Theoria, 2025, 40(2), 154-171
https://doi.org/10.1387/theoria.27141

THEORIA
ISSN 0495-4548 – eISSN 2171-679X

The metaphysics of symmetries: a map

(La metafísica de las simetrías: un mapa)

Cristian López*
University of Lausanne
University of Buenos Aires / CONICET
https://orcid.org/0000-0002-2883-4037

Keywords
Keywords: Symmetries
Metaphysics
Fundamentalism
Physics
Realism
Anti-realism

ABSTRACT: My main aim in this paper is to lay out a metaphysical map of the possible metaphysical attitudes that philosophers may hold with respect to physical symmetries. Even though it is customary to distinguish between realism vs. anti-realism, I show that the metaphysical landscape looks a bit more complex. To show this, I differentiate at least nine different views that have been held, or might be held, concerning which place physical symmetries occupy in one's ontology.

Palabras clave
Metafísica
Fundamentalismo
Física
Realismo
Anti-realismo

RESUMEN: Mi objetivo en este artículo es desarrollar un mapa metafísico de las posibles actitudes metafísicas que los filósofos pueden adoptar con respecto a las simetrías en física. Aunque es usual distinguir entre realismo y anti-realismo, en este artículo muestro que el panorama metafísico es un poco más complejo que eso. Para ello, distingo al menos nueve posiciones diferentes que han sido adoptadas, o podrían ser adoptadas, en relación al lugar que las simetrías pueden ocupar en la ontología que uno conciba.

1. *Introduction*

Modern physics has been built upon symmetries. From Galileo's ship to fermion-boson symmetry, different symmetry-based arguments have guided not only theory construction but also empirical research. Examples abound. Consider non-relativistic quantum mechanics. In standard presentations of the theory, Galilean invariances permit us to identify abstract operators with measurable dynamical variables, which introduces physical content into the theory (see Ballentine, 1998, sections 3.3-3.4). Thus, Galilean invariances play an active role in theory construction. Or think of the discovery of the omega-negative baryon (Ω^-), which has been a milestone in particle physics. In this case, the "Eightfold

* **Correspondence to:** Cristian López. University of Lausanne, Anthropole, Section de Philosophie, Of. 5155, CH-1015, Switzerland – cristian.lopez@unil.ch – https://orcid.org/0000-0002-2883-4037

How to cite: López, Cristian (2025). «The metaphysics of symmetries: a map»; *Theoria. An International Journal for Theory, History and Foundations of Science,* 40(2), 154-171. (https://doi.org/10.1387/theoria.27141).

Received: 01 December, 2024; Final version: 18 June, 2025.
ISSN 0495-4548 - eISSN 2171-679X / © 2025 UPV/EHU Press

Way" (or SU(3)-symmetry) has strongly guided empirical research during the 1960s, culminating in February 1964 with the discovery of the particle at the Brookhaven AGS.

In the last decades, philosophers have increasingly drawn their attention to the pervasive occurrences of symmetry claims in physics. Why do symmetries work so stupendously well? Do they reveal profound features of the world? Or are they a clever way to represent the natural world? The interest has been multiplefold, ranging from methodological to mathematical as well as ontological issues. What concerns me here is the metaphysical facet of the debate. On this, the attention was mainly drawn towards space-time symmetries (since they may reveal the nature of space-time), local gauge, and permutation symmetries (since they may reveal the aspects of the world's fundamental ontology). Symmetry claims, then, became not only crucial premises to infer the fundamental ontology (see North, 2009, 2021; see López, 2023a for criticisms) but they were also meant to refer to aspects of the fundamental ontology, reifying the concept (see Heisenberg, 1975; Weinberg, 1987; Baker, 2010; French, 2014, Schroeren, 2020, among others; see López, 2025 for criticisms). In opposition to these views, various forms of anti-realist or epistemic views have also been defended, gravitating around notions like "heuristic value", "epistemic principles", or even "prescindible postulates".

The main aim of this paper is to clarify the metaphysical landscape by laying out a map of the different metaphysical attitudes that may *possibly* be held on physical symmetries, whether or not they are represented in the literature. My aim is not to defend or attack any of these views, but to show their relations, differences, and common bases where they exist. I will refer to existing literature defending or attacking the different views when pertinent. The idea of laying out a metaphysical map of symmetries is to show the different metaphysical attitudes that address the problem of which place symmetries occupy in one's ontology; and while the division between realist–anti–realist views might be operationally useful, it falls short of capturing all the nuances that diverging metaphysical attitudes may have. I start off by distinguishing between *Symmetry Dispensabilism* and *Symmetry Indispensabilism*. Within the dispensability camp, at least four different views can be identified: the *No Symmetry View, Symmetry Agentialism, Symmetry Conventionalism, and Symmetry Expressivism*. To a good extent, these views represent anti-realist attitudes in different ways. In turn, within the indispensability camp, five positions can be distinguished: *Symmetry Realism, Symmetry Fundamentalism, Symmetry Inferentialism, Symmetry Epistemicism and Symmetry Normativism*. Even though many views represent realist attitudes, there is no linear association since some views, such as Symmetry Epistemicism and Symmetry Normativism, may well be viewed as anti-realist.

2. *The Philosophical Problem(s) of Symmetries*

Although physical symmetries come in many flavors and shapes (internal vs. external, local vs. global, theoretical vs. observational, geometrical vs. dynamical, and so on), all of them are, for the most part, formal notions that apply to mathematical structures. From an abstract viewpoint, symmetries are transformations that keep some relevant structure unaltered. In physics, most mathematical structures of interest are sets of differential equations that relate to other mathematical structures (e.g., topological and differential spaces). In consequence, physical symmetries are transformations that preserve the space of solutions of such sets of differential equations. In this precise sense, physical symmetries are said to be structure-preserving functions that map solutions to solutions.

This definition is, however, insufficient to obtain a *physical* symmetry. If this were so, it would always be possible to define a transformation that maps solutions to solutions, augmenting the symmetries of a theory on demand. Thus, as Gordon Belot mentions (2013), symmetries are hard to come by, so their physical definition should not be too liberal to capture that fact. This, in general, amounts to imposing further constraints on the abstract definition (see Read and Møller-Nielsen, 2020, for further constraints). Some of them may be purely formal —e.g., for Lie transformations, they must be continuous or smooth; for classical symmetries, the infinitesimal generators must only depend on the independent and dependent variables of the theory, etc. Others may be physical —e.g., some symmetries are required to not only preserve the geometrical structure of the phase space, but also specific objects (e.g., the Hamiltonian). And others may be interpretative —e.g., physical symmetries are required to preserve the observational content of a physical theory (see, for instance, Dasgupta, 2016), or to identify surplus structure (see Redhead, 1975; Dewar, 2019. See Hall and Murgueitio Ramirez, 2024, for discussion and an overview).

There are, of course, plenty of problems around the theoretical status and role of symmetries in physics. Christopher Martin (2002) has, for instance, centered on the role of local gauge symmetries in relation to other theoretical principles (e.g., renormalizability). Michael Redhead has tackled the problem of the role of symmetries for assessing redundant structures and inter-theoretical relations (Redhead, 1975). Katherine Brading and Elena Castellani have focused on classifying symmetry principles and symmetry arguments in different theories (Brading and Castellani, 2003, 2007). Others have focused on the methodological role of space-time symmetries in elucidating problems around the debate between relationalism and substantivalism (Earman 1989). Lately, the focus has been put on the role of symmetries in the interpretation of physical theories, distinguishing between interpretational and motivational views (Møller-Nielsen, 2018; Luc, 2022). In a similar line, many have concerned the role of symmetries in the invariance principle (Dasgupta, 2016). All this shows to what extent symmetries provide a fertile terrain for philosophical debate. I, however, focus here on the *metaphysical* facet of the problem, concerning the place that symmetries occupy in the ontology.

In metaphysics, this is "the problem of accommodating symmetries" (see French, 2014). Modern physics involves propositions that putatively refer to some transformations that keep some mathematical-physical structure invariant. How should we, philosophers, stand with respect to them? An analogy to laws can be instructive. Physical theories involve propositions that refer to differential equations of motion that intend to represent dynamical laws. But *what* are the dynamical laws? Philosophical landscape, as is well known, is rather leafy. Nonetheless, in one way or another, the problem boils down to accommodating dynamical laws in one's worldview –for some, they represent genuine laws of nature, for others, they do not; for some, they represent laws of nature that govern phenomena, for others, they represent just regularities, etc. So, the problem of accommodating symmetries may be analogously couched. Propositions involving symmetries refer, first and foremost, to *properties* of differential equations within a physical theory's formalism,[1] but the metaphysical question is whether they represent some entity, property, structure, or relation in the ontology.

In the literature, it is customary to distinguish between those who think that symmetry claims refer to aspects of the world (realists) and those who think that they do not (anti-realists) (see, for instance, Brading and Castellani, 2007; Livanios, 2010). Such a division can shed light on the alternatives, but it is still a bit coarse-grained when we pay attention to the details. When we say things such as "symmetries are epistemic", do we mean that they are just conventions of some sort and that we might sooner or later dispense with them? Or when it is defended that symmetry claims refer to aspects of the world, does it mean that symmetries themselves are aspects of reality, or that they can assist us in discovering reality? And if they are part of reality, are they fundamental or derivative in the ontology? This article aims to clarify all these questions.

When the metaphysical problem of symmetries is viewed as a problem of accommodating symmetries in one's worldview, or as a problem of "locating" symmetries in one's ontology, there are at least three options: primitivism, where symmetries are fundamental (irreducible) parts of one's ontology; conservative reductionism, where symmetries can be reduced to something else more primitive, but still conserved as parts of the ontology (but not as parts of the fundamental ontology); or eliminative reductionism, where symmetries are not even part of the ontology (nor fundamen-

[1] To be clear, the symmetries that have lately drawn philosophers' interests (as space-time symmetries, local gauge symmetries, and permutation symmetries) are primordially *known* in dynamical contexts and employed to simplify and handle dynamical problems. The respective symmetry transformations act upon terms appearing in dynamical equations and the symmetry is hence a property instantiated by the whole formal structure. It is true that we may, a fortiori, predicate the symmetry with respect to the structure of space-time, for instance. But, as I will argue shortly, this already supposes a philosophical position to take with respect to symmetries.

tal, nor derivative), but parts of the epistemic-methodological machinery to account for the ontology. It can be thought that eliminative reductionism, in this sense, it is not a metaphysical view of symmetries. I disagree. Eliminative reductionism implies a very clear statement on one's metaphysics and ontology —*there are no* symmetries in any relevant sense of "there are". Naturally, all these options have their advantage and difficulties as I will show in due course.

A final comment is relevant. Since symmetries come in many shapes and flavors, it would be tempting to think that some of them are real, whereas others are epistemic, leading to a kind of 'symmetry pluralism'. Methodologically, this approach could work (see Read and Møller-Nielsen 2020 for a methodological pluralist view of symmetries). But as I am interested in a metaphysical problem (which place symmetries occupy in one's ontology), the step from methodological pluralism to metaphysical pluralism is not so straightforward. It seems prima facie reasonable to think that, as different symmetries serve different purposes in physical theories, they will have different metaphysical status (i.e., some of them will be ontologically fundamental, others supervenient; others matter of convention, and others epistemically essential). This is a hard problem that deserves a deeper engagement, but the following warning is noteworthy. Even though symmetries are used differently in physical theories, an independent metaphysical argument in favor of such a metaphysical pluralism is needed. In other words, the fact that symmetries are used in different ways does not per se imply that they are all metaphysically different (promoting metaphysical pluralism).

An analogy with the metaphysical debates on law is instructive. Laws are quite varied (e.g., some of them are deterministic, some indeterministic, some probabilistic, some are first-order, others second-order, and so on). Humeanism about laws does not defend that some laws are regularities, whereas others govern phenomena. Neither do defenders of the governing view accept that some laws govern, whereas others supervene upon dispositional properties. My view is that symmetries should be treated similarly: while some form of methodological, or epistemic pluralism about symmetries can be endorsed (which allegedly follows from scientific practice), the plurality of symmetry kinds shouldn't be necessarily translated into the ontology automatically —scientific practice is insufficient for it, independent *metaphysical* reasons must be provided. In any case, this problem doesn't really affect the metaphysical map I lay out: all the metaphysical views I will distinguish can perfectly fine cohabitate in a metaphysically pluralist framework; or they could be alternative metaphysical stances in a globally monist metaphysical view.

3. Symmetry Dispensabilism and Symmetry Indispensabilism

In the Introduction, I briefly described two different kinds of symmetries that physics presents to us, but there are many. So, let us begin by clearly stating a blatant fact, the 'symmetry fact'.

Symmetry Fact Modern physics presents us with symmetry claims, that is, modern physics' discourse involves propositions p_i stating that in a theoretical framework a symmetry σ holds. Such propositions have contributed in the empirical success of physical theories.

Two comments are in order. The **symmetry fact**, as stated, is completely descriptive —it just happens that today's physics involves certain propositions referring to symmetries. As such, it is descriptively true, and everyone agrees on it. What is philosophically interesting about this, then? To my mind, the general problem is *whether* putative references to symmetries in p_i can be removed from our physical theories while preserving their empirical success[2]. I take that those that believe that we can*not* do this endorse what I call *Symmetry Indispensabilism* (**SInd**), while those that believe the opposite fall under what I call *Symmetry Dispensabilism* (**SDis**). It might be thought that this is just a convoluted way to rephrase the distinction between realism vs. anti-realism. But I do not think so, since **SInd**, as I argue later, does not

[2] It is worth noting that such a formulation of the problem is not an ontological problem yet. As it will become clearer later on in the paper, I take the ontological problem to be derivative from the general problem as just stated.

https://doi.org/10.1387/theoria.27141

necessarily imply a realist view of symmetries. In the same vein, I believe that an epistemic view of symmetries does not imply either the endorsement of **SDis**.

SInd Putative references to symmetries appearing in the **symmetry fact** cannot be dispensed with while preserving physics' empirical success.

SDis Putative references to symmetries appearing in the **symmetry fact** can be dispensed with while preserving physics' empirical success.

4. Symmetry Dispensabilism

Let us start with **SDis**. According to it, it is true that current physics employs propositions that refer to symmetries (**symmetry fact**), but we should not be misled into thinking that physics must formulate physical theories with such propositions. Future physics might well do it without symmetry claims. There may be scientific as well as philosophical reasons to hope for such a scenario. Think of renormalization in quantum electrodynamics (QED). For instance, it is a fact that in calculating some loop Feynman diagrams in QED, the integrals diverge. Hence, it is a fact that to calculate finite and testable expectation values, renormalization techniques are required. Yet, it is considered that they may be dispensable, in the sense that we can regard QED as an effective field theory, that is, a low-energy approximation of a still-unknown underlying high-energy physical theory. Then, physics could be dispensed with renormalization techniques. An analogous reasoning can, mutatis mutandis, be applied to symmetries —they can, for instance, be symptomatic of redundant structure that we should be dispensed with in future physics.[3]

Indeed, many have taken symmetries as symptomatic of redundant structure, suggesting that they guide new formulations of theories where such redundant structures are expunged entirely (see Dewar, 2015). This instrumental role of symmetries has, however, been the focus of controversy lately. Concerning the specific role of symmetries in symmetry-related models, two approaches have been distinguished: the *interpretational* and the *motivational* (see Møller-Nielsen, 2018; Luc, 2022). The interpretational approach holds that symmetries "allow us to interpret theories as being committed solely to the existence of invariant quantities, even in the absence of a metaphysically perspicuous characterization of the reality that is alleged to underlie symmetry related models" (Møller-Nielsen, 2018, p. 1256). In turn, the motivational view asserts that symmetries "only motivate us to find a metaphysically perspicuous characterization of the reality that is alleged to underlie symmetry related-models, but they do not allow us to interpret that theory as being solely committed to the existence of invariant quantities in the absence of any such characterization" (Møller-Nielsen, 2018, p. 1256).

Although this debate does not directly address the metaphysical problem of symmetries (its target is different) and it is in some way orthogonal to it, it is important to note that it might have some important metaphysical consequences. After all, symmetries are indeed employed as means to identify surplus structure. And, from it, some metaphysical lessons could be drawn. In due course, I will stress whether interpretational and motivational approaches favor one metaphysical view or the other.

Coming back to **SDis**, the symmetry discourse in the **symmetry fact** can also be dispensable based on purely metaphysical reasons, that is, our metaphysics could lead us to reject the symmetry discourse as referential. Think of dispositional

---

[3] It might be argued that the analogy doesn't really run because the elimination of symmetries will have ontological consequences, but not the elimination of renormalization techniques. But the argument already presupposes that symmetries might have ontological consequences, something that **SDis** denies. If symmetries were eliminated, the consequences would be purely methodological, as the elimination of other techniques. For the argument to go through, it should first be shown that the elimination of symmetries does have ontological consequences, which needs to be proved independently.

monism (e.g., Bird, 2007). Conforming to it, the basic ontology is given by dispositional properties from which laws are obtained. But, if this is so, then the laws can be only metaphysically constrained by the dispositions. Where should symmetries be placed? Are they genuine meta-laws that also constrain the laws? If they constrain the laws, then laws become over-constrained, and dispositions' fundamentality is contested. Bird's dispositional monism then takes symmetries to be pseudo-laws that form invariant structures that ultimately must be regarded as background structures; but "a desirable feature of physical theories is that they should eliminate background structures" (Bird, 2007: 213).

Bird would well represent what I call the "No Symmetry View" (**NSV**), a radical form of **SDis**. This is in close analogy with Nancy Cartwright's view of laws (Cartwright, 1983), mutatis mutandis. It can thus be argued that it is not an important fact of the scientific enterprise "to discover" anything like symmetries, but they are just useful devices that are found in highly idealized models. In that sense, physical symmetries would also 'lie' as they fail to refer to something external; or they 'lie' as they do not constrain phenomena, but idealized laws that can only be obtained in "shielded" models. In this sense, they also fail to represent an essential element in physics theorizing.

NSV Putative references to symmetries appearing in the **symmetry fact** fail to refer to entities, properties, or relations of the world's fundamental ontology. Nor do they capture an epistemically essential element in physics theorizing.

The most obvious problem for this view, one that will be recurrent in metaphysically light views, is that it doesn't really explain why symmetry claims have been so empirically successful. **NSV** seems to dispense with symmetries for metaphysical reasons (which are well-grounded), but it doesn't really explain why physical theories feature symmetries. It is nevertheless possible to find other views that are more systematic and explanatory, still within the **SDis** camp: *Symmetry Conventionalism* (**SC**) and *Symmetry Agentialism* (**SA**).

SC regards symmetries as conventions, that is, as a regular phenomenon observed in a determined community that does not depend on Nature or universal features found across communities. It rather depends on our choices (scientists' choices), which can be driven by numerous facts. Conventions are, then, "up to us", and thereby, the endorsement of symmetry claims that appear in the **symmetry fact** (as previously described) is also up to us —symmetries work like conventions among physicists that for pragmatic reasons became established in a community that share some epistemic standards and canons for theory acceptance. However, a crucial feature of conventions is that they can always be changed, and, to different degrees, are arbitrary. Then, if physical symmetries are conventions, whatever role they may play, it may be played by a choice. Therefore, they are dispensable. Christopher Martin (2002), Alexandre Guay (at least for Yang-Mills theories, 2004, 2008), and Sabine Hossenfelder (2018, where symmetries are almost aesthetic values) seem to uphold a form of **SC**.

An example of **SC** can be found in the so-called gauge symmetries. Alexandre Guay holds that gauge symmetries (i.e., the gauge structure) of Yang-Mills theories play a role in the quantization process as tools to obtain a field theory, being essentially pragmatic (Guay, 2008, p. 353). The fact that there are no alternative tools for quantization at sight, as Guay affirms, doesn't mean they could not exist. Nor does he argue that the gauge principle is *fundamental* for quantization. It just happens that physical theories *pragmatically* need the gauge principle, but it is not strictly necessary. Christopher Martin, in turn, argues that, in the case of the gauge principle, there exist different approaches to the gauge structure with different consequences for the "logic of nature", downplaying the role of the gauge principle –it might even not exist! (Martin, 2002, p. S233-S234).

SC Putative references to symmetries appearing in the **symmetry fact** refer to community-relative conventions that became established by various (epistemic, aesthetic, or pragmatic) reasons among the members of the community.

Poincaré's conventionalism could easily be extended to symmetries, making a case for **SC.** According to him, the adoption of a certain geometrical framework –and by extension, the symmetries inherent in them—is a matter of convention, selected on the basis of simplicity, unificatory power, and effectiveness in describing phenomena. **SC** is stronger than **NSV** because it explains what symmetries are (i.e., conventions), while **NSV** does not say anything about it. It does not explain the empirical success of physical theories, but because symmetries are not responsible for it (as the employment of the imperial metric is not responsible for the empirical adequacy of theories that use it). Nonetheless, although stronger than the **NSV**, conventionalism is still too weak, substantively diminishing the relevance of the **symmetry fact** for physical theories: there are good reasons to think that symmetries are *not* like metric units, for instance.

There is a more substantive naturalistic approach to epistemology and metaphysics that may be more satisfactory to those who want to avoid conventionalism, but to preserve **SDis** –*Symmetry Agentialism* (**SA**). **SA** can fairly be framed within what is known as the Sydney Plan (in square opposition to the famous Canberra Plan; see Price, 2011; Ismael 2014).

As far as I am aware, nobody in the literature has argued for **SA**, but I think it may be a workable philosophical position towards symmetries within **SDis**. In essence, the Sydney Plan is a systematic program for metaphysics that opposes viewing (scientific) concepts as representations (or 'mirrors') of reality. It is rather an anti-representationalist understanding of our scientific concepts that emphasizes the stories about agents and their relation to the world and how such concepts facilitate the interaction (Ismael, 2014). When facing a scientific concept, say *x,* we should not ask what *x* represents or how we can locate *x* in the scientific ontology, but what facts about our scientific understanding and the world jointly support the formation of *x,* and what role does it play in our scientific practice. In this way, scientific concepts and practices constitute "façades" (or user interfaces) to cope with the world: they do not represent external properties, objects, or structures, but "conceptual tools" to deal with the world.[4] The Sydney Plan then provides a fertile terrain for a naturalistic analysis of symmetries (as scientific concepts in the user interfaces), where the right question to raise is what facts about theory construction and experimental practice may require symmetries to cope with phenomena.

Two things are noteworthy. First, the relation of scientific-philosophical concepts to *agents*, and their purposes in the knowledge enterprise, is crucial (hence the name). Second, nothing in **SA** commits us to take symmetries as indispensable. After all, the basis is (at least partially) pragmatic, though more robust than conventionalism.

SA Putative references to symmetries appearing in the **symmetry fact** refer to elements in scientists' user interfaces[5] to navigate the natural world and to understand scientific practice and theorizing.

One of **SA**'s advantages is that it explains why physicists (as agents in active and pragmatic relations to the external world) employ symmetry claims in formulating physical theories. The potential problem is that it is essentially an anti-representationalist philosophy that is very critical of metaphysical projects as usually conducted. So, if SA is an alternative, it is a very radical one that doesn't even address the metaphysical problem of symmetries as usually presented.

Finally, it is worth mentioning a more radical, non-representationalist view of symmetries that can be framed within what I call *Symmetry Expressivism* (**SEx**). Expressivism is a well-known philosophical current in philosophy of language and metaethics claiming that sentences (moral sentences, for instance) are devices for expressing non-cognitivist positive or negative attitudes towards their objects. In moral language, expressivists would say that moral terms function much like "boo to ban abortion" or "hurrah to death penalty" (Ayer, 1974; Sinclair 2009). Therefore, semantic or moral sentences merely convey a non-cognitive attitude of approval or disapproval. It can be argued that in the physics community, physicists analogously employ symmetries. The **symmetry fact** expresses a non-cognitive attitude of physicists towards physical theories: they approve physical symmetries (or express a "pro attitude" towards them) in their physical theories for various non-cognitive reasons (e.g., an example would be "aesthetic pleasure"). This is clearly an eliminativist, metaphysically radical view of symmetries since it places physical symmetries on the side of scientists' non-

[4] I believe that the anti-representationalist spirit of SA is the reason why it cannot qualify as a realist view, at least in the traditional sense.

[5] In the Sydney plan, representations of all kinds are users' interfaces that facilitate interaction between the agent (as an active system) and an open environment. This is slightly different from mere conventions since scientific-philosophical concepts as interfaces play a specific and more active role in helping human beings navigate the world.

cognitive states of mind, introducing a good dose of irrationalism in physics. But it is a coherent view and can well be part of the metaphysical landscape.

SEx Putative references to symmetries appearing in the **symmetry fact** refer to scientists' non-cognitive states of mind that convey positive attitudes towards positing symmetries in physical theories.

Even though expressivism is a well-established philosophy in many brands of philosophy, it is alien to the philosophy of science. However, some types of expressivism have been lately defended in the philosophy of science for different scientific concepts. For instance, Josh Hunt has defended an expressivist account of explanation and relevance in science (2024). In the same line, he has proposed *nomological expressivism* for the case of laws of nature (Hunt work-in-progress, personal communication). Although nobody has thus far defended expressivism in the case of symmetries, symmetries involve concepts like explanations, laws of nature, counterfactuals, among others, which have been accounted for on expressivist grounds.

All these views make sense of physical symmetries as dispensable posits in physical theory. Contemporary physics indeed posits symmetries in physical theories, but it might as well stop doing it. The reason is that the apparent reference to symmetries in scientific discourse fails to refer to some external structure, relation, or entity. The problem is then to explain the specific role that symmetries play in knowledge, despite being dispensable. They may merely refer to contingent community-relative conventions, to strategies to cope with an external world, or to scientists' non-cognitive positive attitudes. Be that as it may, all of them do not only claim that symmetries are not part of one's ontology, but that even in our way of describing the ontology, they play an accessory role. Whoever thinks that this falls quite short of making sense of symmetries would rather endorse some form of *indispensabilism*, **SInd**.

5. *Symmetry Indispensabilism: Realist Views*

For many, **SDis** categorically fails to make sense of physics' success. The **symmetry fact** captures something crucial of physics that cannot be dispensed with if its success is to be preserved. In this way, **SInd** endorses the opposite view: not even in principle can all the putative references to symmetries in the **symmetry fact** be removed. Symmetries are nothing like renormalization techniques, nor are they just conventions. Even less do they express scientists' pro attitudes. We do not even have a good reason to expect their future elimination, but quite the opposite, since the trend in the last decades has moved towards a "symmetry-first-approach". Also, if a philosophical position cannot accommodate symmetries' crucial role, then this is per se a form of reductio against it (see Steven French's argument against Bird's dispositional monism, French, 2014, p. 249). This could suggest that **SInd** entails some form of realism. Nonetheless, as I previously mentioned, **SInd** does *not* directly imply a realist attitude towards the symmetry discourse. Indeed, I submit that **SInd** can be divided into five different views, not all of them realist: *Symmetry Realism* (**SR**), *Symmetry Fundamentalism* (**SF**), *Symmetry Inferentialism* (**SI**), *Symmetry Epistemicism* (**SE**), and *Symmetry Normativism* (**SN**).

Let's start with *Symmetry Realism* (**SR**). **SR** simply claims that the justification of the **symmetry fact** is that symmetries do refer to mind-independent structures, relations, or entities in the external world. Physics cannot dispense with symmetries without stopping to capture something important about the world that is within the physics domain (physical entities, properties, relations, or structures). It just happens that the world has such a structure that makes our theoretical statements involving symmetries (approximately) true, which is just a wordy way to say that symmetries are indispensable because they are (somehow) out there in the world. Two arguments uphold **SR** as stated –a type of the No Miracle argument and a type of the Quine-Putnam Indispensability argument. According to the former, from the **symmetry fact** we can infer that the empirical success of the introduction of symmetries in physics can only be explained by stating that symmetries must be 'out there' in the world; otherwise, the empirical success of modern physics would be a miracle. Since we do not believe in miracles, the best explanation of the **symmetry fact** is that symmetries must be 'out there' in the world. A No Miracle type argument, therefore, forces us to take symmetries as real.

https://doi.org/10.1387/theoria.27141

A type of Quine-Putnam Indispensability Argument places them in one's ontology:

> P1. We ought to be ontologically committed to only those theoretical posits that are indispensable to our (best) physical theories,
>
> P2. Symmetries are properties of laws of nature that are indispensable to our best physical theories,
>
> C. Therefore, we ought to be ontologically committed to symmetries.

The argument is Quinean in spirit: physical theories existentially quantify over symmetries. Physical theories cannot be formulated without symmetries and involve true propositions (or, at least, it is far from clear how physical theories can dispense with symmetries without losing empirical adequacy). Therefore, symmetries exist, and we should be committed ontologically to them. Nonetheless, **SR** is weaker than expected. The reason is that 'existence' can be a generous word and, paraphrasing Armstrong, symmetries could enter the ontology as 'an ontological free-lunch' (Armstrong, 1997, p. 12; Schaffner, 2009, p. 353). Then, physical symmetries, according to **SR**, do exist but they are not necessarily part of the fundamental ontology; they can rather be supervenient (or derivative) structures, relations, or entities that depend on more fundamental structures, relations, or entities.

SR Putative references to symmetries appearing in the **symmetry fact** refer to entities, properties, or relations of the world's ontology, although they are not necessarily fundamental.

SR in this sense could be endorsed by some versions of contemporary Humeanism. Physical symmetries play the role of meta-laws in the best systems, constraining first-order facts. This is the view of Michael Hicks (2019), where symmetries provide constraints on first-order facts, that is, the regularities that are find in the Humean mosaic. In this sense, as constraints of first-order facts, symmetries cannot be purely epistemic: facts about symmetries can be located in the Humean mosaic, although they are not fundamental structures, relations, or entities in the Humean mosaic. In this sense, physical symmetries may exist as constraints as constraints, but not as fundamental, primitive structures in the Humean mosaic. Toby Friend (2024), in turn, has argued that symmetries are not merely meta-laws, but have something to do with the world's structure, in particular, with the world-making relations —they are grounded in the space-time structure, therefore, revealing fundamental aspects of it. I then take this view as implying that symmetries supervene upon the Humean mosaic, qualifying as a realist view of symmetries.

It is important to note that **SR** can employ against **SDis** the same argument that scientific realists employ against instrumentalist views. Indeed, if symmetries are in some sense real, then **SDis** is not a viable option. Of course, **SDis** of any sort can argue that empirical success is not enough for truth; or, in other words, that empirical success is not a good guide to metaphysics. The dialectic can then be viewed like the following. **SDis** regards that symmetry claims appearing in the symmetry facts are dispensable. The challenge is then to explain *why* they are there despite being dispensable. I think that there are ways to do this, as I have shown before. Yet, some could claim that this is not enough, that it is still mysterious why symmetry claims have been so (empirically) successful in physics. This prima facie suggests some form of **SR** that makes sense of symmetry claims in virtue of their reference to something physical out there. Nonetheless, empirical adequacy might not be the best guide to ontology. In addition, indispensability doesn't necessarily imply realism, as I will argue later.

More popular is the view that physical symmetries *are* fundamental. This is what I call here *Symmetry Fundamentalism* (**SF**), which takes **SR**'s arguments a step forward. There seems to be an additional step from the Quine-Putnam Indispensability Argument to the claim that symmetries are therefore metaphysically fundamental. The Quine-Putnam Indispensability Argument introduces symmetries into the ontology, but it doesn't say anything about the role they play in the ontology. It could then be argued, following Armstrong, that we might be ontologically committed to symmetries, but they are an 'ontological free-lunch'; that is, they are derivative structure, relations, or entities that are "no addition to being". Therefore, they might well be dispensable when determining the *fundamental* ontology (see Armstrong, 1997; and Schaffer, 2009, for a general argument in the same line). To put it differently, while the Quine-Putnam Indispensability argument deals with existence questions (what there is), the metaphysically important question is not about existence but about modes of existence (i.e., as fundamental or derivative). After all, if some theoretical posits are introduced in one's ontology as an ontological free lunch, then one's ontology is no less sparse for containing them than it is for containing the entities which ground them.

SF avoids this by promoting symmetries to the fundamental ontology, both for scientific and philosophical reasons. When the **symmetry fact** is closely examined, symmetries do not merely 'appear' in our physical theories, but they also play a (theoretical) grounding role –for instance, a theory's dynamics is seen as relying on symmetry statements; symmetries are said to 'dictate' the fundamental interactions or, even, the kind of particle that intervene. So, it is very plausible to read this symmetry-way-of-talking as representing an ontological relation. In the theory, symmetry facts ground, for instance, nomological facts or property facts (e.g., facts about elementary particle masses or energies). On this basis, there is also an ontological relation that places symmetries as fundamental, and the rest as derivative (see McKenzie 2014 for a similar argument).

One way to understand **SF** is then that it justifies **SInd** on a metaphysical basis —symmetries are indispensable because they are (or directly represent) aspects of the fundamental ontology. **SF** can then be viewed as **SInd** plus a strong realist attitude towards symmetries and their promotion as part of the fundamental ontology. It then goes beyond empirical adequacy. Symmetries are thus not only part of the ontology in general, but they are entities, properties, structures, or relations of the building blocks of the physical world, upon which the derivative ontology supervenes

SF Putative references to symmetries appearing in the **symmetry fact** refer to entities, properties, or relations of the world's fundamental ontology.

Some advocates of **SF** are Steven Weinberg (1987, 1993), Abdus Salam (1989), Richard Feynman (1987), and Werner Heisenberg (1975) on the physicists' camp. On the philosophers' camp, Steven French (2014) and David Schroeren (2020, 2021) have endorsed **SF**, though on different grounds. As an example, this view has been explicitly defended by, for instance, David Schroeren (2021). Within wave-function monism, state-space symmetries (i.e., automorphisms) are established as fundamental relations that correspond to automorphisms in the (fundamental) ontology. In this sense, then, **SF** amounts to two claims: (a) state-space symmetries correspond to fundamental aspects (relations) of physical reality and (b) particles and fields are ontologically derivative from these fundamental aspects.

The natural advantage of **SF** is that it does justice to the exceptional role of symmetry claims in physics over the last decades. The **symmetry fact** just reflects how physics has discovered what's fundamental. The natural criticism of **SF** is that it overloads the fundamental ontology by adding symmetries as fundamental (i.e., primitives). Of course, any ontology has to decide which entities, properties, relations, and structures are primitive and which ones are derivative. It can therefore be argued that it is not necessary to regard symmetries as fundamental (i.e., primitives) since they can be reduced to something else. It can also be argued that **SF** implies a series of ontological commitments that are too onerous, such as being realist about idealizations and laws of *nature* (see López, 2025).

6. Symmetry Inferentialism: an intermediate position

I have said that **SInd** does not per se force us to adopt a realist attitude towards symmetries. The challenge for any anti-realist position is to show, first, why physical theories have been so successful without making symmetries look like a miracle; and second, in which way physical theories may take symmetries claims as indispensable, without adopting ontological commitments to them. I think that *Symmetry Epistemicism* (**SE**) and *Symmetry Normativism* (**SN**) are two possible metaphysical views that are successful in this respect. But a third, intermediate variation of **SInd** can also be identified. One can embrace **SInd** but resist placing symmetries in the ontology (either derivative or fundamental). Yet, symmetries are not absolutely disconnected from the fundamental ontology, since they serve as "indicators" of it. This view, *Symmetry Inferentialism* (**SI**), can be defined as follows:

SI Putative references to symmetries appearing in the **symmetry fact** do not refer to aspects of reality but allow us to *infer* aspects of it.

According to **SI**, propositions referring to symmetries enter as premises into symmetry-based arguments (see, for instance, Shamik Dasgupta's version of the 'symmetry-to-reality inference', Dasgupta, 2016; also, North, 2009, 2021) to draw metaphysical lessons about the world. Then, symmetries are indispensable but not as theoretical posits that latch onto the world, but as theoretical, heuristic tools for probing what is fundamental. Jill North (2021) seems to adopt **SI**:

> There is a reason for formulating things in terms of structure rather than symmetries, though. Structure is what we are ultimately after (both mathematical structure in the formalism and physical structure in the world), and symmetries are simply an (important) guide to that structure. As mentioned in Chapter 2, symmetries are an indicator of structure, not the structure itself. More importantly, there can be more to the requisite structure than what seems to be indicated by dynamical symmetries. (North, 2021, p. 73)

Just to provide some further examples, Eddy K. Chen's nominalization of non-relativistic quantum mechanics also relies on symmetries as a guide to what is fundamental (Chen, 2019, PhD Dissertation, Ch. 1), from which his quantum state realism derives. Paul Horwich's formulation of the problem of the arrow of time accords with **SI**: since time-reversal invariance is a nomological property, it allows us *to infer* the isotropy of time itself (Horwich, 1987, p. 41). Finally, it has been repeatedly claimed that permutation invariance in quantum theories *entails* that quantum systems are non-individuals (Post, 1963; Fortín and Lombardi, 2021). Therefore, from permutation invariance, we can infer a relevant feature of the world's fundamental ontology —it does not comprehend individuals.

Three comments are in order. First, **SI** might also be regarded as construing symmetries epistemically, and that's why I place it as an intermediate position between realist and epistemic views. As I mentioned before, 'epistemic' usually refers to conditions regarding observational indistinguishability (such as observability, measurability, detectability, etc.). This is one of the senses of 'epistemic' that, for instance, Shamik Dasgupta refers to when assessing symmetries in the context of symmetry-to-reality inferences (Dasgupta, 2016, p. 871). In the same line, James Read and Thomas Møller-Nielsen (2020) defend an epistemic view of symmetry transformations, according to which epistemic symmetries "render the general notion of a symmetry transformation redundant as a tool for metaphysical theorizing about scientific theories" (2020, p. 97). Even though they don't directly concern the metaphysical problem of symmetries, their epistemic approach seems to be at odds with, for instance, **SR**, **SF** and **SI**. This would suggest a metaphysically epistemic view of symmetries, but it is not clear of which sort exactly (for alternative epistemic approaches to symmetries in this sense, see Ismael and van Fraassen, 2003, and Caulton, 2015).

Second, that **SI** is an instance of **SInd** can also be disputed. In Section 3, I have referred to the distinction between interpretational and motivational approaches to symmetries. While the interpretational approach can endorse **SI** and **SInd** since symmetries guide our interpretation of theories as *solely* committed to the existence of invariant quantities, the motivational approach would probably endorse **SI** but under **SDis**. Nonetheless, interpretational and motivational approaches to symmetries are insufficient to deliver a clear metaphysics of symmetries —they are mainly concerned with the role that symmetry transformations play in interpreting physical theories rather than with the task of placing symmetries in one's ontology.

Finally, it has been argued that **SI** is not a good guide to metaphysics since symmetries only appear in highly idealized models and are stipulated in theory construction and modelling for theoretical- and pragmatic-driven reasons (see López, 2023). This criticism goes along with Read and Møller-Nielsen's view of symmetries as epistemic, although the emphasis is placed on the conditions under which symmetries are obtained rather than on the interpretation of symmetry transformations.

7. *Symmetry Indispensabilism: Epistemic-Deflationist Views*

In the previous section, I have said that in the literature on symmetries, 'epistemic' usually refers to the conditions regarding indistinguishability between symmetry-related models or to the role of symmetries in the invariance principle. However, there is a different sense in which symmetries can be regarded as epistemic, closely related to the metaphysical problem of symmetries. This sense treats symmetries as 'epistemic' in the sense of not being part of one's physical ontology, but "general conditions of physical knowledge" or "epistemic constraints." Vassilios Livanios, when contrasting 'ontic' and 'epistemic' approaches, says:

> Philosophers, who try to explain the success of symmetry considerations in science, have followed two different approaches. According to one of them (the epistemic viewpoint), the presence of symmetries in physical theories is related to general conditions of physical knowledge or to some limits inherent in our way of describing the physical world. According to the other (the ontological viewpoint), symmetries are real aspects of the world, usually taken to be properties of the world (or of its structure) or second order laws concerning the form of physical first order laws. (Livanios, 2010, p. 296)

Livanios is not here referring to conditions of observational indistinguishability. Nor is he referring to the role that symmetries play in the invariance principle. He is rather referring to symmetries more generally, replying to the metaphysics-oriented question of what *they are.* When I refer to symmetries as 'epistemic', I will do it in this sense.

I have affirmed that **SInd** does *not* necessarily entail a connection between the **symmetry fact** and what the world is like. This is so because I see a distinction between *epistemic* and *ontological* indispensability. Some theoretical posits can be indispensable to, for instance, systematizing and providing unity to a theory, but it does not mean that we must then be ontologically committed to them. For instance, in classical electromagnetism the electric potential is indispensable to formulate and solve Maxwell's equation, but it doesn't seem to be *therefore ontologically* indispensable (See Maudlin, 2018, for discussion)[6] Rigid bodies are equally indispensable in classical mechanics to formulate the kinematics and dynamics, but they don't *therefore* seem to be *ontologically* indispensable.

The distinction between epistemic and ontological indispensability, hence seems valuable and important. Kerry McKenzie runs a similar distinction between being "fundamental to the fabric of the world" and "fundamental in methodological respects" (McKenzie, 2014, p. 1091). According to her, when symmetries are said to have a relation of ontological dependence between them and, say, elementary particles, they are ontologically fundamental; when symmetries are said to be fundamental as heuristic device for theory construction (as in the case of the prediction and the detection of the Higgs boson), they are methodologically fundamental. Be that as it may, as was mentioned before, the word 'fundamental' has been extensively used by metaphysicians to refer to those entities, properties, structures, or relations on which everything depends, already bearing a strong realist commitment. To avoid confusion, I draw a similar distinction but in terms of indispensability. In my case, ontological indispensability refers to the fact that symmetries enter physical theories because, without them, they will miss relevant descriptions of what the world is physically like, either fundamentally (as in **SF**) or derivatively (as in **SR**).

The distinction is also useful because it allows overcoming No-Miracle-type arguments, avoiding realism (**SR**, more specifically). The empirical success of symmetries in physics can be granted, favoring their indispensability. But real-

[6] Maudlin discusses how the different formulations of the basic structure of a physical theory (in this case, classical electromagnetism) entails that the posits of the theory can be either derivative or fundamental. For instance, when the theory is cast into the language of fiber bundles, the fields are derivative, contrary to the canonical formulation. Although Maudlin's point is to show the need of ontological clarity to avoid conceptual problems, the message to drive home here is the following —theories don't per se imply an ontology as indispensable since what it looks indispensable for the canonical formulation might not be so in alternative formulations.

ism needs an additional step *if* indispensability can be made sense of in purely epistemic terms. **SInd** can thus branch out further, opening an entire family of philosophical positions towards symmetries that do regard them as indispensable, but as *epistemically* indispensable. This reveals two remarkable aspects. First, **SInd** is compatible with epistemic-normative interpretations of the **symmetry fact**. Second, some philosophical frameworks seem to embrace **SInd** but are reluctant to adopt **SR**, **SF,** or **SI**, but without making symmetries look like a miracle. In this light, these deflationary-epistemic views claim that putative references to symmetries appearing in the **symmetry fact** do not refer to aspects of reality but have an epistemic justification in terms of giving some "systematic epistemic gain" for physical theories (e.g., by making physical theories simpler).

One of these views is what I call *Symmetry Epistemicism* (**SE**). According to it, symmetries play an epistemic-heuristic role in physics theorizing or modelling that is crucial for physics. They can, for instance, serve to an ideal of optimization between simplicity and explanatory power. An easy example is the unification they confer —instead of formulating different laws for different directions in space, it is more economical (epistemically speaking) to formulate a rotation-invariant law (see Rosen, 2018). Under this perspective, it can be argued that it is not enough to formulate empirically adequate lawlike generalizations about phenomena. It is also highly convenient to formulate them most simply without losing explanatory power; and positing symmetries as epistemic-heuristic constraints can play that role.

Although I have before associated Humeanism with **SR** (but not with **SF**), I think that **SE** can also be viewed as compatible with Humeanism, but emphasizing the epistemic nature of symmetries. In this case, Humeans could rather highlight symmetry claims' epistemic-heuristic nature: symmetries are primarily grounded in the formal relations defined over generalizations about the facts of the Humean Mosaic. Or, even stronger, they play a crucial role in the systematization and unification of the true generalizations within the best system. In this line, symmetries are precisely the kind of theoretical resources that allow the best systems to substantially boost their simplicity and informativeness. Symmetries are therefore epistemically indispensable in scientific knowledge since they confer upon the best systems a substantial gain in simplicity and informativeness in simplicity and informativeness; to the same extent to which our knowledge of the natural world benefits from building generalizations about phenomena, it benefits from imposing symmetries upon how such generalizations must be formulated. To what extent are so-construed symmetries *indispensable*? To the extent that physicists *must* strive to formulate better physical theories, in the sense of the simplest and most informative ones. Or, to put it differently, if physical theories are interpreted as best systems, what makes best systems *best* is their epistemic virtues in terms of simplicity, unification, economy of thought, etc. In that sense, it is indispensable for physical theories to include symmetries since, otherwise, they would not really be the *best* systems (see López and Esfeld, 2023, for an argument in the same line).

SE Putative references to symmetries appearing in the **symmetry fact** do not refer to aspects of reality but have an epistemic justification in terms of the optimal systematization of the first-order generalizations that supervene upon regularities. This optimal systematization is crucial to balance simplicity and informativeness.

Metaphysical frameworks that can easily adopt **SE** are Humean Structuralism (Lyre 2010), Super-Humeanism (Esfeld, 2015), or David Albert and Barry Loewer's *Mentaculus* (Loewer, 2012; Albert, 2015). A similar view has been defended by López and Esfeld (2023) in relation to time-reversal symmetry, although their views can be interpreted as a mixing of **SR** and **SE**. In all of them, symmetries might be regarded as real insofar as they supervene on the Humean Mosaic, but they are also an "ontological free-lunch". Therefore, their indispensability does not derive from their being somehow real. Contrarily, symmetries are then primarily assessed in terms of their epistemic contribution to the construction of physical theories, from which their indispensability does derive. For the case of time-reversal symmetry, López and Esfeld argue that the reason for having time-reversal symmetry in our physical theories is not because the Humean mosaic is temporally directionless, but because it makes the formulation of first-order generalizations simpler: the laws of the theory do not depend on the direction of time, gaining modal scope.

Finally, I would like to introduce a philosophical position that goes farther than **SE** but can still be viewed as epistemic. It also makes **the symmetry fact** completely natural and even necessary, avoiding any form of realism. In fact, the view is not new, though it has lost its luster over the last decades. It can be traced back to early works on symmetries by David Hilbert (1921), Eugene Wigner (1949, 1963) and Hermann Weyl (1952), to the neo-Kantian philosophy of Ernst Cassirer (1923 [1910], 1954 [1936]), and to John Nozick's insights than symmetries are closely connected with the notion of objectivity (Nozick, 2001; for some antecedents, see Dirac, 1947 [1930] and Weyl, 1952). This view accepts that all (or most of) our symmetry claims are indispensable for modern physics, but because they play a *normative* role in making physics (both as a discipline and as an object for such discipline) possible by underpinning the notion of physical objectivity. I call this view *Symmetry Normativism* (**SN**).

SN rather turns to a *critical* understanding of objectivity as the necessary unity of knowledge (in the Kantian sense). Neo-Kantians have exhaustively worked on the notion of objectivity and distinguish two types of theories: the copy (or substance) theory and the critical (or functional) theory (Cassirer, 1923, p. 321-323). According to the former, the primitive concept is that of 'object' (or 'structure'); truth is explained in terms of *adequatio*: a proposition is true iff it mirrors the properties of the object or the structure. According to the critical theory, the copy theory overlooks the epistemic preconditions for having objects (in this case, physical, scientific objects). In this theory, the right question to raise is not what physical objects are like, but what makes them possible. The notion of objectivity, hence, must be understood transcendentally —what are the conditions of possibility for physics theorizing and for empirical research to be about physical objects at all (Cassirer, 1923; Heis 2014).

Which role does the **symmetry fact** play as a result? **SN** holds, first and foremost, that propositions involving symmetry statements are a priori *norms* that are the transcendental conditions of objectivity in modern physics. **SN** regards laws and experimental results as facts of modern physics, which are possible in virtue of some preconditions that cement their objectivity, where the references to symmetries in the **symmetry fact** play a crucial role. What are they crucial for? Eugene Wigner has shed light on this in relating symmetries to the necessary invariance of initial conditions, and the very notion of lawhood (Wigner, 1963). Similar views can be found in David Hilbert (see Ryckman, 2008) and his idea of "des-anthropomorphization" of physics through invariances.

SN Putative references to symmetries appearing in the **symmetry fact** do not refer to aspects of reality but refer to transcendental structures (in the normative-Kantian sense) within which physical objects are possible. For physics (both in the sense of knowledge about physical objects and of the possibility of physical objects themselves) to be possible at all, symmetries are required to give the necessary unity, systematicity and permanency that physical objectivity requires.

It is hard to show that *all* symmetries play a normative role in this specific sense. But think of space-time symmetries in classical mechanics as a clearer example. Nozick thought that one of the conditions for physical objectivity was the invariance of a presumed object under various transformations (Nozick, 2001, p. 78). Objectivity, he says, means that some features are independent from the angle from which we see them. In physics, this matches well with various space-time transformations. It can therefore be argued that objects (or quantities) that remain invariant under space-time transformation are physically objective as they do not depend on the reference frame from which they are described. Then, symmetries would play the role of establishing what is objective within a physical theory: those quantities and objects that are invariant under spatial rotation, spatial translation, time translation, time reversal, boosts, etc. Nozick's view per se is closer to **SR** or **SI**, but on this basis, it can be further argued that the objectivity that symmetries confer is not found in nature but imposed by us. In other words, such invariances are not out there in the world and represented in our physical theories, but normatively imposed by us in order to have objective, physical knowledge.

It is important to stress the scope and limits of **SN** (and also of **SE**). First, **SN** can explain the indispensability of symmetries without appealing to realism: symmetries are necessary as epistemic preconditions for having knowledge of physical objects, so the **symmetry fact** comes out as a natural requirement for physics. Second, when saying that

https://doi.org/10.1387/theoria.27141

physical symmetries are epistemically indispensable, it is not meant that knowledge in general indispensably requires symmetry claims. We can very well obtain valuable knowledge of the world without even acknowledging the existence of the **symmetry fact**. The claim circumscribes itself to knowledge that is obtained from physics. That is, the knowledge that physics provides us indispensably requires symmetry claims, but other forms of knowledge do not necessarily. **SN**, for instance, sets the conditions for having *physical* objects (that is, objects as known by physics), not objects in general.

8. Conclusions

In recent years, the problem of accommodating symmetries in one's ontology has drawn the attention of many philosophers of physics and metaphysicians. In general, it has been customary to distinguish between realist and anti-realist views. Although this distinction is useful, it is perhaps not sufficient to capture all the possible metaphysical attitudes that can be adopted towards symmetries. In this article, I have laid out alternative views that configure a map of the metaphysical attitudes towards physical symmetries. Although not aiming for completeness, it goes beyond the realist *vs.* anti-realist opposition, highlighting the subtleties of similar, but different views, and paving the way for yet unexplored views:

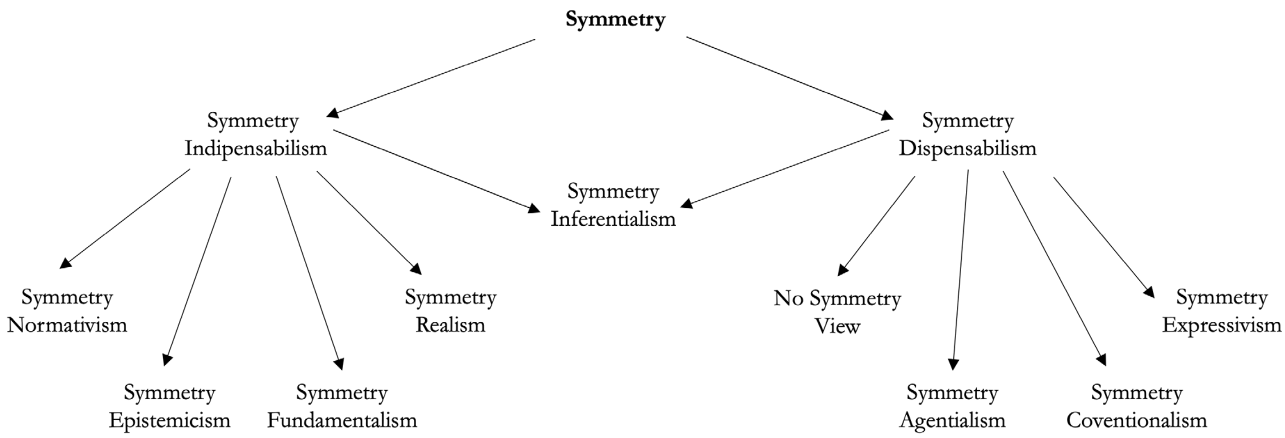

Figure 1

A coarse-grained map of possible metaphysical attitudes towards symmetries.
Dotted arrows represent possible connections

Acknowledgments

I am grateful to Olimpia Lombardi, Michael Esfeld, Alexander Guay, the *Buenos Aires Group of Philosophy of Particular Sciences*, and the *Buenos Aires Group of Metaphysics of Science* for comments and discussion on earlier versions of this article. Some sections of this article have been presented at EPSA 2021, Foundations of Physics 2021, and the BSPS 2022 conference, so my thanks to their audiences for valuable comments. I also grateful to two anonymous reviewers for their valuable feedback, comments, and suggestions. This research was supported by the Swiss National Science Foundation (SNSF, grant no. 105212B_200464), by the Université de Lausanne, and by the National Scientific and Technical Research Council of Argentina (CONICET).

REFERENCES

Albert, D. (2015). *After Physics*. Hardvard University Press.

Armstrong, D. M. (1997). *A World of States-of-Affairs*. Cambridge University Press.

Ayer, A. (1936/1974). *Language, Truth and Logic*. Penguin.

Baker, D. (2010). Symmetry and the metaphysics of physics. *Philosophy Compass* 5, 1157-1166.

Ballentine, L. (1998). *Quantum Mechanics. A modern development*. World Scientific

Belot, G. (2013). Symmetry and equivalence. In R. Batterman (ed.). *The Oxford Handbook of Philosophy of Physics* (pp. XXX), Oxford University Press.

Bird, A. (2007). *Nature's metaphysics.* Oxford University Press.

Brading, K. and E. Castellani. (2007). "Symmetries and Invariances in Classical Physics". In J. Butterfield and J. Earman (eds.). *Handbook of the Philosophy of Science, Philosophy of Physics, Part B* (pp. 1331-1367). Elsevier.

Cartwright, N. (1983). *How the laws of physics lie*. Clarendon Press.

Cassirer, E. (1923). *Substance and Function*. Open Court. [1910]

Cassirer, E. (1954). *Determinism and indeterminism in modern physics*. Yale University Press [1936]

Caulton, A. (2015). The role of symmetry in the interpretation of physical theories. *Studies in History and Philosophy of Modern Physics*, 52, 153-162.

Dasgupta, S. (2016). Symmetry as an epistemic notion (twice over). *British Journal for Philosophy of Science*, 67, 837-878.

Dirac, P. (1947). *The principles of quantum mechanics*. Oxford University Press. [1930]

Earman, J. (1989). *World enough and space-time. Absolute versus relational theories of space-time*. MIT Press.

Esfeld, M. (2015). Quantum Humeanism, or: physicalism without properties. *Philosophical Quarterly*, 64 (256), 453-470.

Feynman, R., and Weinberg, S. (1987). *Elementary Particles and the Laws of Physics: the 1986 Dirac Memorial Lectures*. Cambridge University Press.

French, S. (2014). *The structure of the world.* Oxford University Press.

Friend, T. (2024). How to be Humean about symmetries. *British Journal for the Philosophy of Science*. Forthcoming.

Guay, A. (2008). A partial elucidation of the gauge principle. *Studies in History and Philosophy of Modern Physics*, 39, 346-363.

Hall, G. and Murgueitio Ramírez, S. (2024). Symmetries and Representation. *Philosophy Compass*, https://doi.org/10.1111/phc3.12971

Heis, J. (2014). Realism, functions and the a priori: Ernst Cassirer's philosophy of science. *Studies in History and Philosophy of Science*, 48, 10-19.

Hicks, M. (2019). What everyone should say about symmetries (and how Humeans get to say it). *Philosophy of Science,* 86, 1284-1294.

Heisenberg, W (1975). Development of concepts in the history of quantum theory. *American Journal of Physics,* 43, 389:394

Horwich, P. (1987). *Asymmetries in time*. MIT Press.

Hossenfelder, S. (2018). *Lost in math*. Basic Books

Hunt, J. (2024). Expressivism about explanatory relevance. *Philosophical Studies*, 181, 2063-2089.

Ismael, J. (2014). Naturalism on the Sydney Plan. in M. Haug (ed.). *The Armchair or the Laboratory?* (pp. 86-103), Routledge.

Ismael, J. and van Fraassen, B. (2003). Symmetry as a guide to superfluous theoretical structure. In E. Brading and E. Castellani (eds), *Symmetries in Physics: Philosophical Reflections* (pp. 371-392), Cambridge University Press.

Livanios, V. (2010). Symmetries, dispositions and essences. *Philosophical Studies*, 148, 295-305.

Loewer, B (2012). Two accounts of laws and time. *Philosophical Studies,* 160, 115-137.

López, C. (2021). The philosophy and physics of time reversal in standard quantum mechanics. *Synthese*, 199, 14267-14292.

López, C. (2023). Should physical symmetries guide metaphysics? Two reasons why they should maybe not. *European Journal for the Philosophy of Science,* 13, 23

López, C. (2025). Against Symmetry Fundamentalism. *Erkenntnis*, vol. 90, 1821-1845.

López, C. and Esfeld, M. (2023). Humean Time Reversal. *Synthese,* 202, 31

Luc, J. (2022). Motivationalism vs. interpretationalism about symmetries: some options overlooked in the debate about the relationship between symmetries and physical equivalence. *European Journal for Philosophy of Science*, 13, 40.

Lyre, H. (2010). Humean Perspectives on Structural Realism. In F. Stadler (ed.). *The Present Situation in the Philosophy of Science* (pp. 381-97), Springer.

Martin, C. (2002). Gauge principle, gauge arguments and the logic of nature. *Philosophy of Science,* **69**, S221-234.

Maudlin, T. (2018). Ontological clarity via canonical presentation: Electromagnetism and the Aharanov-Bohm effect. *Entropy*, 20(6), 465.

McKenzie, K. (2014). On the fundamentality of symmetries. *Philosophy of Science,* 81, 1090-1102.

Møller-Nielsen, T. (2018). Invariance, interpretation and motivation. *Philosophy of Science*, 84, 1253-1264.

North, J. (2009). The structure of Physical theories. *Journal of Philosophy*, 106, 57-88.

North, J. (2021). *Physics, structure, and reality*. Oxford University Press.

Nozick, R. (2001). *Invariances: the structure of the objective world*. Harvard University Press.

Post, H., (1963). Individuality and Physics. *The Listener*, 70, 534–537.

Price, H. (2011). *Naturalism without mirrors*. Oxford University Press.

Read, J. and Møller-Nielsen, T. (2020). Redundant epistemic symmetries. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics*, vol. 70, 88-97.

Redhead, M. (1975). Symmetry in intertheory relations. *Synthese,* 32, v. 1/2, 77-112.

Ryckman, T. (2008). Invariance Principles as regulative ideals: from Wigner to Hilbert. *Royal Institute of Philosophy Supplement*, 63, 63-80.

Salam, A. (1989). Gauge Unification of Fundamental Forces. *Nobel lecture* on December 8, 1979.

Schaffer, J. (2009). On what grounds what. In D. Chalmers, D. Manley and R. Wasserman (eds.). *Metametaphysics* (pp. 347-383), Oxford University Press.

Schroeren, D. (2020). Symmetry fundamentalism: a case study from classical physics. *Philosophical Quarterly*, 71 (2), 308-333.

Schroeren, D. (2021). Symmetry fundamentalism in quantum mechanics. *Philosophical Studies*, 178, 3995-4024.

Sinclair, N. (2009). Recent Work in Expressivism. *Analysis* 69 (1), 136-47.

Weinberg, S. (1987). Towards the Final Laws of Physics. In R. Mackenzie and P. Durst (eds), *Elementary particles and the laws of physics – The 1986 Dirac Memorial Lectures* (pp. 61–110) Cambridge University Press.

Weinberg, S. (1993). *Dreams of a final theory*. Vintage.

Weyl, H. (1952) Symmetry. Princeton: Princeton University Press; extract in E. Brading and E. Castellani (eds), *Symmetries in Physics: Philosophical Reflections* (pp. 21-22.) Cambridge University Press, 2010.

Wigner, E. (1949). Invariance in physical theory. *Proceedings of the American Philosophical Society*, 93 (7), 521-526.

Wigner, E. (1963). Events, laws of nature, and invariance principles. *Nobel Lecture*, December 12.

Cristian López is a SNF Senior Researcher at the University of Lausanne (Switzerland) and a CONICET Associate Researcher at the University of Buenos Aires (Argentina). His areas of specialization are the philosophy of physics, the philosophy of time, the metaphysics of science. He has also worked on the philosophy of economics and the political philosophy.

Address: University of Lausanne, Anthropole, Section de Philosophie, Of. 5155, CH-1015, Switzerland. E-mail: cristian.lopez@unil.ch – ORCID: 0000-0002-2883-4037