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The humanities can help make physics greener

Jaco de Swart, Ann C. Thresher & Carlos A. Argüelles

Making physics more sustainable raises complex interdisciplinary questions. Answering them needs input from the humanities and social sciences.

When it comes to sustainability, every large-scale physics experiment faces unique challenges. The environmental challenges of a gravitational wave detector in the pine forests of Louisiana, USA are not the same as those of a low-background experiment in the Jinping Mountains of Sichuan, China, and a neutrino detector in the Antarctic demands different types of care than a cosmic-ray experiment on the flanks of an active volcano. The success of large-scale and long-term experiments depends on special environmental conditions — whether arid deserts or underground laboratories — and thus it also brings special environmental responsibilities. Drawing more attention to the impact of experimental infrastructure, materials, and maintenance in their various fragile locations should be high on the agenda. But without an overarching approach to the field as a whole, improving the sustainability of experiments can seem like a daunting task. How can physics become greener? Where to start? We want to suggest a critical but often-overlooked place to look for answers: collaboration with humanities and social science (HASS) scholars.

Why would physicists need help from outside their discipline? Because every experiment is unique, building a more sustainable — green — physics requires specificity. It demands scrutinizing experimental methods, materials, locations, decommissioning plans and the many other parts of setting up and running an experiment. In addition, environmental issues interface with other questions of values and ethics. Developing a greener physics hence requires engagements with a wide range of complex topics outside of the standard scope of physics, such as understanding local contexts, histories, and stakeholders. Physicists don't have to do this all themselves, and nor should they. Here we share three ways, among others, in which HASS scholars can be critical to building a greener physics.

Large-scale physics experiments may be located in regions with unique environmental needs.

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What the humanities offer

First, improving the sustainability of physics research infrastructure demands reflection on what it means to be sustainable in the first place. We might, for example, take a 'sustainable experiment' to be one with a low carbon footprint, and certainly some studies have analysed the carbon footprints of experiments in ways that are important in the bid to make physics greener[1]. But carbon footprint is not a straightforward proxy for environmental impact: it does not consider local circumstances such as the impact of resource procurement, waste streams and transportation infrastructure on local land, water and biodiversity.

In moving beyond the carbon footprint paradigm, physics will depend not only on methods from environmental sciences, such as life-cycle assessments, but also on qualitative expertise on the particularities of the experiment sites. HASS scholars are able to address how historic or social contexts of particular regions are affected by — and should inform — developing experimental facilities. Which species, ecosystems or environmental value structures should we prioritize and why? What does permission to build look like from local communities who are bearing the environmental impacts? How do local social and political structures impact our environmental requirements? By providing critical inquiry into experimental 'externalities' — the unseen costs of running an experiment in a particular place — and related value decisions, HASS scholars can help think about what it would mean to do physics sustainably in a particular place.

A second reason for involving HASS scholars in experimental collaborations is that their expertise that can help understand and

involve local communities and stakeholders. For instance, the issues surrounding the Thirty Meter Telescope in Hawai'i emphasize that environmental and social impacts are hard to disentangle. Experimental systems and infrastructure affect the surrounding environment and local inhabitants in unequal ways. Protests in Hawai'i centre not just on astronomy's failure to consult with and benefit local communities, but on the colonial history of the island, the cultural importance of Mauna Kea as a mountain, the environmental impact of the telescopes, and the role of tourism and extractive science more broadly in the state. All these topics are interwoven — the environmental issues draw on Hawai'ian land stewardship practices, which are tied to religious and cultural practices that have been suppressed by colonial histories[2]. In this case, HASS scholars who have studied these regions, their local knowledge systems and histories, can help identify stakeholders and aid in a smoother, better communication process. They help not only by making physics greener, but also more socially responsible.

Thirdly, HASS scholars can be pivotal in guiding the governance and broader policy of science in society. Physics does not happen in a vacuum, and broader social, civil and historic contexts are needed to shape successful policy. How does the community build better green guidelines? Who enforces them, and what does it mean for them to succeed? Partnership with HASS scholars increases the chance of physicists developing successful long-term policies on regulating and reducing environmental impact. A key example is that of nuclear technologies. Interdisciplinary collaborations with humanists and social scientists have helped engineers and physicists improve management systems related to nuclear safety and waste management — like in the case of an interdisciplinary national advisory board that reformed the Swedish nuclear waste system, and "human factors experts" in the US Nuclear Regulatory Commission who improved organisational safety norms[3]. NASA's User's Advisory Group, which represents non-government voices in conversations about space development and exploration, similarly includes HASS scholars as part of its membership, helping ensure that space research is done in ways that benefit the broader communities, as well as science. More recently, HASS scholars have been working on space law, including the regulation of space junk, the idea of 'space environmentalism', and the policies surrounding space infrastructure.

Emerging collaborations

Physics, indeed, would not be alone in tackling complex interdisciplinary questions with the help of HASS scholars. Similar issues have been faced in numerous other areas of science as they develop socially and environmentally sustainable practices. Historians have been key to understanding how extractive practices in archaeology sit within broader issues of colonialism, and have helped develop better frameworks for engaging with local communities[4], philosophers are central to work being done in synthetic biology on when and how to go about genetically modifying plants and animals to save them[5], and scientists, lawyers, and policy-makers have turned to environmental justice scholars to figure out how best to deploy emerging eco-technologies in partnership with governments and local groups[6]. In terms of governance, biotechnology policy spaces depend heavily on bio-ethicists, and the rapid developments in generative AI created a high demand for philosophers and science studies scholars to join advisory councils. In each case, scientists engage with experts across fields to develop more responsible practices.

Some such collaborations are beginning to emerge in physics too. One of the authors of this piece (A.C.T.) helped establish the Responsible Siting Working Group for the Next Generation Event Horizon Telescope, which has integrated HASS experts into the collaboration to engage with the environmental and social impact of telescope construction. In their search for new telescope sites, the group has sought to consult with a broad array of stakeholders to try to better understand what fair and sustainable astronomy would look like — and what the local challenges are. This process includes coordinating surveys of local sites for archaeological and historic importance, consulting with traditional landowners and local residents who have important expertise on the sites themselves, thinking proactively about how to integrate structures into the local landscape to minimize visual and environmental impact, and planning for site restoration once the project is ultimately completed[7]. In another example, the other two authors (J.d.S., C.A.A.) organized a think tank with social scientists and politicians to address the complexities of building a suggested neutrino observatory in the Peruvian Andes (TAMBO) — mapping stakeholders and addressing issues to do with condor habitats and extractive mining operations.

In these cases, HASS scholars have been able to contextualize, communicate and engage with the environmental and social factors of large-scale experiments in ways that go beyond the traditional expertise of physicists. Collaboration with humanities scholars like these are still unusual, yet interdisciplinary collaborations are already at the core of many large-scale physics experiments — involving engineers, electricians, theorists, chemists, and so on. So our call is for institutions and large experimental collaborations to extend these interdisciplinary relations and integrate and support long-term collaborations with HASS scholars that can help create a more sustainable physics. HASS experts exist across the globe, often within the same institutions as many members of these physics collaborations. By starting cross-disciplinary conversations as early as possible, scientists can build solutions into the very beginning of projects, rather than trying to retroactively respond to problems as they emerge.

Jaco de Swart [1] ✉, **Ann C. Thresher** [2] **& Carlos A. Argüelles** [3]
[1]Program in Science, Technology, and Society & Department of Physics, Massachusetts Institute of Technology, Cambridge, MA, USA. [2]McCoy Family Center for Ethics in Society & Stanford Doerr School for Sustainability, Stanford University, Stanford, CA, USA. [3]Department of Physics & Laboratory for Particle Physics and Cosmology, Harvard University, Cambridge, MA, USA.
✉e-mail: deswart@mit.edu

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Competing interests

The authors declare no competing interests.