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MODERATE ONTIC STRUCTURAL REALISM ABOUT THE NATURE OF SPACETIME: MONISTIC AND DUALISTIC APPROACHES*

INTRODUCTION

In this paper I examine spacetime structural realism, where the meaning of the term "spacetime" is understood as it is presented in general relativity (GR) in its standard tensorial formulation (see GREAVES 2011). I focus on *moderate ontic structural realism* (MOSR) (ESFELD and LAM 2008, 2011; LAM and ESFELD 2012), a variant of ontic structural realism (OSR), and in particular on its metaphysical implications for spacetime. Roughly, MOSR holds that metaphysical interpretations of GR should treat objects (properly understood as spacetime points) and relations (metrical, physically meaningful ones) as ontologically on a par. MOSR is usually classified as a form of substantivalism, since it takes spacetime relations to be irreducible to properties of material objects or fields.

There are two versions of MOSR. The first, which I call MOSR1, adopts the outlook just described. It has been critiqued by Christian Wüthrich (2011), who argues that MOSR1 leads to the absurd conclusion that there is only one spacetime point. The other version, MOSR2, offers a response to Wüthrich's critique, but at a possibly undesirable metaphysical cost. The key difference between MOSR1 and MOSR2 relates to the way objects and relations figure in the ontology of spacetime. In MOSR1, objects and relations are treated as

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ontologically distinct, though fundamentally interdependent. In MOSR2, this distinction is taken to be merely conceptual: spacetime consists solely of objects with relational modes of being. MOSR2 is explicitly inspired by Spinozian monism, although Esfeld and Lam do not claim that there is only one substance. Rather, their monism about spacetime amounts to the view that, while there is a plurality of fundamental objects (spacetime points), all are of a single ontological type—objects without intrinsic identities whose mode of being is relational. In this sense, MOSR2 is monistic about spacetime, whereas MOSR1 is dualistic, since it posits objects and relations as two distinct ontological categories in describing spacetime in GR. Other senses of "monism" and "dualism" that are relevant to spacetime philosophy and discussions presented in this paper will be discussed in section 1.1.

MOSR1 must confront Wüthrich's critique. I will call this critique the Wüthrich problem, which boils down to the following question: how to account for the plurality of spacetime points while maintaining the ontological robustness of relations? I introduce an additional difficulty, inspired by Meyer (2025). Drawing on Kerry McKenzie's (2024) discussion in the context of quantum field theory, one can argue that structuralist interpretations of fundamental physics rely too heavily on loose characterizations of structures as ontological entities. This vagueness motivates, according to McKenzie, the view that OSR does not constitute a substantive metaphysical thesis, but rather an interpretative stance or methodological framework for doing metaphysics in mathematically formulated physics (a similar idea can be found in GLICK 2020). I will call this the McKenzie problem. As I argue, MOSR1 is susceptible to the McKenzie problem and so is MOSR2. The issue matters not only for assessing the metaphilosophical status of MOSR, but also for clarifying its place within the substantivalism–relationalism debate in spacetime philosophy. In particular, it raises the question of whether MOSR is genuinely distinct from existing substantivalist positions, or merely a way of reformulating them. Finally, I argue that MOSR2 faces yet another problem. Because relations in MOSR2 are not treated as something ontologically robust, it is unclear whether MOSR2 still qualifies as a genuinely structuralist ontology. This worry, raised by Meyer (2025), will be referred to as the Meyer problem.

In this paper I argue for a version of MOSR concerning primarily the *nature of spacetime as such*, while departing from MOSR1. I present MOSR1 in sections 1.1 and 1.2. Since I emphasize the dualism of the objects–relations distinction—against the monistic aspects of MOSR2, discussed in detail in section 2.1—I call my view D-MOSR. I presuppose realism about spacetime in

GR and argue that D-MOSR, developed in detail in section 2.2, is a form of substantivalism. In section 1.1 I characterize spacetime substantivalism. I claim that an adequate account of the nature of spacetime requires reference to two kinds of entities—objects and relations—and that these are ontologically on a par. In this sense, my view is dualistic. I hold that whenever a spacetime obtains, then there necessarily exists a numerical plurality of spacetime manifold points as objects without fixed intrinsic identities, and there necessarily exists a spacetime metric; and conversely. I do not claim that spacetime relations individuate spacetime points. Rather, I interpret spacetime relations as concrete, physical relations encoded by a metric field, standardly obtained by solving the Einstein field equations in GR.

In section 1.3 I reconstruct the Wüthrich problem. In section 2.3 I explain how MOSR2 addresses it and argue that D-MOSR provides a superior response. In section 1.4 I present the McKenzie problem for MOSR1; in section 2.4 I discuss the McKenzie problem for MOSR2 and show how D-MOSR avoids it. Finally, in section 2.5 I examine the Meyer problem and argue that it does not arise for D-MOSR.

1. MODERATE ONTIC STRUCTURAL REALISM ABOUT GENERAL RELATIVITY: CHARACTERISTICS AND PROBLEMS

There are two versions of MOSR, as formulated by its main proponents,[1] Michael Esfeld and Vincent Lam. The first version (ESFELD and LAM 2008), MOSR1, contains two main theses:

[1] This fact is largely omitted or barely addressed in the literature. To illustrate this, let us assume that the three texts mentioned above and co-authored by Esfeld and Lam are "canonical" when it comes to formulations of MOSR. Let us further assume that referring the complete set of those texts in an article/book/chapter comprises a property of texts of being maximally MOSR-referential. A Scopus search reveals that when one browses references found in articles, books, and chapters indexed in this database and the search phrases are titles of all three Esfeld's and Lam's texts joined by the AND operator (so the search is for texts with maximal MOSR-references), then the number of hits is only seven (the exclusion criteria being self-citations, counted if at least one author was either Esfeld or Lam and no further inclusion criteria were specified). In five of them (VOOSHOLZ 2025; MEYER 2025; BENI 2019; BENI and NORTHOFF 2021; JIANG 2024), the differences between versions of MOSR are unacknowledged even when the texts are maximally MOSR-referential. In the remaining two papers (BERGHOFER 2018; ALLORI 2022) the differences between versions of MOSR are recognized, but only in passing (ALLORI 2022, 147) or in a small section mentioning the potential shortcomings of the second version of MOSR in the context of quantum field theory (BERGHOFER 2018, 183). If this inquiry is accepted, then a claim that identification of

MOSR1	(1) There are no intrinsic properties of objects. (2) Objects and relations are *both* ontologically fundamental, none of them is ontologically primary.

These theses are formulated against the backdrop of OSR, which posits that in the ontology of the world's fundamental level (described by quantum mechanics, QM, or general relativity, GR) the category of objects should be eliminated, and the category of objectless structure should be viewed as the correct ontological commitment if one is willing to be a realist regarding fundamental physical theories, especially QM.[2] The first main thesis of MOSR comes from accepting the result of an impactful critique of OSR—that it is impossible to have relations without relata (see footnote 4). Objects are ineliminable from fundamental ontology, but they cannot be viewed in analogy to objects of everyday experience: physics provides resources (the crucial role of symmetry groups in fundamental physics, descriptions of certain physical phenomena like quantum entanglement) strongly suggesting that fundamental objects do not have strict identity conditions, nor determinate intrinsic properties. Yet, those resources do not support the claim that there are no objects whatsoever.

Esfeld and Lam further elaborate on this. The classical view is that relations depend on the existence of objects with intrinsic properties, which Esfeld

different versions of MOSR is underdeveloped in literature is in force. As such, by heavily utilizing the distinction between main versions of MOSR, this paper serves also the (secondary) purpose of systematizing the discourse on MOSR.

[2] OSR, grounded in standard realist intuitions—namely, that the empirical success of fundamental physical theories justifies taking them to be approximately true—comes in two main versions: eliminative (LADYMAN 1998; FRENCH 2014) and reductionist (LADYMAN ET AL. 2007). Eliminative OSR, developed primarily in the philosophy of physics with respect to quantum mechanics (QM), holds that the ontology of fundamental physics should not include (individual) objects. Its central motivation is the metaphysical underdetermination argument (FRENCH 2014, 2025), which draws on concrete features of QM. In outline, the argument shows that (i) quantum particles can be interpreted as either individuals or non-individuals; (ii) both interpretations are equally compatible with fundamental physics; and (iii) given this underdetermination, it is preferable to abandon object-based ontologies altogether and, instead, commit metaphysically to objectless structures, such as symmetry groups (especially permutation invariance) and laws (FRENCH 2014, 33–38). Reductionist OSR, by contrast, does not eliminate objects but claims that objects, properly understood, are reducible to networks of relations conceived as real patterns (LADYMAN ET AL. 2007, 118–22). Eliminative OSR has faced substantial criticism. Objections include the claim that relations conceptually presuppose objects, making the postulate of objectless relations incoherent (BUSCH 2003; PSILLOS 2006), and the charge that treating symmetries and laws as ontologically fundamental amounts to reifying mathematical structures (CAO 2003). The metaphysical underdetermination argument itself has also been challenged, both in general terms (DORATO 2016) and through detailed critiques of eliminativist readings of quantum theory (BIGAJ 2022, 28–33).

and Lam understand as metaphysical "anchors" for identity facts about objects. But since there are no intrinsic properties in fundamental objects, as MOSR-ists claim, relations are supposed to individuate them in the sense of providing identity conditions for such objects in virtue of their place in a relational structure. Hence the second MOSR1 thesis: objects and relations are ontologically on a par: "We get the relata and the relations at once as the internal structure of a whole, neither of them being eliminable or reducible to the other one" (ESFELD and LAM 2008, 34).

1.1 MOSR1 AND THE SUBSTANTIVALISM THESIS

The main debate on the ontological status of spacetime is the debate between substantivalists and relationalists (STACHEL 2014). Esfeld and Lam (2008, 43) explicitly claim that MOSR1 is a kind of substantivalism with respect to spacetime: "Moderate structural realism claims that the space-time structure exists as a mind independent physical network of spatio-temporal relations among spatio-temporal constituents (such as space-time points) that do not possess any intrinsic properties.… Our claim that space-time is purely relational in the sense that there are no fundamental intrinsic properties of the constituents of the ("empty") space-time structure has nothing to do with any kind of relationalism about space-time."

Roughly, the relationist would claim that spacetime relations are reducible to properties of material fields or bodies and do not enjoy the status of a substance. It should be clear from the quote that MOSR1 is not meant as a relationalist position.

At the core of spacetime substantivalism lies the claim that "spacetime is a substance, a thing that exists independently of the processes occurring within spacetime" (NORTON ET. AL. 2023). Schaffer (2009, 132) stresses that the substantivalist core thesis is independent from any further considerations about whether matter is a second type of substance, from particular solutions as to the question about spacetime structure, and from particular conclusions about what counts as the most basic spacetime region (unextended points, mid-sized regions, or whole spacetime). Let us view the main two theses of MOSR1 as its core theses about the nature of spacetime. Here, the interpretation of the nature of GR spacetime is presented in terms of objects without intrinsic identities, metrical relations and the equivalence of the ontological status of such objects and relations. The core theses refer to *two types of entities*—objects (without intrinsic properties) and relations. The latter sense is *dualistic* about the nature if spacetime as such, when no relationships with matter fields are specifically considered.

The further issue is how MOSR1 picture of spacetime fares within the debate about the relationship between spacetime and matter. Here we have other senses of "dualism" and "monism", more common in spacetime philosophy. Esfeld and Lam propose that MOSR1 can be understood either as a type of "Newtonian substantivalism", where spacetime structure is a separate, physical entity existing over and above material bodies/events/processes, or as "Cartesian-Spinozian substantivalism", understood as a claim that "spacetime and matter are ontologically identical and form the same substantival entity" (ESFELD and LAM 2008, 42). Newtonian substantivalism is a dualistic position in the context of the relationship between spacetime and matter. Dualistic substantivalism of this sort admits matter as a second type of substance. Furthermore, "On the dualistic picture, spacetime is the container and material objects are the contained. There is also a fundamental relation of containment which links the container to what it contains" (SCHAFFER 2009, 133). Cartesian-Spinozian substantivalism is a monistic substantivalism. Here, the distinction between the container and the contained is superfluous—it is claimed that fundamental (material) properties are directly "pinned to" spacetime (SCHAFFER 2009, 133). One type of monism is "identity monism", which identifies matter with spacetime regions; in other contexts a similar position is called "supersubstantivalism" (LEHMKUHL 2016).

This discussion allows us to underscore two senses of "dualism" and two senses of "monism" in the context of both MOSR1 and MOSR2:

Context	**Monism**	**Dualism**
The nature of spacetime	Description of the nature of spacetime requires one ontological category (e.g. objects with no intrinsic identities)	Description of the nature of spacetime requires two ontological categories (e.g. objects with no intrinsic identities and metrical relations)
Spacetime–matter relationship	Spacetime and matter are not distinct types of substances	Spacetime and matter are distinct types of substance, connected by containment relations

The distinction between contexts permits two things. First, in the context of the nature of spacetime, it lets us formulate a difference between a typical substantivalist and structuralist spacetime ontology. When the structural realist talks about spacetime as a real entity, she talks about spacetime structure at the same time. In Schaffer's characterization of substantivalism, commitments to views about the structure are secondary. I claim that structural realism (including MOSR and its versions) about spacetime treats such commitments as primary, but this doesn't mean that structural realism about spacetime is not a type of substantivalism. Second, the distinction between contexts systematizes theses a given metaphysical position on spacetime espouses. This is relevant to our argument since Lam and Esfeld explicitly follow the distinction at hand (ESFELD and LAM 2008, 42; LAM and ESFELD 2012, 252) and, as I claim, it is needed to clearly see the McKenzie problem for MOSR1 and MOSR2 (sections 1.4 and 2.4), and to show how D-MOSR avoids this challenge.

1.2 JUSTIFYING MOSR1

The main reason for admitting the first MOSR1 thesis in GR ("There are no intrinsic properties of objects") is the hole argument (EARMAN 1989). In the standard tensor formulation of GR, a general model of spacetime is a pair (M, g) where manifold M is a topological space (a set of points) with certain properties: it is four-dimensional, smooth, connected and Lorentzian. g is the metric tensor (or simply: the metric) which encapsulates all the geometrical (e.g. distance, curvature, volume) and causal (separation of past and future) properties of spacetime. Particular models of spacetime are solutions of the Einstein field equations:

$$R_{ab} - \frac{1}{2} g_{ab} R = 8\pi T_{ab},$$

where R_{ab} is the Ricci curvature tensor, g_{ab} is the metric tensor, R is the Ricci curvature scalar, and T_{ab} is the energy-momentum tensor, representing, roughly, the matter in a model.[3]

[3] For simplicity and because of the paper's metaphysical perspective, I omit the indexes. Since there are solutions of Einstein field equations in which $T_{ab} = 0$, I assume that (M, g) is indeed the most general model of GR spacetime; however, I will refer to the energy-momentum tensor when needed (HAWKING and ELLIS 1973).

The hole argument targets manifold substantivalism, an adaptation of Newtonian substantivalism to GR. On this view, the manifold *M* and its points and regions represent spacetime and its parts, and reference to spacetime models requires ineliminable existential quantification over manifold points (EARMAN 1989, 201). The metric and energy-momentum tensors are defined on *M*, understood as the underlying "canvas". The argument proceeds as follows. Assume spacetime points are primitively individuated, with identities preserved under any diffeomorphic symmetries of *M*. GR is generally covariant (EARMAN and NORTON 1987, 520), and under its active interpretation this allows matter fields to be redistributed over the same set of points (NORTON 1993). Leibniz equivalence is the claim that diffeomorphically related GR models represent the same world with respect to all observable properties encoded in the metric and energy-momentum tensors (STACHEL 2014). Leibniz equivalence, roughly, can be viewed as expressing background independence of GR—the idea that spacetime geometry is not fixed in advance, but is itself a dynamical part of the physical system. Consider a non-trivial hole diffeomorphism *h* generating a region *H*. The resulting models agree everywhere except within *H* in how metric and matter fields are assigned, yet remain observationally indistinguishable. Manifold substantivalists must therefore reject Leibniz equivalence, treating these models as representing distinct states of affairs solely due to undetectable differences in spacetime point identities. This yields an unwanted proliferation of indistinguishable worlds (HOEFER 1996) and threatens determinism even in otherwise deterministic spacetime models. If the hole argument is sound—though this was recently questioned (WEATHERALL 2016; BIGAJ 2023)—then treating manifold points as individuals with fixed identities is untenable, or at least lacks physical significance.[4]

The MOSR1 claim that "objects and relations are ontologically on a par" amounts to the GR proposition that in a spacetime model (*M*, *g*) both are needed to correctly assess the nature of spacetime. Manifold points are indispensable for conceiving spacetime relations encoded by the metric field, while the metric confers physical, structural identity on those points. As Esfeld and Lam stress, without the metric identity cannot be ascribed without reproducing hole-argument problems. Hence, as Esfeld and Lam claim, physical spacetime points are relationally individuated (2008, 36). This yields an ontological dependence between points and metrical relations: "As far as the physical world

[4] For the many responses to the hole argument developed by friends of substantivalism, see BUTTERFIELD (1989), HOEFER and CARTWRIGHT (1993), MAUDLIN (1988, 1993, 2012), BARTELS (1996), HOEFER (1996), and BIGAJ (2023).

is concerned, there is a mutual ontological as well as conceptual dependence between objects and structure (relations): objects can neither exist nor be conceived without relations in which they stand, and relations can neither exist in the physical world nor be conceived as the structure of the physical world without objects that stand in the relations" (ESFELD and LAM 2008, 32). This dependence is therefore symmetrical. No further details are provided by Esfeld and Lam in that regard.

In regard to the thesis discussed, Esfeld and Lam appeal to the ontological robustness of relations. They invoke the Bergmann–Komar pseudo-coordinatization, which "labels" spacetime points *via* four suitable functions of the eigenvalues of the Weyl tensor, itself derived from the metric as the representor of metrical relations (ESFELD and LAM 2008, 38). Through this procedure, the metric provides structural identity conditions for spacetime points, leading Esfeld and Lam to claim that a spacetime point "is the values of the intrinsic degrees of freedom of the gravitational field" (DORATO and PAURI 2006; ESFELD and LAM 2008, 39). Since the Riemann tensor measures deviation from flat geometry, the Bergmann–Komar procedure fails in spacetimes with symmetries rendering the geometry flat, notably cosmological models. In such cases Esfeld and Lam accept numerical plurality of spacetime points as primitive (ESFELD and LAM 2008, 16), denying that this entails primitive identity: numerical plurality concerns only cardinality, not individuation. They conclude that this commitment supports the interdependence of objects and relations, which are given together as the internal structure of a whole, neither reducible to the other. Where no individuating factors beyond numerical distinction exist, MOSR1 opts for primitive plurality rather than primitive thisness (16).

1.3 THE WÜTHRICH PROBLEM

Wüthrich's (2009) "abysmal embarrassment" argument challenges MOSR1 strategy of individuating spacetime points. The problem concerns the nature of spacetime itself. Following Wüthrich's notation, MOSR1 is taken to claim that objects exemplify only intrastructural (relational) properties, understood as properties invariant under automorphisms f: an element a has such a property iff its image $f(a)$ does. A structure (D, R) thus contains only automorphically invariant relational properties R. Applied to a spacetime model (M, g), M is the domain and g is the metric field encoding relational properties of spacetime points preserved under relevant automorphisms. Wüthrich then considers highly symmetric cosmological spacetimes satisfying the cosmological principle, i.e. exact spatial homogeneity and isotropy, where the Bergmann–Komar procedure fails. The paradigmatic case is the Friedman–Lemaître–Robertson–Walker (FLRW) solution.

Such spacetimes admit a unique foliation by spacelike hypersurfaces Σ_t with global cosmological time. Spatial homogeneity means that for any $p, q \in \Sigma_t$ there exists an isometry $f$of (M, g) with $f(p) = q$; isotropy excludes any preferred spatial direction. Consequently, all points on a given Σ_t are metrically equivalent. Wüthrich formalizes this as $\forall F \in B\ (Fp \leftrightarrow Fq)$ for all $p, q \in M$, where B is the set of admissible physical properties with respect to which points must be "the same" (WÜTHRICH 2009, 1043). For the MOSR-ist, $\forall F$ ranges only over relational, automorphically invariant properties. The key step invokes a principle of the identity of indiscernibles (PII): $\forall F \in Q(Fx \leftrightarrow Fy) \rightarrow x = y$, where Q contains structurally admissible properties. Since in cosmological spacetimes $Q \subseteq B$, any two points on a hypersurface are indiscernible with respect to all admissible properties (WÜTHRICH 2009, 1045). By PII, they must therefore be identical. The result is that all points on Σ_t collapse into a single point, implying that such a spacetime contains only one spacetime point—an obviously false conclusion. Hence, MOSR1 cannot structurally account for the plurality of spacetime points in highly symmetric spacetimes, an outcome Wüthrich deems "abysmally embarrassing" (WÜTHRICH 2009, 1046).

As I see it, the source of the problem lies primarily in the claim that relations individuate objects. But this claim is not present in the core theses of MOSR1, or rather the symmetrical ontological dependence between objects and relations need not be understood in accordance with the mentioned claim. It follows that the source of the problem is not connected to dualism in MOSR1 with respect to the context of the nature of spacetime (sec. 1.1). In D-MOSR (sec. 2.2) I follow these insights.

1.4 THE MCKENZIE PROBLEM PART 1

The McKenzie problem arises first and foremost for MOSR1 given the relationship between spacetime and matter. The problem is twofold. First, it concerns the declared neutrality of MOSR1 between Newtonian substantivalism and Cartesian–Spinozian substantivalism: "Moderate structural realism about space-time remains open with respect to whether or not the space-time structure and (non-gravitational) energy-matter are distinct ontological beings.

If we extend our moderate structural realist position to matter and interaction fields, these could be conceived as structures being ontologically independent of the space-time structure” (ESFELD and LAM 2008, 43). Nothing in MOSR1 forces a choice between these options, and as such I view this as harmless. The difficulty lies in the accompanying claim: “In particular, a realist position towards space-time endorsing Leibniz equivalence—as the structural realist position does for instance … is often called ‘sophisticated substantivalism’ in the recent philosophical literature about space-time” (ESFELD and LAM 2008, 43). Sophisticated substantivalism (BRIGHOUSE 1994, 2020) is a claim that even though spacetime points are represented by the manifold, those points possess only qualitative properties represented by the metric field. Many distinct positions fall under this label while denying the primitive identity of manifold points and respecting Leibniz Equivalence (HOEFER 1996; BARTELS 1996; POOLEY 2006; STACHEL 2005). If so, the question naturally arises: why adopt MOSR1 about spacetime at all, rather than one of these developed substantivalisms? This is precisely the McKenzie problem. MOSR1 appears more plausible as a general stance for *formulating* substantivalisms, but emphasizing its compatibility with many substantivalist views does little to support it as a distinct position.

The second route to the McKenzie problem for MOSR1 is revealed in the following statements:

> Moreover, we would like to stress that, in a broader sense and despite the ontological commitment to space-time points defended here, moderate structural realism as a metaphysical conception about space-time is *not* necessarily committed to the existence of space-time points. In this broader sense, it is the claim that space-time is a mind-independent physical structure whose basic constituents have no fundamental intrinsic properties independently of the structure they are part of. In particular and at a fundamental (possibly *quantum*) level, these latter do not have to be space-time points (such as described in this paper), but could also stem from a generalization of the notion of a space-time point. Indeed, with respect to the enormous empirical and explanatory success of quantum theory, it seems natural (but however not obvious) to look for possible quantum aspects of space-time which would be described by a still to be developed theory of quantum gravity. (ESFELD and LAM 2008, 44)

On the one hand, these claims can be seen as expressing methodological fallibilism about scientific progress. On the other hand, however, this point of view may be classified as some type of non-reductive relationalism, where the relata are material quantum fields, and the relations between them are not reducible to any intrinsic properties, as the traditional, eliminative relationalist like Leibniz would have it (SAUDERS 2003). Dorato (2008) demonstrates that if we keep the distinction between spacetime and matter in GR, spacetime structural realism collapses into relationalism, though Dorato's view hinges on relationalism defined as a negation of the claim that spacetime points can be treated as substances, and on the assertion that substances always have some intrinsic identity (DORATO 2008, 24). On this account any denial of intrinsic identities of spacetime points automatically makes a position a relationalism, therefore Dorato's account may be seen as not fully convincing. Nevertheless, MOSR1's explicit openness to treating the relata of spacetime relations as either spatiotemporal or material lends support to Dorato's concern. Even if MOSR1 does not completely reduce to relationalism, the McKenzie problem reappears: MOSR1 can be seen, considering the relationship between spacetime and matter, as a stance not only on formulating substantivalism, but also on formulating relationalism, which is a negation of substantivalism.

For MOSR2, in contrast, Esfeld and Lam provide more detail regarding the possible ways MOSR can be seen either as substantivalism or relationalism. As I will show, those details do not help in resolving the McKenzie problem (section 2.4).

2. MODERATE ONTIC STRUCTURAL REALISM STRIKES BACK—OR DOES IT?

The second version of MOSR (ESFELD and LAM 2011; LAM and ESFELD 2012) was framed in the papers following WÜTHRICH (2009), and it contains a response to the Wüthrich problem. While it is never stated explicitly by Esfeld and Lam that the Wüthrich problem is the main reason for developing MOSR2, the abysmal embarrassment argument is referred to when they voice their doubts about MOSR1 in identifying the crucial shortcoming of this view:

> Being committed to … primitive numerical diversity is the main reservation [against MOSR1]. Due to weak discernibility, there is no primitive, naked numerical diversity of objects, being entities on a par with relations, there being a mutual ontological dependence between both of them. Insofar as there are objects, these stand in irreflexive, symmetric relations, although these relations do not distinguish them.… In case weak discernibility holds firm in the case of symmetric

> space-times such as the FLRW solutions of the Einstein field equations as well…, the reservations that Wüthrich (2009) voices in challenging the space-time structuralist could also be addressed. (ESFELD and LAM 2011, 149)

So the source of the problems with MOSR1 lies, according to Esfeld and Lam, in the second main thesis of MOSR1, if we interpret it as the claim that objects and relations are "both given at once" (146) in the sense of being ontologically dependent on each other (150).

In section 1.3 I stated that the main reason the Wüthrich problem appears in MOSR1 is due to the requirement of individuation that is put on spacetime relations, not due to dualism present in MOSR1, nor the notion of ontological dependence. As I see it, Esfeld's and Lam's decision to dismiss (weak) discernibility of points (presupposed independently from relations and treated as primitively numerically plural) *jointly* with ontological dependence between objects and relations suggests that they have confused existence dependence with identity dependence. In section 2.1 I present MOSR2 as Esfeld's and Lam's new version of MOSR, and I demonstrate its shortcomings in sections 2.3 and 2.4. In section 2.2 I propose my version of MOSR, which I call D-MOSR. It is a variant of MOSR1, motivated by observations about ontological dependence mentioned above. I will also provide more details regarding ontological dependence. In sections 2.3 and 2.4 I show how problems afflicting MOSR2 do not appear in D-MOSR.

2.1 SECOND VERSION OF MODERATE ONTIC STRUCTURAL REALISM AS A METAPHYSICS OF OBJECTS

Weak discernibility allows us to directly circumvent the Wüthrich problem. Objects are weakly discernible if there exists a relation R having two properties: it is irreflexive, i.e. $R(x,x)$ is false for all x, and it is symmetric, i.e. $R(x,y)\ iff\ R(y,x)$. In MOSR2, relations in the domains of fundamental physics (QM, GR) are viewed as physical, concrete relations (not as universals; ESFELD and LAM 2011, 151) which weakly discern objects such as spacetime points or quantum particles. But given the fact that weak discernibility does not provide identity conditions for objects and allows only for a statement of numerical plurality of objects, there is no meaningful sense in which objects can ontologically depend on relations—either in the case of their existence or in the case of their identity. According to Esfeld and Lam, the case is, however, that physical weakly discerning relations account for having a numerical plurality of points, established through these relations, so this plurality does not have to be presupposed independently (2011, 149). This numerical plurality of objects is considered primitive, but only in virtue of the weakly discerning relations (153).

To conclusively dispel any reliance on some ontological dependence between objects and relations in the case of the nature of spacetime, Lam and Esfeld conceive the relations in question as modes of being of fundamental objects (2012, 255), while there is no ontological distinction between objects and relations. This move is directly inspired by Spinoza, and though Esfeld and Lam do not follow him in claiming that there is just one substance, they subscribe to a monistic view, admitting that even though there may be many objects (e.g. spacetime points), all of them fall under exactly one ontological type: "In reality, there is only one type of entity, namely objects that exist in particular ways" (2011, 151). And finally: "There thus clearly are fundamental physical objects (moderate OSR being a metaphysics of objects), but there is no question of a mutual ontological dependence between objects and relations, no question of having to accept a naked numerical diversity of objects as primitive, and this position also enables us to recognize genuine intrinsic properties as ways in which the fundamental physical objects exist without jeopardizing OSR" (157).

MOSR2 can be summarized, generally, by the following theses:

MOSR2	(1) There is a primitive numerical plurality of objects which are without intrinsic identities. (2) (1) is established through physically meaningful weakly discerning relations. (3) Relations are modes of being; they are ways in which objects are.

When applied to GR, this approach yields the following picture: "In the case of space–time points as treated in GR, their ways of being are exhausted by the metrical relations that tie them together in constituting a space–time" (LAM and ESFELD 2012, 255).

2.2 DUALISTIC MOSR ABOUT THE NATURE OF SPACETIME

The position of D-MOSR is conceived as an alternative to MOSR2, a modification of MOSR1. D-MOSR is proposed with metaphysics of spacetime in mind only, with respect to GR physics in standard tensorial formulation. D-MOSR differs from MOSR1 in conceiving the ontological dependence relation, in dealing with the requirement that relations individuate objects, and in the fact that the Wüthrich and McKenzie problems do not arise for D-MOSR as they do for MOSR1. D-MOSR differs from MOSR2 in endorsing a dualistic interpretation of the nature of spacetime instead of MOSR2's monistic one, in the way the concreteness of relations is viewed, and in the fact that the McKenzie and Meyer problem do not emerge in D-MOSR like they do in MOSR2.

Here are the core theses of D-MOSR:

D-MOSR	(1) Objects and relations are ontologically on a par: (a) fundamental objects (e.g. spacetime points) have no intrinsic identities; (b) fundamental relations (e.g. metrical relations) are physically concrete. (2) Necessarily, whenever a certain structure obtains, then necessarily a plurality of points of certain type obtain and necessarily a certain type of relations obtain.

Thesis (1a) of D-MOSR incorporates, in GR, the standard lessons of the hole argument concerning Leibniz equivalence and background independence. A worry arises immediately: if spacetime points are ontologically distinct from metrical relations, how are they not part of a background? The very separation of objects and relations seems to suggest that spacetime points reduce to manifold points, pushing the view toward a form of sophisticated substantivalism. Spacetime substantivalisms often adopt a pragmatic strategy, traceable to Earman's presentation of manifold substantivalism (with reference to FIELD 1980). The manifold is endowed with ontological significance as a set of spacetime points because, in physical practice, the manifold appears to come first, with fields (metrical and energy-momentum) defined on it. While this reflects methodological practice rather than metaphysical necessity, it can motivate an ontological interpretation of spacetime models (M, g). Manifold substantivalism (section 1.2) exemplifies this strategy. When translated into metaphysics, these pragmatics yield a specific order of predication: the manifold is taken as primary, consisting of subjects (points) to which properties, such as metrical properties in GR, are ascribed. The hole argument can then be read not only as rejecting primitive individuation of spacetime points, but also as undermining this very approach to substantivalist metaphysical interpretation of tensorial GR.

What matters here is that this approach invites a counterstrategy: what if the order of predication was inverted? Teller (1991) explicitly follows this avenue within a relationalist framework, proposing that spatiotemporal properties be predicated on material fields (TELLER 1991, 382). A different variant of this inversion is found in Carl Hoefer's metric field substantivalism, according to which spacetime, as a real entity, simply has physical continuity, topology, and metrical structure (HOEFER 1996, 24). Predicating such properties of spacetime does not reduce this view to relationalism, since GR admits spacetimes with empty regions or metrics without matter fields. Teller interprets such metric fields as representing sets of dispositions, but Hoefer objects that this commits one to "free-floating dispositions," that is, dispositions of something that does not exist, and so it is better to assume that spacetime exists as a real entity (25).

I suggest, however, that the very "order of predication" approach in spacetime metaphysics is misguided, insofar as it forces a choice about the primacy of some entity type in accounting for the nature of spacetime. In GR, to specify a spacetime is to solve the Einstein field equations for the metric; at the same time, specifying such a metric simultaneously fixes a topological structure, given by the manifold. If a pragmatically motivated order of predication generates the tug-of-war illustrated by the Teller–Hoefer exchange, a different perspective is available: manifold points and metrical relations together account for the nature of spacetime. This does not amount to any "deep dualism" about spacetime, as Hoefer suspects (1996, 24), but only to a modest one. On this view, manifold points—conceived as entities without primitive intrinsic identities—cannot form an immutable background for metric (and matter) fields. If manifold points and the metric are given together in specifying a spacetime, there is no meaningful sense in which the manifold functions as a prior "canvas" for the metric field.

This is where thesis (2) of D-MOSR comes into play. Manifold points—as objects without primitive intrinsic identity—never appear as separable particulars, but only as elements of a plurality standing in metrical relations. Bare manifold points can never be interpreted as physical spacetime points, since M is never given independently of g. Because D-MOSR does not claim that relations *individuate* objects (i.e. that objects acquire their identity from their position in a relational network), it remains possible to "swap" manifold points within a spacetime structure without any physical effect. The necessity expressed in thesis (2) is intended to capture an existential ontological interdependence between manifold points and metrical relations. The guiding idea is the MOSR1 claim that "we get the relata and the relations at once as the internal structure of a whole, neither of them being eliminable or reducible to the other one" (ESFELD and LAM 2008, 34). Accordingly, thesis (2) states that whenever a spacetime obtains, there are manifold points without primitive intrinsic identity *and* a metric field; and conversely: whenever a spacetime obtains, there is a metric field *and* such manifold points. The numerical plurality of spacetime points is therefore taken as primitive, as in MOSR1 and MOSR2, but its primitiveness is derived from the joint existence of objects and relations: metrical relations require a plurality of relata, and that is all.

Ontological dependence is symmetrical here, as Esfeld and Lam note (2011, 146). As a rule, the most philosophically interesting cases of ontological dependence are taken as *asymmetrical*, since these allow for accounts of ontological fundamentality, grounding, and metaphysical explanation (TAHKO and LOWE 2025). Roughly, asymmetrical ontological dependence holds when an entity x cannot exist unless y exists; the same idea, roughly, can be applied at the level of entity types. Esfeld and Lam's further requirement that spacetime points depend for their identities on relations has two effects. First, it breaks the symmetry by shifting from ontological existence dependence to identity dependence of one entity type on another. Identity dependence can be characterized as follows: an entity x (or entity type) is identity-dependent on y (or another entity type) iff x's identity conditions cannot be fixed without y. Second, because identity dependence is stronger than mere existence dependence, this move introduces a tension in MOSR1: it is no longer that x cannot exist without y, but that x would not be the very same thing without y.

By rejecting the requirement that relations individuate objects, D-MOSR preserves symmetrical ontological dependence. In general, such dependence holds between x and y if and only if, necessarily, x exists if y exists. From the perspective of fundamentality, this symmetry may appear trivial, since without asymmetry it collapses into mere necessary co-existence and offers no account of ontological priority or grounding (see BARNES 2018). However, thesis (2) of D-MOSR in the context of GR is not merely a claim about co-existence between manifold points (lacking primitive identities) and the metric field. The necessity involved derives from a structure obtaining—specifically, from a spacetime model being fixed by solving the Einstein field equations.

Ontological interdependence in D-MOSR is thus itself necessitated by the existence of spacetime in this sense. Consequently, metaphysical explanation may legitimately appeal to spacetime as a whole, but not separately to manifold points or to metrical relations.

The compatibility of *symmetrical* ontological dependence between points and relations with the denial of intrinsic identities to points and the physicality of relations can be clarified by unpacking thesis (1b) of D-MOSR. Since I do not take metrical relations to individuate spacetime points (here I agree with Esfeld and Lam in MOSR2; I return to this in section 2.3, and treat weak discernibility as secondary), nor do I regard the Bergmann–Komar procedure—central in MOSR1—as crucial for addressing the (structural) identity of points. I do, however, agree with Esfeld and Lam that relations in MOSR should not be treated as universals but as *concrete*. One way to understand the concreteness of metrical relations in GR is straightforward: metrical relations are concrete insofar as they are the relations encoded in a particular metric obtained by solving the Einstein field equations. Another way is to point to paradigmatic relations explicitly defined within GR. Let me exemplify.

Consider gravitational free fall in GR. Since D-MOSR is a substantivalist position, this phenomenon must be understood in terms of underlying spacetime structure. Free-fall motion is represented by geodesics, which describe the inertial trajectories of freely falling bodies and light rays. Geodesics are defined *via* the Levi-Civita connection. This connection provides the structure required to define differentiation, transport, and motion on a spacetime manifold. Because vectors at distinct spacetime points belong to different tangent spaces, there is no natural way to compare them directly; the connection provides a rule for doing so by specifying parallel transport along curves. Crucially, the Levi-Civita connection is uniquely fixed by the spacetime metric through two conditions: it is torsion-free and metric-compatible, meaning that lengths and angles are preserved under parallel transport. Hence, once a metric is given, no further freedom remains at the level of affine structure. While the manifold is indispensable for defining the connection, the connection itself is determined entirely by the metric and not by the manifold structure alone. From this perspective, geodesics connecting manifold points are best understood as *concrete, dynamical relations* corresponding to spacetime trajectories of material particles.

Several points emerge from the preceding discussion. First, treating geodesics and the Levi-Civita connection as concrete relations from the perspective of D-MOSR is fully compatible with GR physics. This supports the dualistic view of spacetime defended by D-MOSR, according to which describing spacetime requires reference to two ontological categories: objects (manifold points endowed with a topological and differentiable structure) and relations (the metric field). Second, the claim that manifold points lack primitive intrinsic identities is naturally accommodated. The manifold points "underlying" a given geodesic trajectory can, in principle, be freely permuted: nothing intrinsic to the points fixes a particular trajectory to a specific subset of manifold points. Third, the Levi-Civita connection coheres with symmetrical ontological interdependence between manifold points without intrinsic identity and metrical relations. Necessarily, whenever a spacetime obtains, there are both points and a metric; when attention is restricted to dynamics in GR, the connection can be understood as a concrete relation that relies on the existence of manifold points, and *vice versa*, insofar as those points are spacetime points (obtaining only when a spacetime obtains). Fourth, the Levi-Civita connection is universally available in GR: every smooth Lorentzian metric uniquely determines one. Cosmological spacetimes therefore automatically possess a Levi-Civita connection. Accordingly, D-MOSR—by grounding concreteness in the metric and its associated connection—straightforwardly accommodates cosmological spacetimes.

2.3 Responding to the Wüthrich problem

Wüthrich lists four escape routes for the spacetime structuralist (2009, 1047): (1) deny the relevance of homogeneous cosmological models (and similarly symmetric spacetimes); (2) reject PII(i) even for classical physics and replace it with another individuation criterion; (3) claim PII(i) is inapplicable because no individuation criterion is needed; (4) argue that we have misidentified spacetime structure—i.e. spacetime should not be identified with a manifold of points plus physical fields. Lam and Esfeld arguably take routes (1) and (3) in MOSR2. They dismiss highly symmetric spacetimes and contend that Wüthrich's argument covertly imposes an extra requirement on MOSR: that relations must *absolutely* discern points, which is (a) unreasonable because highly symmetric spacetimes are, in their view, not physically important, and (b) unmotivated because MOSR is not committed to absolutely or relatively discernible objects (2012, 253–54).

On (a) Lam and Esfeld offer little support beyond the claim that highly symmetric spacetimes form a measure-zero subset of solutions to Einstein's equations (2012, 253). This suggests that such solutions are negligible and that "typical" spacetimes—those exhibiting familiar gravitational effects in curved spacetimes, as in applications like the global positioning system—are more representative, given that our universe contains matter generating these effects. I find this too narrow. Highly symmetric spacetimes are central to cosmology's empirical and explanatory successes, and the FLRW metric is among the most intensively studied solutions of GR (GÜRSES and HEYDARZADE 2020). FLRW cosmology indeed relies on many idealizations, not only with respect to the metric, but also in modelling the stress-energy tensor as a perfect fluid. But if idealizations of this sort are dismissed as physically irrelevant, it is unclear why we should not likewise question other standard idealizations, including the point particle, which plays a foundational role in classical physics. Taken seriously, this stance would not merely constrain what we learn from GR; it would undermine very basic notions across physics. Moreover, since D-MOSR can accommodate cosmological spacetimes, it is clearly possible for a version of MOSR not to dismiss cosmological spacetimes. This is the first reason I take D-MOSR to provide a better reply to the Wüthrich problem than the one offered by Esfeld and Lam.

Option (b) is more promising, since neither MOSR1 nor MOSR2 is committed to any version of PII or to a specific notion of discernibility. If pressed, a MOSR-ist indeed may appeal to weak discernibility as the most natural option for them, given that both views deny intrinsic identity to spacetime objects from the outset. Lam and Esfeld cite Fred Muller's example of weak discernibility in spacetime physics: "any two space–time points are always at least weakly discernible (Muller 2011): for instance, the open geodesic connecting two space–time points always weakly discerns them" (2012, 254). Two comments are in order. First, Muller does not mention open geodesics in his text. Second, this motivates a further advantage of D-MOSR over MOSR2. Although I do not propose a new paradigmatic relation for GR spacetimes, I do clarify what can count as a *concrete relation* in this context—namely, geodesics and the Levi-Civita connection (section 2.2). Crucially, I do not tie these relations to weak discernibility. It should be emphasized that Muller's position is neither MOSR1 nor MOSR2; nor does he frame his view in terms of "monism" or "dualism". Even so, Esfeld and Lam's appeal to Muller is clearly intended to support MOSR2 and therefore deserves scrutiny in precisely this context.

Muller begins by challenging assumptions in Wüthrich's argument that need not be accepted. He identifies two such assumptions. The first concerns the status of relations: Muller argues that Wüthrich reduces relations to (relational) properties instead of treating relations as a distinct ontological category. This already sets Muller's approach apart from MOSR2. On Muller's view, one can always construct a relation that discerns spacetime points at least weakly. This leads to his critique of Wüthrich's second assumption, namely the version of PII employed. Muller argues that Wüthrich in fact relies on what he calls the principle of the identity of automorphic absolute indiscernibles (PIAI). While Muller provides a formal definition (MULLER 2011, 1051), it suffices here to note that under PIAI an object is discernible iff it has a property that no other object has. Muller shows that applying PIAI leads to a proliferation of "abysmal embarrassments": when applied to structures such as a line, a sphere, or Euclidean space, it yields the absurd conclusion that each contains only one point (1053). Muller therefore introduces a principle of relational indiscernibility, according to which objects are indiscernible iff they are related in exactly the same way. On this basis, he proposes a category of relationals, distinct from objects and properties: entities that are absolutely indiscernible and thus not individuals, yet discernible in virtue of relations (1053). Spacetime points, Muller contends, are such relationals. They can be weakly discerned by introducing an appropriate relation, so-called L-relation, which he proposes to ground in the light-cone structure defined at each manifold point:

$$L(p,q)\ iff\ (\exists r \in M{:}\, r \in LC(p)/LC(q)) \\ \vee\ (\exists t \in M{:}\, t \in LC(q)\ /\ LC(p))$$

That is, there always exists a point that lies in the light-cone (LC) of one point, but not in the other one, and this fact suffices for stating that $p \neq q$. Now, without doubt the L-relation has physical significance since it refers to a fundamental fact of relativistic physics about limitations of propagation of causal influences. Though Muller proves that L-relation is invariant under many symmetries of GR and special relativity, the worry is that this is somewhat ontologically trivial—it comes with the most basic assumptions in relativistic physics about causality. L-relation itself doesn't require reference to any specific metric for its validity within theory of relativity. In general, this may be beneficial for spacetime structuralism since the L-relation can contribute to establishing that the numerical distinctiveness of points can be taken as primitive regardless of the metric used (including highly symmetrical metrics), and so no problems arise when it comes to avoiding absurd consequences about only one spacetime point existing in highly symmetrical spacetimes.

However, the abysmal embarrassment argument crucially relies on properties of a specific metric and on the question of how numerical plurality can be grounded via this metric field. Muller himself acknowledges that if the metric is identical at every point of a spacetime, homogeneity follows and Wüthrich's argument still applies—provided that admissible properties and relations are restricted to those constructed from the metric alone (MULLER 2011, 1054). Muller briefly mentions a discerning distance relation defined directly from the metric tensor, but he neither deploys it against the abysmal embarrassment argument nor develops it in his published work.

To reiterate: Muller does not defend MOSR2 (nor MOSR1), and Esfeld's and Lam's reference to his work is brief. Yet it remains the only concrete example of a weakly discerning spacetime relation in their discussion of MOSR2, aside from the Bergmann–Komar procedure, which is available to the MOSR-ist only in curved spacetimes. Crucially, Muller's L-relation does not support MOSR2's conception of spacetime as a network of objects (spacetime points) whose mode of being is relational. There are two reasons for this. First, Lam and Esfeld deny an ontological distinction between M and g, whereas the L-relation is arguably defined for M alone. Second, MOSR2 understands the relational being of spacetime points in terms of the physicality of metrical relations. As Lam and Esfeld explicitly state, MOSR2, when situated within the substantivalism–relationalism debate, is a form of metrical essentialism (2012, 251), which again highlights the centrality of the spacetime metric. If primitive numerical plurality in MOSR2 is secured by weakly discerning relations defined in metrical terms, then the L-relation offers little support to MOSR: it allows numerical plurality to be established independently of any particular metric, thereby undermining the intended metrical grounding. Precisely for this reason L-relation can be considered as giving support rather to D-MOSR, since it allows for an argument for the primitive plurality of manifold points, even though such an argument based on weak discernibility is not indispensable for D-MOSR. This is the third reason as to why I think D-MOSR is more promising than MOSR2. MOSR2 defends itself against the Wüthrich problem, but—apart from accepting primitive numerical plurality of spacetime points—it appears to do so by appealing to the L-relation, which is not fully compatible with its own commitments, and by relying on the problematic distinction between physical and allegedly negligible spacetimes. D-MOSR likewise treats numerical plurality as primitive (albeit it introduces it in a different way) and thereby blocks the Wüthrich problem, but it does so without these costs. It permits a more seamless incorporation of the *L*-relation, if such a relation is required at all, and it does not marginalize cosmological spacetimes in any way.

2.4 The McKenzie problem part 2

The McKenzie problem arises for MOSR2 in much the same way as for MOSR1, namely in the context of the spacetime–matter relationship. Here, however, the focus shifts to whether this relation is even a meaningful topic within GR. If it is not, then the substantivalism–relationalism debate—understood as affirming the container metaphor in the former case or rejecting it in favor of reducing spacetime relations to properties of matter in the latter—loses its significance. This claim was famously defended by Rynasiewicz (1996), who appealed to background independence and to the fact that in GR the spacetime metric encodes both classically spatiotemporal and material properties (this is the so-called "dual role of the metric field"). If spacetime and matter cannot be sharply distinguished in GR, then asking about their mutual relation is misguided. Lam and Esfeld reject the conclusion that the dual role of the metric dissolves the substantivalism–relationalism distinction altogether. Instead, they argue that it forces a serious modernization of the debate. On their proposal, the question becomes whether the gravitational field is ontologically on a par with non-gravitational matter fields, or whether it is ontologically special (2012, 251). Positions of the former kind count as relationalist, while positions of the latter kind count as substantivalist. The real point of contention thus shifts to arguments for the ontological distinctiveness of the gravitational field (see also Duerr 2019).

As noted in section 1.4, Dorato (2008) draws on Rynasiewicz's strategy to argue that spacetime structuralism collapses into relationalism, but only if the traditional substantivalism–relationalism debate is retained. If that debate is abandoned, spacetime structuralism instead becomes an investigation of spacetime as exemplified structure (35), at the cost of dissolving substantive metaphysical questions about the nature of spacetime. If the debate is modernized, Dorato's collapse argument may fail, and MOSR need not reduce to a modified relationalism or to a stance for formulating relationalist views.

Lam and Esfeld (2012) directly and unambiguously reject Dorato's view, but they refer his earlier claims (Dorato 2000) that spacetime structural realism is a third, mediatory option between substantivalism and relationalism. This claim is not actually later maintained by Dorato (2008, 124). Nevertheless, Lam and Esfeld insist that, even under the modernized debate, OSR is not a *tertium quid*:

> we do not think that OSR about space–time is a tertium quid beyond substantivalism and relationalism (against Dorato 2000, 2008). The brief presentation of the OSR conception of space–time above rather suggests that OSR constitutes a substantivalist claim about space–time in the straightforward sense that it holds that space–time exists, namely as a physical structure. In particular, in the above presentation, we have quantified over space–time points and we have taken space–time points to be the objects that stand in the relations in question, namely metrical relations. We are thus committed to acknowledging the existence of space–time points. (LAM and ESFELD 2012, 251)

The McKenzie problem for MOSR2 in Lam's and Esfeld's hands appears for two reasons. First, because of the decision to interpret the abovementioned statements in terms of another substantivalism; second, because of the formulation of a neutrality thesis about MOSR2 regarding the spacetime-matter relationship. Regarding the first reason, according to Lam and Esfeld (2012), MOSR2 is a version of metrical essentialism (MAUDLIN 1988; BARTELS 1996), particularly in Bartels' characterization of the view, in which metrical properties are quasi-intrinsic essential properties of spacetime points. Metrical essentialism turns into MOSR2 "by laying stress on the fact that the metrical properties as conceived in GR are relations" (LAM and ESFELD 2012, 251). Especially here it is visible how MOSR2 appears to function primarily as a stance toward a certain kind of substantivalism, recommending specific modifications of that view. If so, MOSR2 does not itself amount to a substantive metaphysical claim about spacetime. This is precisely the McKenzie problem as it emerges for MOSR2.

The second reason the McKenzie problem appears in MOSR2 derives from the following puzzling statements: "Nonetheless, OSR about space–time is not committed to regarding space–time points (or regions) as the objects that stand in the metrical relations" (LAM and ESFELD 2012, 251) and, considering the question of the relationship between spacetime and matter, "both a substantivalist and a relationalist answer to this question can be an OSR about space–time. OSR … is neutral with respect to the controversy between substantivalism and relationalism" (252). These claims are motivated by the possibility that further developments in quantum gravity may provide arguments that the gravitational field is indeed ontologically on a par with other matter fields. This would be cashed out in terms of quantum properties, which may not include spatiotemporal properties; it may be, however, that spatiotemporal properties are fundamental, so reference to spacetime points proves ineliminable.

The McKenzie problem thus reappears: MOSR2 cannot be understood as advancing substantive theses of its own, but rather as an attitude toward formulating substantivalist or relationalist positions in response to developments in the physical sciences concerning spacetime. This invites further difficulties. Both versions of MOSR clearly belong within the practice of naturalized metaphysics, understood minimally as the view that metaphysics should be constrained by science (see also BRYANT 2024, 16). In deliberately metaphysical interpretations of science, as it is common in philosophy of spacetime, this constraint seems often satisfied trivially due to the subject matter itself. Yet one consequence of scientifically constrained metaphysics cannot be overstated: science is a dynamic, self-correcting system in which new theories and discoveries can overturn views once regarded as unassailable. Metaphysical interpretations may therefore fall with the theories they interpret, prove inadequate in light of successor theories, or require explicit qualification as interpretations relativized to a given theory and its ontological posits, which may themselves later be abandoned. I take this dependence on contingency to be an unavoidable cost of naturalized metaphysics. In return, if pursued carefully, it gains access to a rich range of meanings and genuinely substantive problems. For this reason, I do not think that the best strategy for any version of MOSR about spacetime is to seek validation in virtue of possible hospitability (or non-hospitability) of quantum gravity to substantivalism or relationalism.

Another difficulty is that the statement about the neutrality of MOSR2 in the substantivalism and relationalism debate seems to evoke some tensions with the declaration that MOSR2 is a type of substantivalism (in the guise of metrical essentialism). The neutrality statement is formulated in the context of the relationship between spacetime and matter, so maybe the (MOSR2-ist) metrical essentialism can be considered as a thesis on the nature of spacetime (the gravitational field) as such. But these two claims are incompatible—no sources support the idea that any forms of metrical essentialism are at least non-dualistic with respect to the issue of the spacetime–matter relationship. So subscribing to this type of substantivalism should automatically grant some ontological autonomy to spacetime. The neutrality statement undercuts this immediately in a fashion that rather brings to mind doubts about calling one-self a MOSR2-ist, if it ultimately doesn't really matter whether we are rather substantivalists or rather relationalists from the perspective of MOSR2.

D-MOSR is not vulnerable to the McKenzie problem. That problem arises in the context of the spacetime–matter relation. Here D-MOSR should be classified as a substantivalist view that separates spacetime from material fields—as already suggested by the discussion of geodesic motion in section 2.2—while taking seriously the modernized version of the substantivalism–relationalism debate. In this sense, D-MOSR is neither reducible to relationalism nor to being a stance for formulating relationalist positions. When comparing D-MOSR with other substantivalisms, the focus is best narrowed to the nature of spacetime itself. The first difference, noted in section 1.1 with reference to Schaffer's characterization of substantivalism, is that D-MOSR addresses the structure of spacetime simultaneously with its nature, whereas standard substantivalisms typically, according to Schaffer, should treat structure as a subsequent question. D-MOSR is not sophisticated substantivalism, since it does not construe relations as qualitative properties of manifold points but instead appeals to concrete relations. It is not metrical essentialism, because it does not invoke essences in characterizing spacetime points. Nor is it metric field substantivalism: the ontological interdependence between points and metric blocks any appeal to a privileged order of predication in interpreting the pair (M, g). For these reasons, D-MOSR qualifies as a substantive position in the metaphysics of spacetime. Consequently, the McKenzie problem does not arise for D-MOSR. This is the fourth reason why D-MOSR fares better than MOSR2 (and MOSR1).

2.5 THE MEYER PROBLEM

Esfeld and Lam claim that "the position according to which relations are the ways (modes) in which objects exist clearly is a version of OSR" (2011, 152). Meyer (2025) raises doubts about this claim. If the Spinozian commitments that Esfeld and Lam associate with MOSR2 are taken seriously, then construing relations as merely relational modes of being of one type of objects implies, consistently with Spinoza's framework, that objects are ontologically fundamental since substances are prior to their modes (MEYER 2025, 21). On this reading, relations become metaphysically derivative of objects, a consequence that sits uneasily with a structuralist ontology. This is the Meyer problem for MOSR2.

A defender of MOSR2 might reply that the objection is ill-posed because the relevant objects (spacetime points in GR or quantum particles in quantum theory) are not substances in the Cartesian–Spinozian sense. Substances, on that view, are entities capable of independent existence; for Spinoza, this led to monism since only God or Nature exists independently. MOSR2 explicitly denies that individual spacetime points can exist independently of one another. Moreover, the abysmal embarrassment argument presupposes that a view implying the existence of only one spacetime point is absurd. This consequence MOSR2 rejects, partly in response to Wüthrich's challenge. Since the modes of being of spacetime points in MOSR2 are exhausted by the metrical relations they have with one another, individual points cannot exist separately in the manner of Cartesian–Spinozian substances. On this basis, Meyer's objection might seem inapplicable.

However, the Meyer problem does not necessarily depend on treating objects as substances. MOSR2 remains monistic in the sense that it posits only one type of entity in its account of spacetime: points lacking primitive intrinsic identity, endowed with relational modes of being. Although MOSR2 denies any ontological separation between objects and relations, this unity is articulated in a way that accords objects at least logical primacy since the sole entity type is specified as objects together with their modes. Nothing in existing formulations of MOSR2 suggests that comparable primacy could be given to relations (which would risk collapsing the view into radical or eliminative OSR), nor to the whole structure (as in MOSR1), nor to any further entity type. Thus, even if spacetime points are not substances, they appear logically prior to the predication of relational modes of being. For this reason, the Meyer problem still holds for MOSR2: despite motivations behind it, MOSR2 is problematic as a genuinely structuralist ontology. This also can be tied back to doubts about the "order of predication" issue in the strategy of formulating metaphysical interpretations of spacetime (section 2.2).

The source of the Meyer problem for MOSR2 can be traced to its monistic commitment regarding the nature of spacetime, namely the postulate of a single basic entity type. One way to avoid the Meyer problem is therefore to adopt a dualistic position about spacetime. D-MOSR does precisely that. In D-MOSR, relations are neither "overinflated" nor ontologically degraded. As discussed in section 2.2, D-MOSR—formulated as a metaphysical interpretation of spacetime within the standard tensor formulation of GR—explicitly distances itself from the "order of predication" approach. Although MOSR2 is not intentionally framed in those terms, its metaphysics of modes of being, I suggest, cannot fully avoid positing a non-structural entity type as fundamental to spacetime. While talk of relational modes of being does not straightforwardly imply that metrical relations supervene on points—and thus arguably secures their fundamentality—the very notion of a "mode of being" risks obscuring the physical concreteness of metrical relations (see also BERGHOFER 2018, 183). This leads to the fifth reason why D-MOSR fares better than MOSR2. D-MOSR treats physically concrete relations in spacetime physics as *bona fide* relations that exist ontologically in tandem with manifold points. By doing so, it preserves its identity as a genuinely structuralist ontology. For this reason, the Meyer problem does not arise for D-MOSR.

CONCLUSION

This paper has examined moderate ontic structural realism about spacetime as formulated by Esfeld and Lam, with particular attention to its two variants, MOSR1 and MOSR2, and to the difficulties they face when applied to general relativity in its standard tensorial formulation. I leave open the question whether the same analysis applies if any of those versions of MOSR is formulated in a different formal way with respect to GR, e.g. the fiber bundle formalism or category-theory formulation. Three interconnected challenges structured our discussion: the Wüthrich problem concerning the plurality of spacetime points, the McKenzie problem regarding the status of MOSR as a substantive metaphysical position, and the Meyer problem questioning whether MOSR2 genuinely deserves the label "structuralist."

I have argued that MOSR1 fails primarily because it combines a commitment to the ontological robustness of relations with a requirement that relations individuate objects. In the context of highly symmetric spacetimes, this requirement generates Wüthrich's abysmal embarrassment. Importantly, this failure is not rooted in the dualism of objects and relations as such, but in the stronger individuation claim. MOSR2 avoids the problem by appealing to primitive numerical plurality and weak discernibility, but does so at a significant metaphysical cost. Its Spinozian-inspired monism dissolves the ontological distinction between objects and relations by construing relations as modes of being of objects. This move renders MOSR2 vulnerable to the Meyer problem, since, as he pointed out, the framework of MOSR2 risks reintroducing an implicit primacy of objects, thereby undermining its claim to be a genuinely structuralist ontology. A similar worry, but more nested in the debate about the relationship between spacetime and matter, is that MOSR2 begins to function less as a substantive metaphysical thesis and more as a flexible stance toward reformulating existing substantivalist or relationalist positions. I called this the McKenzie problem.

In response, I have proposed a dualistic version of moderate ontic structural realism, D-MOSR. The core idea of D-MOSR is modest but principled: an adequate account of the nature of spacetime in GR requires reference to two ontological categories—objects (manifold points without intrinsic identities) and relations (physically concrete metrical relations)—which are ontologically on a par and symmetrically dependent. By rejecting the requirement that relations individuate objects, D-MOSR blocks the Wüthrich problem without marginalizing cosmological spacetimes. By clearly differentiating itself from other substantivalisms and relationalisms, D-MOSR avoids the McKenzie problem and secures its status as a substantive metaphysical position rather than an attitude toward formulating other positions. Finally, by treating relations as bona fide physically concrete relations (illustrated by the role of the metric, the Levi-Civita connection, and geodesic structure) D-MOSR preserves its structuralist credentials and thereby sidesteps the Meyer problem.

More generally, the analysis supports a broader methodological lesson. Attempts to resolve foundational issues in spacetime metaphysics by collapsing ontological categories—whether in the name of monism, modes of being, or flexibility with respect to future physics—risk obscuring rather than clarifying the commitments required by general relativity. A restrained dualism regarding the nature of spacetime offers a more stable framework for the spacetime structuralist, as I claim. D-MOSR should be understood in this spirit: not as a final metaphysical word on spacetime, but as a theoretically disciplined and structurally realist proposal that remains robust under scrutiny from symmetry arguments (like the hole argument), metaphilosophical worries, and concerns about the physical concreteness of relations.

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MODERATE ONTIC STRUCTURAL REALISM ABOUT THE NATURE OF SPACETIME: MONISTIC AND DUALISTIC APPROACHES

SUMMARY

The position of moderate ontic structural realism, presenting a version of spacetime structuralism, runs into several problems. One of them is how to discern spacetime points. This was demonstrated in an argument presented by Christian Wüthrich. In defending their position, proponents of moderate ontic structural realism utilize a sort of monistic interpretation of their structuralism. I argue that this interpretation generates further complications. I make a case for a dualistic version of moderate ontic structural realism with respect to the nature of spacetime. I show how this version is less problematic than the other forms of the position discussed.

Keywords: moderate ontic structural realism; spacetime philosophy; monism; dualism

UMIARKOWANY ONTYCZNY REALIZM STRUKTURALNY W SPRAWIE NATURY CZASOPRZESTRZENI: PODEJŚCIA MONISTYCZNE I DUALISTYCZNE

STRESZCZENIE

Stanowisko umiarkowanego ontycznego realizmu strukturalnego, przedstawiające wersję strukturalizmu czasoprzestrzennego, napotyka szereg trudności. Jedną z nich jest kwestia rozróżniania punktów czasoprzestrzeni. Zostało to pokazane w argumencie sformułowanym przez Christiana Wüthricha. W obronie swojego stanowiska zwolennicy umiarkowanego ontycznego realizmu strukturalnego odwołują się do pewnego rodzaju monistycznej interpretacji swojej pozycji. Twierdzę, że interpretacja ta generuje dalsze komplikacje. Opowiadam się za dualistyczną wersją umiarkowanego ontycznego realizmu strukturalnego w odniesieniu do natury czasoprzestrzeni. Pokazuję, w jaki sposób wersja ta jest mniej problematyczna niż inne omawiane formy tego stanowiska.

Słowa kluczowe: umiarkowany ontyczny realizm strukturalny; filozofia czasoprzestrzeni; monizm; dualizm