experiments (e.g., single-photon detections) reinforced the idea of light as quantized, particle-like entities.

The particle model explained phenomena that waves struggled with, like sharp interactions (e.g., photons knocking out electrons). It coexisted uneasily with wave models, leading to the wave-particle duality problem. However, particles didn't fully displace waves; instead, they merged into a new ontology. The particle model alone couldn't account for interference or diffraction, which required wave-like behavior. This tension drove the next shift.

The limitations of a purely particle-based view, combined with new quantum phenomena, pushed physics toward a hybrid ontology. Louis de Broglie [7] proposed that matter (e.g., electrons) also exhibits wave properties, blurring the line between particles and waves. This set the stage for quantum mechanics' more abstract framework.

3.3. Quanta/Photons: A Quantum Synthesis

Quanta [30] and photons (Einstein, op. cit; term coined by Gilbert Lewis [23]) represent light and energy as discrete packets, but quantum mechanics reframed these as entities with both particle-like and wave-like properties, described by a mathematical wave function. Planck introduced quanta to solve the blackbody radiation problem, where classical wave theory predicted an "ultraviolet catastrophe" (infinite energy emission). He proposed energy is emitted/absorbed in discrete chunks (quanta), breaking from continuous wave models. Einstein's photoelectric work solidified quanta as light particles (photons), explaining discrete energy transfers. In quantum mechanics, Niels Bohr, Werner Heisenberg, and Erwin Schrödinger developed a formalism where particles and waves are unified under a probabilistic wave function. Schrödinger's equation [32] describes quanta as wave-like entities, while experiments (e.g., electron diffraction [6]) confirmed their dual nature.

Quanta/photons challenged sensory intuition. Unlike tangible particles or familiar waves, they're abstract – neither fully one nor the other. This ontology was driven by mathematical necessity and experimental data (e.g., spectral lines, photon counts), not direct perception, marking a move away from "mental paints" toward formalism.

However, it appeared sustainable because quantum mechanics' predictive power (e.g., atomic spectra, laser technology) cemented quanta/photons as a core ontology. It is maybe the most spectacular example of a theory has ditched perceptual biases striving for a matching ontology. But this victory is not absolute. Wave-particle duality, while not a mathematical contradiction, still is a cognitive one, reflecting our struggle to map quantum behavior onto familiar categories. Quantum field theory, in 1940s onward, further abstracted this into fields and excitations (photons as field quanta), but the photon concept endures because it saves phenomena like Compton scattering and quantum entanglement while aligning with relativity.

Ontology of the wave function in quantum physics is being debated so far. According to the author of a very recent paper [33], the true ontology of the wavefunction remains unresolved and is a fundamental issue within quantum mechanics. The article argues against the starting assumption made by the Pusey, Barrett, and Rudolf (PBR) theorem, which associates a wave function with a distribution of physical states. The author contends that this assumption is flawed and contradictory to the linear structure of quantum mechanics and Born's rule. According to the paper, since the axioms and calculations of observable statistical results in standard quantum theory do not depend on specifying the physical nature of a wave function, this indicates that their ontological status in space and time cannot be conclusively defined. This adds to my own contention that, as science digs deeper into what is conventionally called the "fundamental reality", any ontology vanishes by fusing with mathematics, thus leaving the field to the AI.

4. Cognitive Science: Why Physics Reflects Our Minds

Donald Hoffman argues that evolution didn't shape our perceptions to reveal reality's true nature but to provide a functional "user interface" – like icons on a desktop screen [17]. We see a red apple not because it's "really" red (whatever that means) but because that perception helps us survive (e.g., spot ripe fruit). In his terms, our phenomenal "screen" hides the underlying code of reality, offering instead a simplified dashboard tailored to fitness.

In application to physics, our ontology – particles, waves, space – might be interface elements, not the "source code." As Hoffman puts it, "If our senses were shaped by natural selection, then the FBT [Fitness-beats-Truth] Theorem tells us we don't see reality as it is. ITP [Interface Theory of Perception] tells us that our perceptions constitute an interface, specific to our species. It hides reality and helps us raise kids. Spacetime is the desktop of this interface and physical objects are among its icons." [16, p. 97] Density feels real because it's useful, not because it mirrors some ultimate truth. A bat's interface, tuned to echolocation, might not feature "light" or "color" but prioritize temporal gradients. A robot's interface, fed by binary sensors, might skip "warmth" for voltage shifts. Hoffman's stance suggests that all possible scientific ontologies are species-specific dashboards, and ours is just the human version – our physics reflects our cognitive makeup.

Karl Friston's predictive processing model sees perception as a Bayesian update of internal world-models based on sensory data [29]. Duhem's view aligns here as well: physical theories are like formalized world-models, refined to minimize discrepancies with observations (akin to Friston's free energy minimization [13]). Wave-particle duality, as we may propose basing thereon, emerges because our cognitive models toggle between wave-like and particle-like interpretations to fit experimental sense-data, not because the math demands it.

Friston's work on the free energy principle and predictive processing posits that the brain is a prediction machine, constantly updating an internal world-model to minimize surprise (or free energy) based on sensory inputs. What we "see" and "know" isn't raw reality but a Bayes-optimal hypothesis about the world, refined by perception [31]. For example, we imagine photons as waves or particles because our brain toggles between models that best fit the data (interference vs. detection), not because reality demands that split. Or, we feel an object as dense because our model infers resistance from touch, not because we're touching "matter itself."

Friston's framework implies that our physical ontology emerges from this modeling process, which is constrained by our sensory channels and evolutionary history. Thus, our brain models light propagation (e.g., as spacetime in SR) to minimize sensory surprise. The wave-particle duality is a cognitive toggle between visual metaphors (ripples vs. grains), not a mathematical necessity.

This raises important questions: Could an AI's correlation-based physics outperform ours by avoiding human biases? Might Hoffman's "code" behind the interface align with Friston's "hidden causes" the brain infers? And if our ontology is so contingent, how do we come to believe it?

5. AI Science: Escaping the Human Canvas?

There has been a recent debate around the argument that AI systems, crunching vast datasets, could sidestep traditional theory-building (hypothesis-driven models like Newton's laws) in favor of pure correlation hunting [1; 21; 25]. Instead of positing "forces" or "particles," an AI might just map patterns – like "when X sensor spikes, Y output shifts" – without ever naming entities or causes. Chris Anderson famously suggested that, with enough data, correlations could rule, and theory might become obsolete.

For a robot scientist, this could be its physics: a web of statistical relationships, unburdened by human concepts like "waves" or "fields." If it works in predicting eclipses or quantum outcomes, why bother with our ontology? An AI science might not resemble ours because AI agents don't share our perceptual need to carve reality into familiar chunks.

For the time, we can hardly evaluate AI's potential to model light propagation without spacetime or photons, using raw data correlations (e.g., photon detector clicks as statistical patterns). Unlike humans, who see light and build the notion of spacetime (per SR), or bats, who might model their physical ontology on acoustic echoes, AI could skip these metaphors, potentially streamlining predictions and accelerating progress in research. Spacetime, as a mindset, is unnecessary if AI correlates "light" events directly, without human or bat-like sensory constraints. This could make AI-based science more efficient, as it avoids puzzles like duality or ether.

Someone might rebute that if an AI calculates numerical values using formulae, it cannot but interpret variables as representing some "things", thus inheriting or constructing an ontology. However, in fact, nowadays' generative AI operates with statistical distributions and inferences – much like our brains do – rather than determined analytics. That means that, paradoxically, the supposed "Big Data Science" would be closer to a mundane reasoning of laymen and housewives than to the strict academic calculations, if not for it enjoying access to an ocean of data and its freedom from our animal cognitive biases and limitations. Sometimes, for the sake of communication with humans, it will certainly be able to put its probabilistic wisdom into analytic formulae, but it will be no more than an public disguise of its hidden reasoning.

6. Ontology and Theory Proper

In physics, as in almost any other science, there is a theory proper (say, equations) and an ontology (imagined entities). Success of a theory is essentially determined by a happy match of them both. But ontologies as interpretation models for theories are sometimes indifferent in that respect (as caloric whose replacement didn't lead to changes in thermodynamics), but in other cases they matter (as in astronomy where computations are simpler with Copernicus than with Ptolemy). So, unless they impact functioning of theories and their inferences, perceptual ontological metaphors are indifferent and may be tolerated by humans or bats and neglected by AI researchers. But what if they really do?

In Ptolemaic astronomy (2nd century CE), the geocentric model placed Earth at the universe's center, with planets and stars moving in complex epicycles to explain retrograde motion. Copernicus [5] proposed a heliocentric model, with the Sun at the center and planets in circular orbits. Geocentrism aligned with sensory experience – Earth feels static underfoot, and stars appear to circle us. Epicycles were a mathematical fix to save phenomena like retrograde motion, rooted in the intuition of circular motion as "natural." Heliocentrism challenged sensory intuition (we don't feel Earth moving) but drew on the visual metaphor of simpler, centralized motion, like objects orbiting a fixed point.

The heliocentric ontology wasn't just interpretive – it transformed the theory's functionality. Ptolemy's epicycles required dozens of parameters to predict planetary positions, making computations complicated. Copernicus' model reduced these, as planetary orbits were simpler around the Sun. Later refinements (Kepler's ellipses, Newton's gravity) built on this, proving heliocentrism's predictive power. Heliocentrism enabled new predictions, like stellar parallax (later observed) and gravitational dynamics, which geocentrism couldn't naturally accommodate. The shift from geocentric to heliocentric ontology, though counterintuitive to sensory experience, streamlined mathematics and opened new theoretical avenues (e.g., Newtonian mechanics). The perceptual metaphor of a central Sun simplified the theory's structure, making it more than a neutral interpretation.

As Bayesian cognitive science (or, predictive processing theory) suggests, our brains select ontologies that minimize sensory surprise, but when phenomena (e.g., diffraction, null ether results) defy these, our internal generative models are forced to new constructs, like quanta. An AI scientist, unbound by human metaphors, might skip these struggles, modeling phenomena as correlations without "wave" or "particle" baggage, potentially streamlining inferences.

7. Conclusion: A Human Science, But Not the Only One

If bats were a civilization and had their own physics, we would observe them curiously and, having deciphered their publications, we would have a kind of "aha!" moment: their physics is like it is because it is absolutely grounded in their perceptual constitution. Even if we had reasons to admit its success, we would inevitably consider it a product of this species' cognitive biases and limitations, keeping our conventional arrogant belief that it is us who are "chosen" to see things as they are. So, probably it is time to see our science and ourselves with the "eyes" of bats and AI agents.

As I have untertaken to show, physics' ontology – ether, particles, quanta – bears the imprint of our cognitive constitution, and this is evidenced by some angle-changing ideas from philosophy of science and cognitive research: from Duhem's phenomena-saving to Hoffman and Friston's cognitive insights. The history of light theories show this in action.

We are nevertheless lucky to have physics as one of few valid maps for navigating the world behind our cognitive dashboard, shaped and painted by our minds. Does this mean physics is subjective? Not quite. Physics strives for objectivity – its laws hold regardless of who's observing. But my point is subtler: the ontology – the entities we pick out and the problems we prioritize may reflect our cognitive wiring. The underlying reality might be describable in many equivalent ways, and our version is just one, evolved together with our very species and shaped by our "mental paints."

Proponents of structural realism famously argue that physics captures reality's structure (relations, patterns) but not its intrinsic nature. The latter is substituted by some perceptually induced constructs that serve to accommodate dry and somewhat alien structures of a mathematized theory with our warm immanent world of forms, colors and densities. Which means that, if structural realism is right, a supposed bat-developed physics might differ in ontology, but there must be a mapping function of true statements of the bat knowledge into those of human physics. But if phenomenal ontologies determine truth values of theory proper statements to any extent, then there is no such mapping function, and structural realism is wrong.

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