https://doi.org/10.1038/s41562-023-01674-x

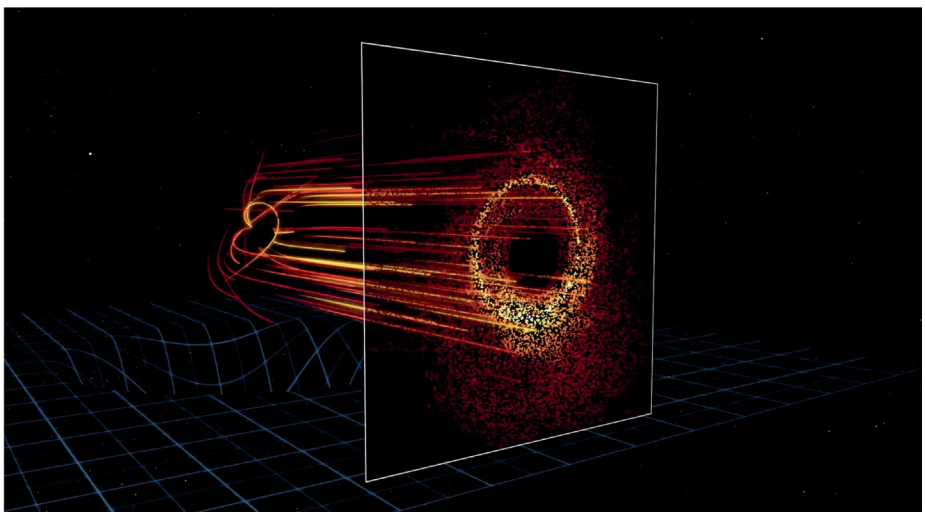
Big STEM collaborations should include humanities and social science

The divide between the natural sciences and the humanities and social sciences in the West is a recent one. Newton considered himself a 'natural philosopher', Thomas Hobbes thought that one of his greatest achievements was laying the foundations of optics, and Margaret Cavendish was the author of one of the first works of science fiction and the first woman to attend a meeting of the Royal Society. More recently, the space between the so-called STEM ('science, technology, engineering and mathematics') disciplines and the humanities and social and behavioural sciences has widened, until we have come to see them as islands without bridges.

Big STEM collaborations, however, do not operate in isolation but are part of an interconnected web of social institutions, relations and values. Part of this involves recognizing that science often comes with complex effects on the world around it, not all of which are immediately obvious — advances in renewable energy technology, for example, are reliant upon metals that are often mined in regions with lax labour and environmental regulations that endanger workers and surrounding communities[1]. Humanities, social science and behavioural science scholars are positioned to understand and shape these interactions by emphasizing different ways of knowing and different approaches to questions that can, among other benefits, help to mitigate long-term risks from the outset. In return, they become part of a global real-time case study, which enables access to data (both physical and social) and provides unique opportunities to try new ideas with a continuous feedback loop.

What major trans-disciplinary collaborations look like is often hard to picture. As a group of decision theorists, philosophers, historians and astronomers working together on the 'Next Generation Event Horizon Telescope' (ngEHT) we want to offer our own insights into the multimodal interactions that characterize this project[2].

By linking together existing facilities around the world, the Event Horizon Telescope (EHT) created a virtual Earth-sized telescope that produced the first images of a black hole[3].



The warped spacetime near the event horizon of a black hole bends the trajectory of light rays to form a characteristic 'shadow' feature when observed by arrays of radio telescopes on Earth. This graphic shows the twisted paths that light takes around the event horizon, and how the image reconstructed on earth is composed of individual light rays that originate within the deep gravity well of the black hole. Image is a still from an animation produced by Crazybridge Studios. Copyright: Center for Astrophysics | Harvard & Smithsonian.

The ngEHT will substantially enhance this array, enabling it to capture videos of black holes and conduct innovative research projects from event-horizon-scale studies of strong gravity to studies of the cosmological growth and influence of supermassive black holes[4,5]. Below, we sketch in brief three areas in which the science goals of a large STEM collaboration are aligned with those of the humanities, and social and behavioural sciences.

First, the ngEHT is looking to expand its array with new telescopes. Several will be breaking ground on mountaintops across the globe, in places with a history of colonization and exploitation. Even though astronomy looks to the stars, the telescopes themselves can have serious effects on both the environment and communities surrounding them[6]. Ethicists, sociologists, astronomers, historians and community activists are helping to guide the questions of where to build telescopes, how to go about it in ways that benefit both astronomy and local communities, and how to reduce their environmental impact.

Second, over the past several decades, STEM collaborations have grown from dozens to thousands of participants, focusing attention on the intersection of governance and science. With larger collaborations, the likelihood of disagreement about the goals and the interpretation of observations increases. To manage the heterogenous membership of contemporary scientific collaborations, the informal structures of the mid-twentieth century have given way to what political scientists would recognize as a constitutional structure, separation of powers and representative voting. With them also come the frustrations and uncertainties of democratic processes, processes that are being proactively designed and guided by humanities and social science scholars within the ngEHT[7].

Third, large STEM collaborations such as the ngEHT continuously elicit and aggregate judgments from their hundreds of experts, ranging from where to build the next antenna to when an anomaly in their dataset amounts to a new phenomenon. But groups (even expert

ones) are prone to a wide range of biases and miscommunication when trying to harness the wisdom of a large and fragmented community under severe uncertainty. Ecologists[8], intelligence analysts[9] and psychologists[10] (among many others) have expended considerable resources testing various interventions to optimize their decisions. The ngEHT collaboration is learning how to get the most out of their unique pool of experts through applying similar structured expert elicitation techniques.

The challenges outlined above are not unique to ngEHT and neither are the solutions it is developing. The ngEHT has placed a major institutional bet on redrawing the lines that have confined academics to separate departments, professional gatherings and research funding panels in response to the challenges faced by modern science. If done well, this radical interdisciplinary project can help to guide the future of the humanities and social sciences in STEM and encourage more researchers to work at the cross-disciplinary frontier of these fields.

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Published online: 10 August 2023

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Acknowledgements

We acknowledge the hundreds of researchers and engineers worldwide who have contributed to the ngEHT and have helped to define the direction of this collaboration. In particular, we are grateful to the members of the History Philosophy Culture (HPC) Working Group, and the attendees of the 1st HPC Workshop and Responsible Siting Workshop, as well as to J. Nguyen for comments on an earlier version of this manuscript. N.C.M.M. acknowledges support from the European Union's Horizon Europe research and innovation programme for the funding received under the Marie Skłodowska-Curie grant agreement no. 101065772 (PhilDarkEnergy) and the ERC Starting Grant agreement no. 101076402 (COSMO-MASTER). Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or the European Research Council. Neither the European Union nor the granting authority can be held responsible for them. A.C.T, N.C.M.M, S.S.D., P.G. and M.D.J. acknowledge the Black Hole Initiative, a project funded in part by the Gordon and Betty Moore Foundation. It was also made possible through the support of a grant from the John Templeton Foundation. The opinions expressed in this publication are those of the authors and do not necessarily reflect the views of these foundations. S.S.D. and M.D.J. acknowledge support from National Science Foundation grant AST-1935980, and Gordon and Betty Moore Foundation grant GBMF10423. The funders had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

Competing interests

A.M., A.C.T., N.C.M.M., P.G., S.S.D. and M.D.J. are members of the ngEHT collaboration, an interdisciplinary project that spans STEM, the humanities and the social and behavioural sciences. A.M., A.C.T., N.C.M.M. and P.G. are members of the History Philosophy and Culture Working Group (led by P.G.). S.S.D. is the principal investigator of the ngEHT collaboration and the founding director of the EHT collaboration. M.D.J. is the project scientist of the ngEHT collaboration.