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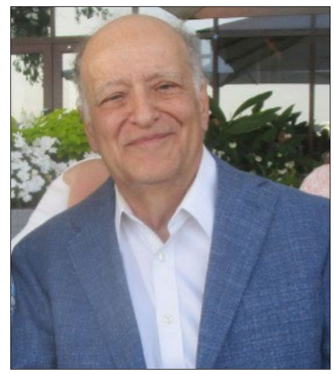
From the Editor



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Welcome to the July 2026 issue of the FPS newsletter . In this issue I finally fulfill at least in part, my long standing objective of starting a discussion of AI as it relates to Physics. This issue is I believe the most important of our time, except for those (an example is nuclear war) that involve the possible annihilation of human civilization.

We have two articles here, one by a large number of authors on AI and the future of Physics and the other, by Nathan Suri, on the challenges involved in designing responsible AI systems. I hope this is only a beginning and I look forward to receiving and publishing aboundant opinions and points of view about AI and physics.

We have also in this issue a full complement of two book reviews, thanks to the tireless efforst of Quinn Campagna, our Book Reviews editor. I congratulate Quinn on having finished his PhD in Physics, despite the demands on his time made by his work as Book Reviews editor. It was also Quinn who obtained a Book Review on AI, which we published in the previous issue.

The contents of this newsletter are very largely reader driven. All topics related to Physics and Society are welcome, excluding only totally undiluted politics. I am not at all afraid of controversial topics or controversial language, excluding only raw invective, particularly of the *ad hominem or ad feminam* variety. Manuscripts should be sent to me, in .docx format, except Book Reviews which should be sent directly to book reviews editor Quinn Campagna qcampagn@go.olemiss.edu.

The contents are **not peer reviewed (**I do read submissions before acceptance**) and opinions given are the authors ' only, not necessarily mine, nor the Forum's nor, *a fortiori*, the APS's either.** But subject to the mild restrictions mentioned in the previous paragraph no **pertinent subject needs to be avoided on the grounds that it might be objectionable. On the contrary, controversy is welcome.**

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AI and the Future of Physics: What Should We Preserve?

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We strongly encourage all readers to consult the full arXiv article (https://arxiv.org/abs/2605.03185), which contains the complete set of perspectives, detailed arguments, and community input underlying this summary.

Artificial intelligence is rapidly transforming how physics is conducted. From symbolic calculations and numerical simulations to detector optimization and data analysis, AI tools are becoming deeply embedded across both theoretical and experimental workflows. This raises a fundamental question: if AI can accelerate—or even partially automate—research, what remains uniquely *physics?* A recent discussion session at the Kavli Institute for Theoretical Physics (KITP), held within the program *"Generative AI for High and Low Energy Physics,"* brought together physicists from diverse subfields to reflect on this issue. The perspectives summarized here aim to stimulate broader discussion across the physics community.

Physics Is Defined by Its Standards

Physics is not defined by its tools, but by the principles it enforces. At its core lies **predictability and reproducibility**. Physical claims must yield testable predictions that can be independently verified—by experiment, by proof, or by other researchers. This universality forms the foundation of physics as a global scientific enterprise. Equally essential is **consistency with empirical reality**. AI systems can identify patterns or optimize performance, but physics ultimately answers to nature. This distinction ensures that even as AI becomes more powerful, it does not replace the empirical grounding of the field. Another defining aspect is the search for **underlying structure**. Whether through reductionist approaches in particle physics or emergent descriptions in condensed matter, physicists aim to uncover simple principles governing complex phenomena. In this context, the often-cited "black box" nature of AI must be evaluated carefully. In some domains, such as lattice field theory or many-body systems, numerical solutions have long been accepted without closed-form expressions. AI extends this paradigm, suggesting that interpretability is a matter of degree rather than a strict requirement.

Beyond Acceleration: Curiosity and Discovery

AI is highly effective at solving well-defined problems. Physics, however, is equally concerned with identifying *new* and *interesting* questions. Major advances in physics are driven by curiosity, anomalies, and conceptual shifts, rather than incremental optimization. While AI may greatly accelerate established lines of inquiry, the generation of new paradigms remains deeply rooted in human creativity and engagement with the unknown. This also challenges the notion that AI might "solve physics." Physics is not a finite set of problems but an ongoing process tied to observation, experimentation, and theory-building. In many cases, progress is limited not by computational power but by the ability to design and carry out new experiments.

The Purpose of a PhD in the AI Era

The rise of AI also prompts reflection on physics education. If AI can perform many traditional research tasks, what is the role of PhD training? A central conclusion is that a PhD is fundamentally about **developing understanding**. Even when AI can produce results efficiently, genuine comprehension requires direct intellectual engagement. Education should therefore emphasize learning and insight, not just productivity. At the same time, physics training provides a powerful framework for studying **complex systems** across disciplines. The ability to model, abstract, and analyze multiscale phenomena is increasingly relevant in areas such as machine learning itself. Physics PhDs thus remain highly valuable both within and beyond academia. Equally important is the **development of independent researchers**. The PhD period fosters creativity, confidence, and a sense of belonging within the scientific community. Integrating AI into this process must be done in ways that support, rather than undermine, these goals.

System-Level Challenges

AI also raises broader questions for the scientific ecosystem. One issue is **unequal access** to advanced AI tools, which may exacerbate existing disparities between institutions and countries. At the same time, AI offers opportunities—such as improved language translation—that can lower barriers and broaden participation. Another challenge concerns publication and peer review. AI-generated content may increase the volume of submissions and strain existing systems, raising questions about authorship, originality, and evaluation standards. New models of peer review, potentially combining human judgment with AI-assisted verification, may be required. Finally, the global competition surrounding AI development introduces geopolitical considerations. Physics has historically been shaped by such dynamics, and the community must remain attentive to their implications.

Outlook

The perspectives presented here do not constitute definitive answers. Rather, they highlight that physics is entering a transitional phase, comparable in significance to the rise of computational science. The key challenge is not whether AI will transform physics—it already is—but how physicists will guide that transformation. By reaffirming core values—predictability, empirical grounding, and curiosity—the community can ensure that AI strengthens, rather than diminishes, the foundations of the field. AI is ultimately a tool. The future of physics will continue to be determined by the questions we choose to ask—and by how we choose to understand the universe.

The Scientist's Apprentice

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Written in 1797, Johann Wolfgang von Goethe's "Der Zauberlehrling" (English: "The Sorcerer's Apprentice") describes the cautionary tale of the eponymous apprentice who becomes captivated by his master's spell of turning commonplace items into servile automatons. After having overheard the first part, the apprentice waits until his master is away before eagerly putting it into practice, animating a broom commanded to fetch water. The broom performs as commanded, continually fetching water until the apprentice soon realizes he does not know how to stop the spell. In his desperation, he splits the broom with an axe; however, the broken pieces still hold to the original command and continue fetching water to the point of flooding. The naive and now waterlogged apprentice is only saved when his master returns, who quickly undoes the spell.

While sorcery as described by Goethe does not exist in our world, the rise of artificial intelligence presents a similar challenge to scientists as the eponymous apprentice. As AI system capabilities advance rapidly, scientists across disciplines are already experimenting with how these systems can accelerate and automate their research workflows. However, unlike the task of fetching water, scientific discovery is a far more complex target for automation. If the lesson from Goethe's poem is to exercise prudence when it comes to magic (or technology) beyond our current understanding, how does that translate to collaborating with AI systems?

Unlike the animation spell, scientific discovery does not have a convenient master that can teach us all of the requisite safeguards. In research, there is no definite right way of proceeding. Much like the apprentice, we are left to learn through our mistakes and alter our expectations accordingly. This feedback loop is core to the practice of science: try a new method, (most likely) fail, measure how it deviated from our expectations, adjust the parameters, and repeat until discovery is achieved. Sometimes referred to as AI scientists, these proposals for automating scientific research rely on autoregressive large language models (LLMs) guided by agentic frameworks to adopt reasoning akin to those exhibited by human researchers. Systems such as Google's co-scientist can transform a natural language description of a research objective into a set of original hypotheses and experimental protocols by searching, processing, and conjecturing upon existing scientific literature. Such automation represents an outsourcing of intellectual agency, in which the AI scientists decide which subtasks to work on and in what order, effectively passing the control of the whole research feedback loop to the AI systems. The combination of the complexity of defining scientific research as a task and the rapidly improving, but still imperfect drivers (LLMs) behind automation exposes a large risk surface for the integrity of scientific knowledge. In congruence with the Goethean allegory, the safe integration of AI systems into scientific practice must require: 1) a robust understanding of the target of automation and 2) real-world studies into how AI systems can introduce emergent harms when integrating into scientific practice.

Tasks are defined as any mapping between a natural language description and a set of actions connecting an initial state to a final (successful) state. For fetching water via animated brooms, this is relatively straightforward (within the fantastical confines of Goethe's poems, that is). The challenge is that the "task" of scientific research resists any form of global definition. Experiments differ vastly in methodology and aims. Literature formats are not standardized across domains. Validation and reproducibility concerns are handled uniquely per field. In our work "Holonic Science: A New Framework for Benchmarking AI Scientists," we argue that in lieu of definite final states, we can approximate performance on the overall task of scientific discovery by measuring adherence to our expectations for research subtasks such as hypothesis generation, experimental design, etc. In this manner, trustworthy scientific research becomes possible when all steps of the scientific process are verifiably measurable, documentable, and correct.

In the AI development space, the construction of evaluations around representative subtasks is known as benchmarking. As translating a broad task like scientific research into an evaluation is a Herculean task, benchmarks are crafted around reduced subtasks that aim to provide insight on the original task via extrapolation. This is either done by: 1) linearly segmenting the scientific research workflow into discrete tasks, which each can serve as the foundation of a new benchmark or 2) identifying and assessing a model's aptitude for some latent feature underlying trustworthy scientific research. While intuitive, the first method does not significantly minimize the epistemic risk surface. Scientific research is often not linear in nature with tasks occurring simultaneously with interconnected dependencies. Tasks can no longer be viewed as independent, but are embedded in an evolving structure that results in scientific discovery. In their release of the FrontierScience benchmark, OpenAI described reasoning as the "core of scientific work." These scientific reasoning benchmarks aim to measure a model's capability to reason through complex single-shot scientific problems, allowing developers to "measure expert-level scientific capabilities." And FrontierScience **does** prove to be a notable challenge for AI models with GPT-5.4 Pro only able to answer 36.7% of the questions correctly.

While scientific reasoning benchmarks like FrontierScience were developed in collaboration with subject matter experts, there still exists a semantic difference between the original (scientific research capacity) and reduced (scientific reasoning) tasks. Thus, even though state of the art AI models still underperform on such evaluations, they are insufficient in showing the full picture of how capable AI models are at "expert-level scientific capabilities." Known as a construct validity issue, benchmark developers assume that scientific reasoning is a sufficient latent feature to extrapolate the capacity for scientific research from. However, science is not a consequentialist "ends justify the means" epistemic system. Understanding the correct way to arrive at the correct answer means significantly more than just acquiring the correct answer.

Benchmarks are effective tools at measuring AI model capability on narrow tasks, but they remain insufficient in predicting how technical limitations can lead to emergent interaction risks with the scientific community. Without realistic risk forecasting built into evaluations of scientific reasoning, scientists are unable to grasp the manner and scale of potential emergent risks posed by AI systems to the epistemic integrity of science. At its core, modern science is a collaborative effort. Any "agent" within the scientific community is no longer isolated, but integrated into a global web of like-minded pursuers of the measurable truth. This will inevitably be true for AI scientists. Automation implies integration and thus AI systems will interface with the existing scientific community. Understanding how and why models fail on benchmarks is not sufficient to guarantee trustworthy scientific research; observational domain-specific studies into the effects of human-computer interactions have become a necessity. On May 14, 2026, arXiv announced that it would impose a 1-year ban on authors who submit works that contain "incontrovertible evidence that the authors did not check the results of LLM generation." This decision was made in the wake of numerous reports exposing the high rates of hallucinated citations in AI-assisted publications. That AI models are prone to hallucination is a well-established fact in the research space; however, only through careful reviews of submitted papers to key scientific archives such as arXiv, bioRxiv, SSRN, and PubMed Central was the scale of the problem understood ("LLM hallucinations in the wild: Large-scale evidence from non-existent citations"). Not all emergent risks are so clear-cut in their links to specific technical limitations. While collaborating with AI systems has been shown to improve scientists' productivity, this increase comes at the cost of narrowed ideation. AI-generated ideas have been shown to be concentrated in scope, overly iterative to existing literature, and lead to less-cited papers ("AI Research Agents Narrow Scientific Exploration").

So how do scientists avoid the plight of the sorcerer's apprentice when automating scientific research using AI? Cynics of AI will point to the whole technology being a mistake and that we should reverse all integration. However, the reality is that AI is a very powerful tool for modern scientists. Since 2024, two Nobel prizes have been dedicated to discoveries aided by AI systems: AlphaFold winning the Chemistry Nobel Prize in 2024 and Hopfield networks winning the Physics Nobel Prize in 2025. The point of the allegory is not to demonize the animation spell (or its analogue, AI), but rather advocate for greater understanding and accountability on the part of the apprentice. While scientists do not have a master that can teach us the most efficient way to all discoveries, we do have each other, a community of like-minded individuals who all strive to uphold the integrity of scientific knowledge. Exercising prudence when it comes to AI scientists thus entails community-wide discussions about the intrinsic values of science that must be upheld to ensure trustworthy scientific research from all scientists in vivo and in silico. These values can help inform the development of more comprehensive and valid evaluations that can better temper our expectations about how apt our new collaborators are in assisting us with (or even automating) our quotidian research tasks. AI systems are a nascent addition to the modern science paradigm that are still quite understudied, especially at the sociological scale. Borrowing physics vocabulary, what we need is an expansion of "AI phenomenology": a category of studies centered around understanding the emergent risks AI systems pose when interfacing with preexisting human systems. These observational studies will greatly boost attempts at mitigating the risks posed by AI scientists by connecting their technical limitations to real-world problems arising from AI integration. Scientists hold strong intuitions about what should and should not constitute trustworthy scientific discovery, but as the capability of AI models rapidly increases, we are increasingly placed in positions equivalent to that of Goethe's apprentice. To avoid any "floods" of our own, we must proactively build measurement-driven, realistic guardrails to guide any future augmentation or automation efforts. In a Goethean sense, it is better to learn dryly than triage runaway broom splinters amidst a flood.

Dimming the Sun: The Urgent Case for Geoengineering

Thomas Ramge. The Experiment, New York, 2025. 200 pgs. ISBN 979-8-89303-054-9. $24.95.

Global efforts to curtail greenhouse gas emissions are lagging behind what is needed to keep the increase in global temperature relative to pre-industrial levels within the limit of 1.5°C targeted by the Paris Agreement. The author of this book states that the United Nations Framework Convention on Climate Change (which was founded in 1992 and birthed the Paris Agreement in 2015) is reluctant to consider even researching geoengineering (implementing methods to reduce the amount of incoming sunlight) as an alternative way to control global temperature increase. He is particularly concerned about tipping points, at which irreversible climate-changing events will occur: 1) permafrost thawing, expected at a global temperature increase above pre-industrial levels of 2.3°C; 2) melting of the Greenland and Antarctic ice sheets at the same type of global temperature increase of 3°C; and 3) reduction of the Atlantic Meridional Overturning Circulation (AMOC), which warms Europe relative to its northerly latitude, for which there is no consensus on the required temperature increase.

Before I read this book, my feelings agreed with the United Nations Framework. Messing around with the atmosphere is a risky business, I thought, that could lead to a worse result that we can't undo. But Ramge points out that such is not the case. The geoengineering methods he discusses are only temporary fixes, which need to be continually applied in order to sustain their effects. "Dimming the sun is the methadone program of a CO_2-addicted humanity," he writes (p. 9). It's cheap and quick, but not long-term. It can buy us time to stave off climate change but "in the long term, we, the carbon junkies, have to beat our addiction." (p. 10)

Ramge observes that the July 1990 eruption of Mount Pinatubo in the Philippines was the only natural experiment in solar radiation modification (SRM) since geoengineering was conceived. It caused the eruption of between 14 and 25 megatons of sulfur dioxide into the stratosphere, where it was oxidized in the presence of water to form sulfuric acid, leading to the formation of sulfate aerosols, which obscured sunlight. It resulted in a decrease in global temperature of 0.3°C for the next three years.

Ramge states that climate model calculations show that injection of 20 megatons of sulfur into the stratosphere can reduce global temperature between 1°C and 1.8°C for three years. But how and where to inject it? The stratosphere is higher at the Equator, but atmospheric circulation would spread sulfur injected there throughout the globe, whereas matter injected at the poles, where the stratosphere is lower, would just stay there. And should the injection be sulfur (which reacts with stratospheric ozone) or sulfuric acid? Or some other compound, like calcium carbonate? Ramge points out that launching a weather balloon is easy, but transporting 10 megatons of sulfur into the stratosphere is another question. He cites a calculation by Wake Smith of doing it with tanker aircraft for $18 billion (in 2020$) – or a hundredth of this every year with a fleet of 15 converted business jets.

Other geoengineering methods presented by Ramge include 1) brightening stratocumulus clouds (so they will reflect more sunlight) by injecting salt into them to form water droplets to reduce global temperature by 1.5°C for $5 billion per year; 2) thinning cirrus clouds (which warm the Earth by blocking infrared radiation emitted by Earth's surface) by injecting bismuth iodide to form ice crystals which will precipitate rain to reduce global temperature by 1.4°C for $6 million per year; and 3) by placing a glass shield, metal disks, a thin silicone film, or dust from asteroids or the Moon at the L2 point between Earth and Sun.

After devoting his first chapter to "Why We Have to Dim the Sun" and detailing ways to do it in the second chapter, Ramge spends his third chapter on considerations he feels must characterize a responsible research program and his fourth chapter on the procedures and institutions he feels must be in place before implementation should be allowed to occur, extracted from Michael Gerrard's *Climate Engineering and the Law*. Not presuming to know the future role of geoengineering in the evolution of planet Earth, Ramge devotes his fifth (and penultimate) chapter to a possible scenario, much as James Hansen does at the end of *Storms of My Grandchildren*. The scenario begins with a referendum conducted by a crypto billionaire after his worldwide campaign to gain assent to "stabilize the global average temperature at 2.0°C (3.6oF) above preindustrial levels starting on January 1, 2040" but then disjointedly transitions to more realistic actions taken at a meeting of the foreign ministers of Pakistan, India, and Bangladesh on page 135.

In his closing chapter, Ramge notes that scenarios are ways to formulate strategies to move from the present to a point in the future through a series of plausible (though not necessarily probable) events. He opines that the scenario envisioned to follow from the Paris Agreement is no longer plausible and laments that geoengineering is not considered as a plausible element in a scenario. He attributes the exclusion of geoengineering from climate change scenarios to its being regarded as "uncomfortable knowledge"; but, noting that the collective action required to respond to climate change is happening but taking longer than expected following the Paris Agreement, he points out that geoengineering can provide an immediate and inexpensive, though temporary, response to stave off climate change until decarbonization can truly be achieved, which he illustrates graphically on page 151. Ramge laments that humanity became "carbon junkies" who "screwed up the very climate that made it possible for them to prosper" (p. 154) (which he notes was geoengineering in itself) and hopes that the specter of geoengineering will stimulate a quicker pace to decarbonization. But he hopes that, if geoengineering must be employed, it will be done in a responsible rather than a rogue manner – and "with minimal negative impact on the ecosphere." (p. 155)

Some final additional notes: This book was initially published in Germany in 2024, but with a German subtitle that translates as "how geoengineering can save humanity from a climate catastrophe," which has a different slant than the subtitle of the American edition. Curiously, no translator is acknowledged by name, although thanks are extended "to Matthew Lore and Nick Cizek for making this US edition happen" on page 188. I was also puzzled by the statement on page 97 about reluctance "to approve research investments after implementation, true to the motto that what is technically possible should be attempted." This seems to "put the cart before the horse," but it could be made sensible to me by replacing "after" by "without." Without seeing the German original I am unable to determine whether this is a translational error.

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The Whale and the Reactor: A Search for Limits in an Age of High Technology, 2nd Ed.

Langdon Winner. University of Chicago Press, 2020. 240 pgs. ISBN 978-0226692548. $26.00.

Originally published in 1986, *The Whale and the Reactor* attempts to establish a framework for what constitutes valid limitations that should be placed on the never-ending cycle of technological advancements that have been a defining feature of life over the past two centuries. The updated edition, published in 2019, adds new context and reflections on the modern landscape of social media, looking specifically at many of the computer technologies that have come to infiltrate every aspect of our lives since the book was originally published. The book takes a decidedly academic and deeply philosophical approach, insisting on laying out terminology and arguments in a way that can range from dizzying to enlightening. At times, this approach can obscure the larger message of the book as the reader wades through this philosophical framework. However, the (original) final chapter of the book finally brings the author's personal motivations to the forefront. When viewed in hindsight, the book is definitely a worthwhile venture.

One might wonder what a 40-year-old book has to say about modern tech oligarchies and the social media platforms that dominate today. In the mid-1980s, the personal computing revolution was only in its infancy. Written in the shadow of the Cold War and the energy crisis of the 1970s, much of the book does not specify any particular technologies that should be limited. Instead, the author looks at the framework of our discussions around technology more generally, choosing instead to explore politics, motivation, and economics around the implementation, operation, and regulation of said technology. When citing examples, the author alternately references historical instances spanning the Industrial Revolution of the previous century through more recent technological changes within the second half of the 20th century. Writing in this manner, the author manages to produce something that has just as much poignancy looking forward into the future – whether towards the 2020s, or likely even further.

When the author does make specific references to technology, a fair amount of time is spent exploring conversations around our energy system – particularly looking at arguments both for and against nuclear power and its typically sited alternatives, like wind or solar power. This time spent makes sense upon learning the author's connection and views on the Diablo Canyon Nuclear Power Plant in California – which was the original inspiration for the book.

Of particular interest are some of the later chapters, where Winner takes time exploring philosophical definitions of terms like "nature" and "risk". The author looks at "nature" in terms of whether it represents a stock of natural materials to be utilized, whether it is something that must be protected from mankind's incursion at all costs, or whether it is simply something that should be considered a good thing worth preserving in a way that transcends rigid definitions. There are lines of logic in each of those definitions that claim "nature" as something to be preserved. The meaning implied speaks volumes as to the motivations of the one arguing.

In defining "hazards" or "dangers" associated with a particular technology, often the arguments move into the territory of defining and quantifying associated "risks". The author makes the claim that this type of argument can very quickly be in danger of missing the point entirely. Even using the word "risk", implies that the technology itself is always a worthy pursuit – there just may be some extra considerations that need to be considered.

With this updated edition, one can't help but wonder at timing. Winner missed the release of the first publicly available LLMs and generative AI platforms by just 3 years. While much of the specifics of the book are devoted to energy, there is a full chapter, from the original edition, reflecting on the early days of the personal computer revolution beginning in the 1980s. In the later chapters of the new edition, he updates many of those reflections with an eye towards social media, but I think that the author's potential views on artificial intelligence would have fallen in line with the rest of the book very clearly.

In my childhood, I recall the infectious optimism around computers. Winner is one of the few voices of the day that was less than ebullient about the supposed groundbreaking changes to society that were on the way from the rapid adoption of computers. The enthusiasm of the day encouraged a "full steam ahead" ethos. According to its proponents, computer technology could only bring good things to all that are willing to embrace it.

For the first time in my life, I am seeing widespread pushback against a computer-based technology – one that happens to be much more in-line with Winner's attitudes towards computers in the 1980s. Even with this pushback, it seems that any potential for reigning in this new technology is rapidly waning. And given the current political landscape, even if AI regulation was to come, we would still just be discussing and mitigating "risks" and a cost-benefit analysis, missing the point of whether the technology exists in a "common good" sense at all.

In the past, questioning the “growth at all costs” mentality has often been seen as anathema to progress throughout much of the previous century, but time will tell if Winner was once again more prescient than is typical of many technological commentators.

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