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Social Physics in the Age of Generative AI: How, Exactly, Is Society Complex?

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Abstract

The aspiration for a social physics — a science that would reveal universal laws of social life analogous to those governing the natural world—has haunted the social sciences since Comte. Each new wave of quantitative and computational methods breathes fresh life into this vision. The current moment is no exception: advances in artificial intelligence and large language models have reinvigorated attempts to model society through the methods of social physics. This essay argues that these ambitions rest on a confusion about the nature of social complexity. Drawing a distinction between *systems complexity* and *anthropological complexity*, we identify the limitations of analyzing society as a complex system akin to natural systems. One crucial obstacle for social physics is the analysis of meaning and interpretation. Generative artificial intelligence (GenAI) offers important opportunities to model language and reflexivity, inviting and perhaps compelling social physics to confront meaning and interpretation as constitutive features of the social world. At the same time, GenAI leaves untouched and may even aggravate social physics' failure to grasp power, institutions, and inequality.

Keywords: Complexity theory; Modeling; Artificial Intelligence (AI).

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1 Introduction

The specter of social physics has haunted social science from its inception. In its original formulation, French Enlightenment thinkers such as Auguste Comte conceived of social physics as the final frontier of science: after successfully demystifying the natural world, its methods and techniques would illuminate the much greater complexity of social life. For Comte and his contemporaries, social physics was never just about explanation — the newly discovered laws of social life would make it possible to govern society in a more rational and benign way.

The aspiration for social physics episodically resurfaces, buoyed by new scientific methods. The quantitative revolution in the social sciences in the 1960s reinvigorated the belief that models borrowed from physics might be applied to social phenomena; the proliferation of digital data and computational techniques in the 2000s breathed new life into social physics; and at present, breakthroughs in artificial intelligence and specifically large language models animate renewed attempts to model society.

Although they trade in advanced computational techniques rather than philosophical contemplation, contemporary proponents of social physics are heirs to Comte. Physicist Geoffrey West (2017) examines cities, corporations, and ecosystems, viewing them all as complex systems whose metabolism is governed by allometric scaling laws. Alex Pentland (2014) asks how computational models and big data can allow us to "engineer" society for better productivity, innovation, and cooperation.

In this essay, we argue that there are fundamental differences between the social and natural worlds that stand in the way of social physics. While both societies and ecosystems are complex systems, they are complex in different ways, with far-reaching consequences for how we can and should study them. To describe these differences, we develop the distinction between *systems complexity* and *anthropological complexity*, with the crucial difference that the latter rests on cultural signification. Crucially, these conceptions of complexity were not simply discovered — they were partly constituted by the methods available to study them. We then examine generative social simulations as a new method that has the potential to redraw the complexity divide, potentially forcing social physics into a productive encounter with reflexivity, meaning, and interpretation that its earlier methods allowed it to avoid.

2 The Complexity Divide

If there is one thing that scientists and scholars agree on, it is that social life is complex. In the primer Society is a Complex Matter, the physicist journalist Philip Ball uses insights from complexity theory to study patterns of crowd movements, social networks, and cooperation. On the other side of the academic spectrum, anthropologists, too, emphasize complexity. Thomas Eriksen notes that what "characterizes anthropological research today more than anything is the recognition of complexity; the world is complex, cultures are complex, communities are complex, and analytical strategies must acknowledge complexity" (Eriksen, 2017, p. 8). Yet beneath this apparent agreement lies a fundamental disagreement about what it actually means for something to be complex — a divide that runs through the academy.

You can discover on which side of the divide you stand by answering the question: *is the purpose of science to simplify or to complexify*? Physicists, mathematicians, computer scientists, and positivistic social scientists will tend to answer *simplify*; anthropologists, qualitative researchers, and humanities scholars will say *complexify*. Those who decline to answer because the question seems too simplistic have already declared themselves. These responses reveal not

just conceptions of science but of complexity itself. Schematically, we can discern two conceptions: *systems complexity* and *anthropological complexity*.

Systems complexity is the kind that interests physicists and complex systems researchers. "Complexity" here has a relatively precise meaning: systemic features cannot be read off from the attributes of individual components. The complexity arises from interactions *between* components. Anthills and bird flocks are the go-to metaphors — characterized not only by massive interaction across elements, but by the simplicity of those elements. System complexity does not abandon the reductionist aims of traditional science, but merely suggests the need to take a different route that accounts for emergent dynamics. Principles like Occam's razor and the axiom that "everything should be made as simple as possible, but not simpler" reflect a conception of science as — in Popper's phrase — "the art of systematic over-simplification" (Batty, 2014). As Hayles (1999) has shown, this approach performs what she calls a "Platonic backhand": inferring from the world's noisy multiplicity a simplified abstraction, then constituting that abstraction as the originary form from which multiplicity derives. Systems complexity as an epistemology emerged alongside the computational methods that made it possible to study (Törnberg & Uitermark, 2021). Computer simulation allowed researchers to model systems from the ground up — to specify simple agents, define interaction rules, and observe emergent patterns. The method constituted the ontology: what counted as "complex" was what could be shown to emerge from computational models of interacting components. Systems complexity was a critique of the reductionism of conventional approaches, but not of its ambitions — only of its means of achieving them.

Anthropological complexity is the kind that intrigues anthropologists and many qualitative scholars. "Complex" here means difficult to grasp. It implies multiplicity, ambiguity, instability — the kind of complexity that escapes regimentation, that throws up something new whenever you attempt to fix it. It is because they are committed to understanding this type of complexity that anthropologists see it as their mission to argue against simplification. As Clifford Geertz (1973, p. 10) put it, the ethnographer is "faced with a multiplicity of complex conceptual structures, many of them superimposed upon or knotted into one another, which are at once strange, irregular, and inexplicit, and which he must contrive somehow first to grasp and then to render". Acknowledging complexity here means rejecting the pursuit of universal models — there is no "ethnographic algorithm", that would capture "systematic rules" (Geertz, 1973, p. 11). The "task of anthropology" says Thomas Hylland Eriksen (2017, p. 8), "is to create astonishment, to show that the world is both richer and more complex than it is usually assumed to be".

Both conceptions of complexity carry political implications. The anthropological view becomes committed to preserving complexity against authorities that impose rigid schemes (Scott, 1996). In this perspective, the idea of capturing social life in mathematical formulas is at best naïve and at worst represents a form of colonial erasure — an erasure that feminist scholars and Southern theorists have documented with particular sharpness. Raewyn Connell (2007) has shown how northern theoretical frameworks systematically erase the epistemic traditions of the global South, producing what Boaventura de Sousa Santos (2014) calls "epistemicide" — the destruction of knowledge systems that do not fit the dominant scientific template. Sandra Harding (1986) and Donna Haraway (1988) have traced how claims to universal, view-from-nowhere knowledge have historically served to naturalize particular, gendered, and racialized perspectives as objective science.

Figure 1. Scientists and scholars say society is complex, but they mean different things by it[1]

The systems complexity view, by contrast, positions the researcher as an external observer who can see the whole system, adjust parameters, and observe outcomes — what one might call the *view from the control room* (Medina, 2011). By translating social systems into computational models, it converts political questions into technical ones. Treating segregation as an emergent property of lattice dynamics conceals the political economy of race, property, and state power that actually produces segregated cities — and hence negates the possibility of political action. Systems complexity is hence inherently acritical: it tends to cast outcomes as natural and even inevitable.

3 The Modest Contributions of Social Physics

The conviction underlying social physics from its inception is that human societies are more complex than natural systems, but not *differently* complex. Societies would be like three-dimensional chess: exceedingly difficult to understand but ultimately intelligible since the rules are fixed and the variations finite. An alternative view, however, is that human societies are a qualitatively different kind of complex system (Andersson et al., 2014; Byrne & Callaghan, 2022; Castellani & Gerrits, 2024).

One indication that this is the case is that social physics remains as elusive as when Comte first conceived of it. While physics has since brought people to the moon, created quantum computers, and designed nuclear weapons, social physics' contributions have been exceedingly modest by comparison. There is nothing like a cumulative understanding of universal social laws, let alone a scientific foundation for the rational management of society. There are episodic bursts of enthusiasm, but no Newtonian revolution, no periodic table of

1. This image was generated with ChatGPT using a prompt that specified the text in the speech and thought bubbles. After a first attempt returned the image of the anthropologist as an Indiana Jones-like archeologist, we asked the program to remove the fedora, skull, shovel, and pottery. For both the first and second image, we only asked for an anthropologist and physicist; it was ChatGPT's idea that the first should be a woman, the second a man, and that they both would be white.

social elements. Whereas it may make sense to speak of the "unreasonable effectiveness of mathematics in the natural sciences" (Wigner, 1960), its effectiveness in the social sciences is, at best, highly reasonable.

There is also a more fundamental argument, starting from first principles. This argument is that human societies have one characteristic that makes modeling them with universal laws impossible: *reflexivity*. Social structures are constructed out of meaning. Nations, races, organizations, markets, religions, movements — they are the building blocks of social life and cease to exist once people stop believing in them. Meaning is there before, during, and after analysis; it cannot be bracketed. It is baked into data, informs observation, and defines inference. As Geertz (1973, p. 9) observed, "Right down at the factual base, the hard rock, insofar as there is any, of the whole enterprise, we are already explicating: and worse, explicating explications".

Because humans are reflexive — because they can observe, and therefore undo, any regularity that scientists might identify — there can be no social laws in the strong sense. *Social* complexity (Castellani & Gerrits, 2024) consists, hence, not merely of the intricate mass interaction of particles but is a *reflexive* complexity in which imagined entities and constructions come to define individual behavior. Advances in biology suggest that such reflexivity is not exclusive to humans, but it is certainly foundational to human societies. A nation is not a physical fact but a shared fiction, and yet people will die for it; a market is not a natural system but a web of expectations, and yet it can collapse an economy overnight. The complexity of social life is not that there are too many variables to track; it is that the variables are made of meaning and meaning shifts under observation.

In a complex physical system, the components do not read the papers written about them. In a complex social system, they do, and they change their behavior accordingly. The feedback loop between knowledge and action, between representation and reality, is not a complication to be eventually modeled out; it is the very engine of social life. Any science of society that brackets this reflexivity may produce elegant formalisms, but it will be studying a shadow of the thing it claims to represent.

This does not mean that systems complexity research has nothing to offer. There is a biological substrate to social life: hormones, dopamine, and adrenaline all play a role in social processes (Collins, 2004), and the laws of physics apply insofar as humans are embedded in physical space — which is why scaling laws for organisms translate reasonably well to cities (West, 2017). Methods developed for physical processes have been productively applied to social dynamics: spin glass models developed for ferromagnetism can illuminate the twin dynamics of attraction and repulsion in social polarization; epidemiological models can help to understand the spread of social phenomena (Castellano et al., 2009; Christakis & Fowler, 2013). Formal modeling can serve as a powerful thought experiment. Schelling's (1971) segregation model shows that even slight preferences for co-ethnic neighbors will, *ceteris paribus*, produce high levels of segregation — not to approximate reality closely, but to bring a particular mechanism into view through deliberate abstraction. Yet what is presumed in the model — two groups and their preferences — is precisely what would need to be explained in any serious study of real-world segregation. Models can gesture at mechanisms; they cannot replace interpretation. Rather than treating minimal models as the holy grail, they are most valuable as a small part of a more comprehensive, multipronged approach that uses computational methods to support, rather than supplant, interpretation (Törnberg & Uitermark, 2021).

4 The Generative Turn and the Complexity Crossroads

The rapid advancement of artificial intelligence and large language models writes a new chapter in this debate (Park et al., 2023; Törnberg et al., 2023). Where meaning was largely absent from social physics, it comes into view as machines develop the capacity to interpret and generate discourse. Classic agent-based models assume fairly simple agents — they can take on only a few states and behave according to a limited set of rules. Agents constructed through language models are qualitatively different: they can be endowed with personalities, knowledge, and cultural repertoires; they can evolve through interaction; they can reason about norms, contest them, reinterpret them, and persuade each other.

Generative social simulations thus appear to open the possibility of formally modeling reflexivity — agents can narrate their own reasoning, respond to novel situations they were not explicitly programmed for, and produce behavior that emerges from linguistic and cultural competence rather than from coded rules. They may, in principle, be capable of capturing the emergence of social constructs, rather than a mere social pattern.

This represents an ontological shift in how social life is imagined within computational models (Törnberg & Uitermark, 2025 and 2026). The first generation of social physics imagined society as a clockwork: an intricate mechanical system that could be taken apart and modeled through mathematical representation. The second generation of social physics imagined society as an organic system: an anthill or a flock of birds, whose mass interaction shaped dynamic patterns, which could be captured through computational models. The new generation views it as an ensemble of actors, interacting and telling a story — the implicit metaphor shifts from mechanical to organic to something closer to drama or improvisation.

Yet generative simulations also bring fundamental challenges. Traditional ABMs offer a clear causal story: you know exactly why an agent did what it did because you wrote the rule. Generative ABMs sacrifice this. When an LLM-agent makes a decision, the "why" is distributed across billions of parameters. You gain realism but lose the mechanistic transparency that made ABMs explanatorily powerful in the first place. The model becomes more like an oracle than an explanation.

At the same time, the face validity attained does not come with external validity. As Larooij and Törnberg (2025) argue, it is exceedingly challenging to show that generative social models match real-world mechanisms. Whereas calibration and validation have always represented fundamental challenges for social simulation, generative simulation makes such challenges substantially worse.

There is also the risk of theory leakage. Having been trained on virtually the entirety of published academic knowledge, LLMs tend to recognize the social situations they are made to inhabit. LLM agents cannot naïvely inhabit scenarios that resemble well-known social science findings because they already know the social science. The simulation risks collapsing from construction into enactment — faithfully re-performing the findings from long-published papers. This echoes Giddens's (1984) double hermeneutics — the feedback loop by which social-scientific knowledge re-enters and reshapes the social world it describes — but in a novel and compressed form: the entire circuit between knowing and behaving is internalized within a single system, making it especially difficult to distinguish genuine emergent dynamics from the rehearsal of absorbed findings.

Moreover, the training corpora on which these models are built encode existing power relations, dominant framings, and hegemonic common sense. Ruha Benjamin (2019) has shown how technological design embeds what she calls the "New Jim Code" — discriminatory

practices concealed within the apparent neutrality of computational systems. Zeynep Tufekci (2017) has argued that algorithmic infrastructures are not neutral tools but structures that shape the possibilities of collective action in ways their designers do not fully anticipate or control. When generative agents are built from LLMs, they are not modeling social life from some neutral vantage point but reproducing it as seen through a profoundly skewed archive — one that overrepresents certain voices, languages, and epistemologies. Yuk Hui (2016) has argued that modern technology carries with it a particular cosmological orientation, a "cosmotechnics" that forecloses other ways of relating to the world; generative social simulations, trained on the textual archive of a particular civilization, carry that civilization's assumptions invisibly into their outputs. As Haraway (1988) insisted, all knowledge is produced from somewhere, from a particular position — and the pretense of a "view from nowhere" is not objectivity but a form of power. Generative ABMs invisibly embed situatedness in training data and architectural choices. The danger is that the model's apparent sophistication — its ability to generate natural language, to "reason" — may make the situatedness harder, not easier, to see.

In short, the construction of sophisticated AI agents might go some way towards addressing the reflexivity deficit in social physics. By encoding reflexivity into agents, simulations will become more complex, which potentially helps to show how meaning complicates social structures and mitigates against determinism — this would be the best-case scenario for social physics. An equally likely scenario, however, is that the greater sophistication of AI agents will inspire new hubristic attempts to model social life, mistaking superficial plausibility for realism and simulating rather than studying social relations. Even in the best-case scenario, AI agents do not resolve the fundamental challenges that have haunted social physics from the beginning. New-generation simulation models do not begin to address how social interactions are shaped by broader social structures, institutions, and historically evolved inequalities.

5 Conclusion: Complexity Reimagined

What counts as "complexity" has always been shaped by the methods available to represent it. Systems complexity emerged as a concept because computational simulation made it possible to model emergence from simple interacting components. By enabling the representation and study of a form of complexity, the method shaped what complexity meant within the computational tradition. Hayles (1999) identified this as the "Platonic forehand" — the move that starts from simplified abstractions and, using simulation techniques, evolves a multiplicity sufficiently complex that it can be seen as a world of its own.

Generative AI may come to redefine complexity again. Where systems complexity bracketed meaning — treating agents as simpletons whose interactions produced emergent patterns — generative models enable bringing meaning back into the frame. Researchers must now contend with the ambiguity of language, the situatedness of cultural knowledge, the reflexive capacity of agents who can name and narrate the situations they inhabit. In this sense, generative AI has the potential to produce something like an interpretive turn within social physics — not because researchers have been persuaded by the arguments of anthropologists and critical theorists, but because the methods themselves now demand engagement with the very features of social life that earlier methods allowed them to ignore.

But there is a danger here, and it is precisely the one Hayles identified. The Platonic forehand and the Platonic backhand share a common ideology: privileging the abstract as the Real and downplaying the importance of material instantiation. A generative ABM that produces agents who reason, deliberate, and contest norms may appear to have overcome the flatness of

earlier models — to have captured anthropological complexity at last. Yet there is a risk that generative ABMs become a more seductive version of the same epistemological move — a spectacle of complexity that performs interpretive richness while remaining, at bottom, a closed system whose outputs are determined by the cultural assumptions compressed into its training data. The very realism becomes ideological: it naturalizes outcomes by making them seem to "just emerge" from interactions among agents who "think for themselves", which is a sophisticated repackaging of the methodological individualism that critical scholars have long contested.

The real question, then, is not whether generative simulations are "better" models of social life. It is whether they will compel social physics to reckon with the interpretive, situated, and political character of social complexity — not as a residual problem to be eventually solved, but as the constitutive condition of the social world. If generative ABMs are treated as tools for thinking — devices that provoke new questions, reveal hidden assumptions, and open imaginative space — they may indeed help to bridge the complexity divide. If they are treated as tools for knowing — authoritative representations that close down the very interpretive openness they appear to model — they will merely reproduce it in a more sophisticated guise. A social science with artificial intelligence would use these tools to deepen our understanding of anthropological complexity; a social science of artificial intelligence would investigate how the new methods reconstitute complexity in their own image. We need both — and the urgency of the second grows as AI moves from academic curiosity to institutional infrastructure that reshapes the social world it claims merely to represent.

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