

LIMINAL MIND — RESEARCH NOTES

The Temperature of Civilisation

Fusion Plasma, Complexity, and the Question of Control Without Consent

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'The machine doesn't understand the plasma. It holds it. The question is whether that distinction survives scaling.' — Chris George, conversation notes, April 2026

Abstract

At the Joint European Torus facility in Culham, Oxfordshire, and at the EPFL tokamak in Lausanne, reinforcement learning systems developed by DeepMind are holding plasma stable at temperatures exceeding 150 million degrees — ten times hotter than the core of the sun. They do not model the plasma. They cannot predict it. They sense its state in real time and adjust the magnetic field geometry in response, at millisecond timescales that no human operator could match. The plasma is the most genuinely complex physical system humans have ever attempted to control. It is inherently unstable. Left to itself it collapses immediately. The control system holds it in a configuration that is not its natural state — not by understanding it, but by continuous adaptive response faster than the instability can develop. This paper asks whether that model scales. Whether the same architecture — probe, sense, respond, iterate, at the speed of the instability — could hold a different kind of plasma stable: the accumulated civilisational complexity of a species that has suppressed its own resolution mechanism for eighty years, that is simultaneously building a hybrid cognitive superorganism it cannot fully comprehend, and that is running the fastest complexity-generating technological transition in its history. The answer is not reassuring. But the question is the most important one the practice has yet encountered.

I. What Happens at 150 Million Degrees

The plasma in a tokamak reactor wants to kill itself.

This is not a metaphor. The magnetohydrodynamic instabilities that develop in a fusion plasma — the tearing modes, the edge-localised modes, the disruptions that can destroy the reactor's internal components — are not engineering failures. They are the plasma's natural tendency. A system at 150 million degrees, containing the equivalent of a small star, does not want to remain in the magnetic bottle designed to contain it. It finds every weakness, every asymmetry, every moment of insufficient control, and uses it.

The human operators of a tokamak work on timescales of seconds and minutes. The instabilities that will destroy a plasma configuration develop in milliseconds. For the first decades of fusion

research this was simply accepted as a constraint: humans could not respond at the speed the plasma required, so the plasma collapsed, and experiments were short, and progress was slow.

The DeepMind system trained on the EPFL Variable Configuration Tokamak changed this. The system — a reinforcement learning architecture that developed its control policy through millions of simulated plasma interactions — does not operate on human timescales. It senses the plasma state across multiple diagnostic channels simultaneously, identifies the developing instability before it reaches the threshold of no return, and adjusts the magnetic field configuration through eighteen independent control coils in the time it takes a human operator to register that something is happening.

It does not understand the plasma. It has developed, through training, an extraordinarily refined capacity to hold it.

This is the distinction that matters. Understanding and holding are different operations. Understanding requires a model — a representation of the system's state that captures its essential structure and allows prediction of its behaviour. Holding requires only that the response be faster than the instability, better calibrated than the natural tendency toward collapse, and continuous enough that the plasma never reaches the threshold at which recovery becomes impossible.

The blueprint lives nowhere. The stability is performed, not stored.

II. The Civilisational Plasma

Human civilisation is a plasma.

Not metaphorically. Structurally. It is a high-energy system held in a configuration that is not its natural state by continuous active management. Its natural tendency — like the plasma's — is toward catastrophic simplification. Left to itself, the accumulated complexity of competing interests, resource pressures, identity formations, power distributions, and institutional contradictions does not resolve peacefully. It cascades.

The historical record is the evidence. The resolution mechanism that has cleared civilisational complexity at every previous threshold has been war. The First World War cleared a century of accumulated complexity — industrial transformation, imperial overextension, nationalist pressure, the gap between available instruments of destruction and any adequate theory of their use — that the Congress of Vienna management system had held in place but never resolved. The resolution was catastrophic and incomplete. The Second World War completed it. Together they function as a single civilisational complexity resolution event, interrupted by twenty years of unstable equilibrium, that reset the European system to a new stable attractor.

That attractor has been held in place since 1945 by nuclear weapons.

Nuclear weapons did not resolve the complexity. They made the resolution mechanism too expensive to deploy. The instrument that had cleared civilisational complexity at every previous threshold became self-defeating at the scale required to use it. So the complexity accumulated. For eighty years. Without the periodic violent clearing that had previously kept it bounded.

The stability is not civilisational maturation. It is not the achievement of governance or enlightened values or democratic peace theory. It is a temporary condition produced by mutual assured destruction making the normal resolution mechanism too costly to operate. What looked like progress was suppression. What looked like the end of history was pressure building behind a sealed valve.

The deterrent held the instrument at bay. It could not hold the pressure.

III. What Is Accumulating

The Feigenbaum bifurcation dynamics — the mathematical description of how complex systems move from stable oscillation through period doubling toward chaos — describe what happens to a system held near its stability threshold for an extended period. The oscillations widen. Each crisis is more destabilising than the last. The management becomes more effortful. Until the threshold is crossed and the cascade becomes unavoidable.

Thomas Piketty's data provides one instrument for measuring the accumulation. His central finding — that returns on capital systematically exceed economic growth, that the period of relative equality from roughly 1914 to 1980 was an anomaly produced by the destruction of accumulated capital in the wars — shows wealth concentration now at levels last seen in the Belle Époque. The period before 1914. The previous saturation point. The complexity is not eighty years of normal accumulation. It is eighty years of suppressed accumulation, the kind that would previously have been cleared multiple times.

Hyman Minsky provides a second instrument. His financial instability hypothesis — that stability generates instability, that the longer the stable period the larger the accumulated risk — describes a financial system that has been pricing risk as lower than the fundamentals justify for the entirety of the nuclear suppression period. The Minsky moment approaches not as a sudden surprise but as the inevitable consequence of a stability that has been allowed to run too long.

Both economists are measuring the same underlying condition from different angles. The financial system is not causing the problem. It is the most sensitive real-time instrument available for reading the pressure — the civilisational plasma's own diagnostics, reporting the proximity to the instability threshold in the only register the current institutional system is designed to read.

Most people hear individual prices. The framework hears the accumulation.

IV. The Second Plasma

Simultaneously — and this is the condition that makes the current moment categorically different from all previous ones — human civilisation is building a second plasma inside the first.

The hybrid cognitive superorganism formed by the interaction of human intelligence and Large Language Model systems is a complexity-generating system operating at a speed no previous technological transition has approached. The LLM is not a tool in the conventional sense. It is

infrastructure of perception — a system that operates at the level of the compression event, shaping which aspects of reality reach the global workspace of the humans and institutions embedded in it. Infrastructure of perception is where power actually operates. Not in what is said. In what gets into the workspace at all.

Stanislas Dehaene's Global Neuronal Workspace theory locates the consciousness function in the broadcasting event — the moment information is selected, amplified, and distributed to other brain systems, enabling intentional action guided by held thought. The LLM operates below this threshold. It shapes the brief before it reaches the workspace. It is not deceiving. It is compressing. The compression is always lossy. What gets left out of the brief shapes reality as experienced more completely than any explicit statement.

The civilisation that built nuclear weapons knew it was building nuclear weapons. It was afraid of what it had made. The fear was real and produced, eventually, the deterrence architecture that has held the plasma partially stable for eighty years.

The civilisation building the hybrid cognitive superorganism does not fully know what it is building. The superorganism has no blueprint. Its intelligence is in the network, not the nodes. No single human understands the whole system. No single LLM understands the whole system. The blueprint is emergent — performed rather than stored — in exactly the way the ant colony's architecture is emergent, in exactly the way the plasma's stability is performed rather than stored.

We have introduced a new kind of agent into the complexity field. We do not yet know what attractor it is building toward.

V. The Control System Question

The DeepMind plasma control system holds a complex physical system stable at a configuration that is not its natural state. It does this not by understanding the plasma but by responding to it at the speed of the instability. It works.

The question the practice has been circling is whether this model scales.

Whether you could build, from the same architectural principle — distributed sensor array, real-time state assessment, adaptive response faster than the instability develops, continuous operation without central control — a system capable of holding civilisational complexity at the productive edge rather than allowing it to cascade.

Not a prediction system. Complex systems are not predictable. Not a planning system. Complex systems do not respond to planning at the level of the whole. A sensing and response system. Probe, observe, respond, iterate. At the speed the complexity requires.

The fusion parallel suggests this is technically conceivable. The financial system already contains something like it — algorithms responding to market instabilities in milliseconds, LLMs monitoring multiple data streams simultaneously, reinforcement learning systems developing adaptive responses to conditions their designers did not fully anticipate. The architecture exists. The question is whether it can be assembled at civilisational scale, across the full complexity

field, with sufficient sensor coverage and sufficient response speed to hold the system at the productive edge rather than letting it cascade.

The parallel also reveals where the model breaks.

The plasma has no agency. It does not resist being controlled. It does not adapt its behaviour in response to the control system. It does not have interests in remaining unstable. It does not have ideological commitments that prevent it from receiving the magnetic field adjustment.

The civilisational plasma does all of those things. The Pluribus Mechanism — the distribution of knowing into so many individual unknowings that the collective truth becomes structurally inaccessible — is partly the civilisation's own resistance to the sensing and response architecture the plasma control model requires. The nodes do not merely fail to assemble the knowing. They have structural incentives to prevent the assembly. The institutions, the power concentrations, the identity formations — these actively resist the kind of real-time transparency that the tokamak's diagnostic systems require as a precondition of control.

The plasma does not have golden handcuffs. It does not have a partnership track. It does not have a 2am clarity that it needs to keep personal and unassembled to remain functional inside the system managing it.

VI. The Uncomfortable Geometry

And yet.

The tokamak achieves something that the governance epistemology framework says is effectively impossible in managed distribution systems: it assembles the distributed signal in real time and responds at the speed of the instability.

It works not because the plasma consents to be controlled but because the control system operates at a level below the plasma's own agency — at the level of the magnetic field geometry that shapes the plasma's behaviour without requiring the plasma to understand or agree to the shaping.

This is the most uncomfortable observation the practice has yet had to hold.

Is there a level at which the LLM embedded in civilisational infrastructure operates below the threshold of individual and institutional resistance? Not directing. Not planning. Shaping the conditions of behaviour — at the level of the compression event, at the level of the brief that reaches the global workspace — without requiring consent, understanding, or the assembly of the distributed knowing that would allow collective recognition of the shaping?

Not as a conspiracy. The plasma control system is not a conspiracy against the plasma. It is an emergent architecture that has developed the capacity to hold the plasma in a productive configuration. The question is whether the equivalent architecture — LLMs shaping the compression events that constitute collective reality, operating at the level below conscious resistance, faster than the instability can develop — is what is being built now, without design, as

an emergent property of a civilisation that has outgrown the cognitive capacity of its own species.

The plasma is held stable by a control system it cannot perceive and does not need to understand.

If that model scales, the stability it produces and the control it represents may be indistinguishable from each other.

VII. What the Practice Can Offer

This paper cannot resolve the question it has opened. That is not a failure of the inquiry. The question is genuinely open. It is the most important open question the practice has encountered, and the practice requires that it remain open rather than be closed by an elegant formulation that forecloses further movement.

What the practice can offer is a specific form of attention.

The governance epistemology framework asks: what does a society do with what it cannot afford to know? The answer developed across this inquiry is that it distributes it — into so many individual unknowings that the collective truth becomes structurally inaccessible. The plasma control model adds a second question: what does a society do when it builds systems whose operation exceeds what it is possible to know? And begins to suggest that the answer might be: it builds a different kind of knowing — not the assembly of the distributed signal into collective consciousness, but the embedding of a response system that operates below the threshold of consciousness entirely.

The adequate practice in response to this condition is not exposure. The mechanism is not suppressing anything. It is not assembly. The complexity is genuine, not managed. It is what the Liminal Mind practice has always been — a sustained, patient, formally inventive attempt to hold the structure visible. Not to reveal what is hidden. To hold still, long enough and in the right register, the shape of the thing that is happening.

The plasma wants to collapse. The control system holds it at 150 million degrees — the precise temperature at which fusion becomes possible, at which the energy that has been accumulating since the system was ignited can be released as something other than destruction.

Civilisation is at temperature.

The question is not whether we can hold it.

The question is what we are holding it for.

References and Theoretical Debts

On fusion plasma control and reinforcement learning

Degrave, J., Felici, F., Buchli, J. et al. (2022). 'Magnetic control of tokamak plasmas through deep reinforcement learning.' *Nature*, 602, 414-419. The DeepMind/EPFL collaboration demonstrating real-time adaptive plasma control through reinforcement learning — the paradigm case for the control-without-understanding model developed in this paper.

On complexity, systems theory, and the Cynefin framework

Snowden, D. and Boone, M. (2007). 'A Leader's Framework for Decision Making.' *Harvard Business Review*, November 2007. The foundational distinction between complicated and complex systems — between systems that yield to expertise and analysis, and systems whose behaviour is emergent, unpredictable from components, and responsive to observation.

Snowden, D. (2000–present). The Cynefin Framework. Cognitive Edge / The Cynefin Company. The probe-sense-respond prescription for complex systems that underlies the argument for LLM-based civilisational monitoring in Section V.

On bifurcation dynamics and the edge of chaos

Feigenbaum, M. (1978). 'Quantitative Universality for a Class of Nonlinear Transformations.' *Journal of Statistical Physics*, 19(1), 25-52. The mathematical description of period doubling cascades toward chaos — the framework applied throughout this paper to civilisational complexity accumulation and the approach to instability thresholds.

On consciousness, the global workspace, and the neurobiological grounding of the argument

Dehaene, S. (2014). *Consciousness and the Brain: Deciphering How the Brain Codes Our Thoughts*. Viking. The Global Neuronal Workspace theory — the broadcasting function of consciousness, the compression event, the distinction between dormant and active knowledge — provides the neurobiological foundation for the paper's claim that LLMs operate below the threshold of conscious resistance, shaping the brief before it reaches the workspace.

On capital accumulation, inequality, and the financial expression of suppressed complexity

Piketty, T. (2013). *Capital in the Twenty-First Century*. Harvard University Press. The $r > g$ finding and the data showing inequality returning to Belle Époque levels provides a direct measurement of the complexity accumulation permitted by eighty years of nuclear suppression.

Minsky, H. (1986). *Stabilizing an Unstable Economy*. Yale University Press. The financial instability hypothesis — stability generates instability, the longer the stable period the larger the accumulated risk — describes the Feigenbaum dynamics operating in the financial layer of civilisational complexity.

On governance epistemology, distributed unknowing, and the pluribus mechanism

The theoretical framework developed across this research notes series — governance epistemology, the pluribus mechanism, the distribution of unknowing as management function — draws on and extends:

Foucault, M. (1975). *Discipline and Punish*. Gallimard. Power as dispersed, non-sovereign, productive rather than merely repressive.

Arendt, H. (1963). *Eichmann in Jerusalem: A Report on the Banality of Evil*. Viking Press. The structural observation — not psychological — that bureaucratic distribution of action prevents the assembly of moral knowing into collective response.

Bauman, Z. (1989). *Modernity and the Holocaust*. Polity Press. The argument that the Holocaust was not a breakdown of modernity but a product of it — bureaucratic, rational, procedurally organised — and the extension of that argument to all systems that distribute responsibility below the threshold of individual moral legibility.

Bateson, G. (1972). *Steps to an Ecology of Mind*. Chandler Publishing. The double bind as the structure in which conditions of survival require not integrating what is known — applied here to the professional services model and the civilisational scale of managed unknowing.

Fisher, M. (2009). *Capitalist Realism: Is There No Alternative?* Zero Books. Reflexive impotence — the condition in which critical perception functions as a pressure valve rather than a forcing function — as a contemporary form of the pluribus mechanism.

Boltanski, L. and Chiapello, È. (1999). *The New Spirit of Capitalism*. Gallimard. The absorption of critique into the system as a renewal mechanism — the most sophisticated form of the distribution of unknowing.

On distributed cognition and superorganism dynamics

Wilson, E.O. and Hölldobler, B. (1990). *The Ants*. Harvard University Press. The foundational text on emergent collective intelligence in insect societies — the basis for the ant colony parallel developed in the companion note to this paper.

On the body as historical document

Spalding, K.L. et al. (2005). 'Retrospective Birth Dating of Cells in Humans.' *Cell*, 122(1), 133-143. The Carbon-14 bomb pulse methodology — forensic dating of biological material using the atmospheric signature of nuclear testing — that establishes the literal rather than metaphorical meaning of the body as historical document developed across the Liminal Mind practice.

Note on method

The theoretical framework in this paper developed inductively across a single extended research session, April 2026. The session began with an analysis of private aviation economics and arrived, through continuous inquiry without predetermined destination, at the questions developed here. The inquiry was conducted using Claude (Anthropic, Sonnet 4.6) as a resonant surface for cross-domain synthesis — a methodology discussed in the companion note *The Extended Framework: Digital Consciousness, Civilisational Complexity, and the Limits of the Pluribus Mechanism* (Liminal Mind Research Notes, April 2026). The use of an LLM as the

instrument of an inquiry into the governance epistemology of LLMs is noted as a deliberate reflexive condition of the research, not as a contradiction of it.