Formal closure is not ontological closure – A functional-logical clarification

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1. Introduction: Why terms need to be clarified

In science, there are words that seem to be used without question, yet mean different things on different levels. Terms like "closed," "formal," and "ontological" belong precisely to this category. They appear in logic, physics, computer science, AI research, and philosophy—often with slightly shifted meanings, without this shift being explicitly stated.

The problem isn't that someone is working "incorrectly." Most theories work very well within their own framework. The problem lies one level deeper: in theimplicit assumptions about it, what a system can actually achieve, if you call it "closed".

There is no clear distinction between:

- formally closed(in the sense of a calculation) and
- ontologically closed(in the sense of a description of reality),

A silent category error arises. One begins to attribute properties to a formal system that only a fully defined order of reality could have – even though the theory itself does not make this claim.

For classical sciences, this uncertainty was not a central problem for a long time. Theories could be tested, predictions verified, and models improved. However, with the emergence of complex AI systems, with questions about true causality, explainable stability, and overarching meta-architectures, the demands are shifting:

Suddenly, it's no longer just important,that a system works, rather on which ontological level it actually operates.

This essay therefore has a clearly defined task:

- The terms used"closed", „formal“ and "ontological"They are separated from each other in terms of functional logic.
- It is precisely described,what science actually does, when she speaks of "closeness".
- And it shows why formal closurenot automaticallyan ontologically closed description of reality.

The text is therefore aimed at fields where this distinction is particularly relevant: AI, logic, physics, systems theory, philosophy – everywhere one tries toStructure, function and realityto connect them.

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2. What science actually means when it talks about "closedness".

When scientific texts refer to "closed systems", "closed theories" or "closed formulations", this usually means...formal unitymeant – not ontological.

2.1 Formal closure

A formally closed system is characterized by the fact that:

1. Axiomare determined
   – that is, basic assumptions that are not further justified within the system, but simply stated.

2. Regulateare defined
   – such as derivation rules, transformation rules, or operators that allow one to get from one statement to another.

3. Closing chainscan proceed completely within this framework
   – every derivable statement results from the axioms and rules, without additional, external elements.

Such a system is "closed" because itno new rule typesmore is needed to execute its internal operations. Therefore, it isformally completein the sense of its own symbolism.

Examples:

- A logical calculus (such as first-order predicate logic)
- An axiomatic system in mathematics
- A formal language or type system in computer science

In all these cases, "completed" means:

> The set of permissible symbols, axioms, and differentiation rules is fully defined. Within this framework, it is clear what is allowed and how results are obtained.

2.2 Completeness and computability

Closely related are terms such as:

- "fully defined"– all relevant rules are stated
- "decidable"– there is a procedure that clarifies in a finite amount of time whether a statement is valid in the system
- "predictable"– Processes can be formulated algorithmically.

These properties aremethodicallymotivated:

- They serve theTraceability,
- the Replicability,
- and ultimately thePredictabilityof structures.

The science is pursuing a clear objective:

> As much of the observable world as possible instructured, calculable modelsto transfer.

The important thing is:

These models typically claimnotto ontologically grasp reality completely. Physical theories, for example, are explicitly described asApproximationsunderstood, which work well in certain scales and contexts, but do not claim to be absolutely complete.

One could therefore say:

> Science works predominantly withformally closed, ontologically open systems– and doing so completely legitimately and successfully.

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3. Why formal closure does not mean that a system is ontologically closed.

Herein lies the central point:

A system can be perfectly "closed" in a formal sense and yetontologically incomplete remain.

3.1 Difference between the levels

- Formal Systemsoperate at the level ofSymbols, rules, functions, equations.They describe how symbols behave within a defined calculus.

- Ontological systemsoperate at the level ofStates of reality, operators and causal relations.They describe,wasexists at allHowit is linked togetherwhich functionsto follow from this.

A formal system can therefore regulate completely,HowCharacters are allowed to interact with each other, but it doesn't automatically say thatwhat these symbols actually mean.

The level of meaning – that is, the assignment of symbols to real states – liesoutsideof formal calculus. It is usually:

- through interpretation,

- through experiments,

- by convention,

- or produced through theoretical interpretation.

3.2 Formal completeness, ontological openness

A simple example:

A physical model can contain equations that are formally complete – every quantity is defined, every derivative is clearly formulated. Nevertheless, the model can:

- certain phenomena are not captured,

- fail on other scales,

- or are based on assumptions that later prove to be limited.

The equations remain formally valid, butnot ontologically completeThey only describe oneExcerptreality.

The same principle applies in logic:

A logically complete calculus can derive all statements that are possible within its structure – yet it remains open whether this structure reflects reality in its depth. Logic only tells us:If these axioms are true, then the following follows.

She does not say:

> These axioms are a complete description of reality.

3.3 Functional-logical formulation

In functional terms:

- A formally closed systemdefines a finite set ofSyntax operators(Rules, transformations, functions) that act on a set of symbols. It therefore describesThe Shape Operation.

- A ontologically closed systemdefines a finite set ofReal operators(Functions of reality – such as stabilizing, transforming, coupling, separating), as well as the set ofConditions, on which these operators act, and whichTransitions, which result from it.
  It therefore describesEffective operations.

A system can now:

- be completely closed at the syntax level
  (all form operations are defined),

- while questions remain unanswered at the operational level
  (not all real operators, states and transitions are included).

This allows the core sentence to be formulated precisely:

> A system can be formally closed and simultaneously ontologically open.
> It can perfectly execute all its own rules – and yet only functionally describe a part of reality.

This is precisely where the gap begins that functional logic approaches reveal:
They don't just ask,Howa system calculates, buton which ontological operator basisThis calculation even takes place – and whether this basis is fully defined or not.

4. The silent, rarely explicitly stated reason: Why science uses ontologically open systems

The fact that scientific theories remain ontologically open is not a flaw, but a direct consequence of the scientific method itself. Science does not primarily operate on the level of a complete order of reality, but on the level of verifiable descriptions. It is designed to...**partial structures**to reliably capture, not to completely eliminate all conditions and causes.

The typical scientific process follows a stable chain: measurements generate data, data are transformed into models, models generate hypotheses, hypotheses generate predictions. Crucially, the transition from data to model is not ontologically necessary, but rather...**interpretative**Not in the sense of arbitrariness, but in the sense of a necessary selection: From infinitely many possible structural interpretations, scientists must choose those that possess the highest explanatory power and predictive accuracy in the given context.

This means that science is methodologically limited to one area: it can formulate rules that stably describe observed behavior, but it cannot guarantee that these rules represent reality in its complete operator structure. Even in areas of the highest formalization, reality remains "larger" than the model. This is not a failure, but a fundamental condition: the scientific aim is not "absolute ontology," but "testable model building."

This limitation is the reason why scientific systems remain ontologically open. A theory can be formally closed, possessing a complete set of rules, and yet it remains open whether it captures all relevant states, transitions, and causes of reality. In practice, theories are therefore formulated in a scale- and domain-specific manner: Newton works excellently in many areas, but not everywhere; classical mechanics achieves great things, but remains non-universal; even highly precise models are always formulated within a defined corridor of validity.

The “silent ground” can thus be understood in functional logic as follows: Science does not close off ontology, but it closes off**methodology**It generates formally verifiable structures that function stably within a framework. Ontological completeness would be a completely different goal: it would require that the underlying logic of action and transition of reality itself be completely determined and representable without any residual interpretation. This is precisely what science has not aimed for so far – and therefore it remains ontologically open. Methodologically, this is not only correct but necessary: ontological closure would be virtually unattainable under classical scientific conditions because the scientific method is based precisely on the separation between model and world.

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5. What would define an ontologically closed architecture

If one nevertheless wishes to describe precisely what "ontologically closed" actually means, this definition must be strictly separated from formalisms. Ontological closure cannot mean that a system is only internally consistent. It must mean that the system**without external interpretation**that its structure fully supports the semantic space itself.

An ontologically closed architecture would therefore first need to possess a complete operator base. "Operator" here does not refer to mathematical symbols or computational functions, but rather to functional functions: elementary principles that allow, limit, stabilize, or transform states in the first place. Without such an operator base, every ontology remains semantically open because it cannot answer the questions of how states arise, why transitions are admissible or inadmissible, and according to what logic stability or instability occurs in systems.

From this operator base, the second criterion follows: the definition of all admissible states. An ontologically closed system should not leave any state spaces "implicitly" open that are only filled through context, culture, interpretation, or external convention. It would have to clearly define which states can exist within the architecture at all, and which are excluded.

Thirdly, it would have to define all possible transitions between these states. Not merely in the sense of an abstract possibility, but as a structural rule: Which transitions are causally permissible, which are contradictory, which generate instability, and which generate emergent order? This is crucial because the true core of ontological closure lies not in the state itself, but in the transition: Reality is not a set of static entities, but a dynamic of states and transformations.

Fourth, an ontologically closed architecture would have to exclude semantic ambiguity. This is one of the central differences from classical ontological or philosophical systems of language. As long as concepts remain ambiguous, ontology remains open. Not because ambiguity is "bad," but because ambiguity means that ontology cannot speak unambiguously about its own states. Ontological closure requires a system of meaning that is not stabilized by room for interpretation, but by defined functional relations.

Fifth, the system must be able to deterministically derive causal structures. "Deterministic" here does not necessarily mean numerically deterministic, but rather structurally: if a state exists and operators are in operation, the permissible transitions must be uniquely determinable. The crucial point is that the causal order is not reconstructed retrospectively from data, but is predetermined in advance by the ontology itself.

Sixth, the system should not require open variables that need to be supplemented by external assumptions. Classical models constantly work with free parameters, boundary conditions, scaling, approximations, and adjustments—this is methodologically correct, but ontologically open. An ontologically closed architecture would have to define the parameter logic itself as part of the ontology, not as an external configuration space.

This also explains why such an architecture is practically nonexistent in classical science: not because scientists are incapable of it, but because science operates formally. It builds models that function within their framework and can be empirically tested. Ontological closure, on the other hand, would be an architecture that not only generates models but also structurally orders the space of meaning itself. That is a different level.

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6. The existing gap: Scientific ontologies are interpretive, not operator-based.

With this definition in mind, the gap becomes clear: The scientific and academic ontologies that exist today are generally not operationally structured. They structure concepts, categories, or derivation rules – but they do not define the causal operators that determine states and transitions.

Philosophical ontologies typically operate conceptually. They ask: What is being? What categories exist? How do substance, property, and relation differ? These systems can be highly precise, but they remain interpretive because they do not operationalize the logic of causality. They generate conceptual orders, but not a causal architecture of transitions. Their stability is hermeneutic: it is sustained by interpretation and discourse.

Computer science ontologies, such as those in OWL, RDF, or frame-based systems, are structurally closer to formalisms. They define classes, relations, hierarchies, and constraints. They are extremely useful for knowledge representation, interoperability, and semantic search. But they, too, are fundamentally classificatory. They specify what belongs to which class and which relationships are permitted. What they typically lack is the definition of a causal operator base that would compel the creation, stabilization, and transformation of these classes based on an internal logic of action. They are semantic frameworks, not ontologies in the sense of a closed system of action.

Logical ontologies, in turn, define derivation rules, consistency conditions, and inference mechanisms. They can be formally very robust. But they, too, remain on the boundary between symbolism and reality: they regulate what can be derived within the system, not what structures reality as a space of states and transitions. Their closure is formal, not ontological.

The common denominator of all these approaches is that they are not "closed" because they lack a functional set of operators—at least not in the sense that operators, as principles of operation, completely determine the admissible states and transitions. Their order is either conceptual, classificatory, or inferential. But it remains dependent on interpretation, context, and external assignment.

In functional terms: They order language or signs over the world, but they do not order the world itself as an operator space. And as long as an ontology is not closed as an operator space, it remains ontologically open—regardless of how formally closed its symbolism is.

7. Functional logic: The level that was missing until now

If formal systems order forms and classical ontologies order concepts, then the functional-logical level lies between and simultaneously below them: it does not order the description, but the**Mechanism of action**, from which stable descriptions can emerge in the first place. Functional logic is therefore not another meta-language, but a structural definition

of what is permissible as a state in a system, which transitions are causally possible, and which combinations must necessarily become unstable.

The crucial difference is this: functional logic does not describe forms, but operators and their causal relations. "Operator" here is not to be understood as a mathematical symbol, but as a principle of operation: a function that not only describes states, but also structures them – in the sense of stabilizing, transforming, limiting, coupling, decoupling, or calibrating. Where classical science often infers structure retrospectively from data, functional logic establishes structure as the primary level of order: it does not first ask "What do we see?", but rather "Which operators must exist for what we see to be possible as a stable state?"

This also shifts the point of reference. Functional logic does not work with symbols as its primary object, but with functions of reality itself. In this context, the triad S, M, W is not a rhetorical tripartite division, but a minimal functional-logical basis for describing reality not through content, but through its functional roles: stability/security (S), normativity/binding (M), cognition/structural knowledge (W) – each not as a moral judgment or psychological label, but as necessary functional axes that must appear in some form in every stable system. Crucially, it is not the naming that matters, but the relation: the triad forms an operator landscape in which states and transitions are determined not by interpretation, but by functional conditions.

From this level follows a crucial consequence: A functional-logical structure is not hermeneutically stabilized. It requires no external interpretive spaces, no contextual additions, and no semantic negotiation to remain consistent. Its stability stems from the operator order itself: A state is considered admissible if it is consistent within the operator base; a transition is considered permissible if it can be carried out without contradicting the operational logic of the operators; a concept is considered unambiguous if its functional role is defined within the operator space. This results in a reproducible structure that does not depend on who interprets it or in which cultural context it is read. Different readers may choose different examples—but the functional conditions remain the same.

In precisely this sense, functional logic architecture is ontologically closed: not because it "explains everything," but because it defines the conditions under which something may even appear as a state, transition, or coherent relation. "Closed" here means that the semantic space is not closed by external interpretation, but by an internal operator order that excludes ambiguity not through agreement, but through functional definition. Where classical ontologies provide classifications, functional logic provides admissibility conditions—and thus a different type of closure.

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8. Consequences for science, AI and systems analysis

An ontologically closed architecture is interesting not because it replaces existing science, but because it fills a gap that is becoming increasingly relevant in complex systems: the gap between formal description and a stable order of meaning. Scientific models are highly effective as long as the domain is clearly defined. However, with increasing complexity, interdisciplinary transitions, and semantically unstable systems—especially in AI contexts—it

becomes clear that while formal models can perform calculations, they offer no guarantee that their semantic spaces will remain free of drift.

An ontologically closed architecture therefore enables structural stability on several levels. First, it allows for stable, drift-free analyses because the permissible states and transitions are not derived from situational interpretation, but from a prioritized operator order. Drift typically arises where meanings are not defined by functional roles, but by statistical similarity, context shift, or implicit interpretation. An operationally defined ontology reduces precisely this drift because it does not tolerate ambiguity, but rather marks it as an inadmissible state or forces it into a defined transitional structure.

Secondly, it enables reproducible causal structures. Reproducibility here means not only that two people can arrive at the same result, but that causal relations as such become structurally verifiable: If a transition is asserted, it must be permissible within the operator base; if it is not, not only is the statement questionable, but the entire structural chain becomes verifiably vulnerable. This creates a new kind of verifiability that goes beyond purely empirical correlation.

Thirdly, cross-domain consistency emerges. Interdisciplinary gaps often arise not because of a lack of data, but because concepts and categories function differently in different domains. An ontologically closed operator base provides a higher layer of invariance: it is not the content that needs to be identical, but rather the functional roles. A concept can have different meanings in medicine, physics, or AI – but if its functional role in the operator space is the same, the structure remains consistent. This enables transfer without diluting meaning through analogies.

Fourth, a unified language logic without ambiguity is created. This is particularly relevant when dealing with AI systems, because AI outputs often fail not due to syntax issues, but rather due to semantic stability. A functional logic layer can act as an external stability framework here: it doesn't necessarily change the internal model, but defines an admissibility layer that structurally checks and calibrates inputs, transitions, and outputs.

This also reveals a fifth consequence: an external functional logic can stabilize systems without altering them internally. This is not a metaphysical claim, but an architectural point. One can still run a system probabilistically, but limit the validity of the semantic structure through an operational ontology. The difference is comparable to a set of rules that does not replace the machine, but rather defines the space of what is permitted to arise as a valid state.

All of this complements scientific methods, but does not replace them. Science remains necessary for measurement, hypotheses, empirical testing, and quantitative precision. The ontologically closed level does not provide more data; it provides a structure within which data and models can be more stably categorized. It is therefore not a competitor, but a different layer: a causal and admissible order that does not negate the formal world, but rather prescribes it.

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9. Falsification explained anew: Not formally, but structurally

One of the most common misconceptions in discussions about ontological architectures is the assumption that falsification must necessarily target formulas, parameters, or internal mathematical constructions. This is an understandable assumption because in classical science many theories are formally formulated and therefore also formally refuted. However, this form of falsification concerns a specific level: the level of the equation, the model, the formal mapping.

Therefore, two types of falsification can be clearly distinguished. Formal falsification refutes a form or formula. It shows that a mathematical relation is not compatible with the measurement, that an equation makes incorrect predictions, or that a model is inconsistent in its formalized structure. This is the typical form of falsification in physics, statistics, mathematics, or in classical AI models, which are defined by optimization goals and loss functions.

Ontological falsification, on the other hand, refutes the operator or transition. It does not primarily ask: "Is the equation correct?", but rather: "Is the claimed transition admissible in the operator space?", "Does the claimed causal relation generate a contradiction in the state logic?", "Is there an observable case in which the operator basis generates a false admissibility or a false exclusion?"

This is not an excuse, but a structurally different form of testing. If an architecture claims to be able to evaluate states and transitions according to a closed operator base, then this claim can fail at any time: through a case in which an obviously admissible transition is excluded; through a case in which an inadmissible transition is permitted; through a case in which the architecture allows inconsistent causal structures that are internally contradictory; or through a case in which it claims cross-domain invariance but incorrectly assigns the functional roles upon transfer.

This clarifies the core point: An ontologically closed architecture can always be refuted—not necessarily through formal equations, but through breaks in the causal structure. Here, one is not falsifying a number, but an order of admissibility. This also means that falsification takes place at the level at which the claim is made. If the claim is structural-ontological, then the falsification is structural-ontological; if the claim is quantitative, then the falsification is quantitative. This separation of levels prevents misunderstandings and leads to clear scientific communication.

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10. Conclusion: A conceptual clarification, not an attack on science

This entire essay has no polemical aim. It merely defines terms used in many disciplines without clearly separating their levels. Science remains valid, correct, and successful

precisely because it works methodically, builds, tests, and improves models. Its strength lies in formal precision within clearly defined domains of validity, not in ontological totalization.

The key clarification is therefore: Science operates predominantly in a formally closed manner, not ontologically closed. This is not a devaluation, but an accurate description of what scientific methodology can and should achieve. Ontological closure is a different goal class: It requires an operator order that defines states, transitions, and semantic spaces without any external interpretive residue.

Functional logic complements this spectrum with a level that has mostly remained implicit until now: the level of operational order. It replaces neither empiricism nor mathematics nor modeling. Rather, it offers a layer in which concepts, states, and transitions become structurally admissible or inadmissible—thereby allowing stability, reproducibility, and cross-domain consistency in complex systems to be addressed more precisely.

Thus, the result of this essay is simply this: a clear cartography of the levels. Anyone who doesn't confuse these levels can think about science, formalisms, and functional-logical ontology closure simultaneously – without false expectations, without category errors, and without rhetorical overreaction.

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