Substance-Relation Identity and Causal Relationality: Suggestions from the Philosophy of Physics

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Abstract. Philosophers, as well as sociologists and scientists, have always been perturbed about the intrinsic meaning of relations and they have tried to understand it through both theoretical and empirical analysis. Speaking at the broadest metaphysical level, the notion of relationality applied to ontological investigation provides an extremely interesting pattern to work with, especially when counterposed to its alternative: substantialism. What I would like to undertake in this paper is a focused analysis on the concept of relationality adopting the viewpoint of my specific academic field, the philosophy of physics, on the background of social network analysis. I will mainly focus on the attempt of showing the inconsistency of the metaphysical question concerning the ontological primacy between substances and relations, analyzing the notion of relationality emerging from theoretical physics, in particular classic space-time theories and quantum mechanics. I believe that the case of classical physics represents a good instantiation of the juxtaposition of substantialist and relational views, but it does not really allow to look at the problem of the connection between entities and relations under a new light; the danger of regression would in fact be reiterated, maintaining ontological priority at the core of the quest. The metaphysical implication of the relational interpretation of quantum mechanics, what I shall call "substance-relation identity", represents instead the radical change in the paradigm 'substance-relation' able to break the counterposition loop and create symmetry between the system components, in a way that the one can be perfectly reduced to the other. In the final section of the paper I will rephrase the problem of substance-relation under the light of causality, a frame of reference in which reinterpreting the notion of relationality with a weaker ontological commitment than the one entailed by substance-relation identity, but still able to interrupt the "fundamentality" recursiveness.

Keywords. Relational ontology, relational quantum mechanics, substance-relation identity

Trying to delimit the semantic domain of the word 'relation', circumscribing the area of its concept within well defined boundaries is extraordinarily difficult, although relations are an everyday part of life that most people take for granted. There are physical, logical, sentimental, moral, cultural and sexual relations, just to mention a few, and most of us would have no problem at all with any of this. However, philosophers, as well as sociologists and scientists, have always been perturbed about the intrinsic meaning of relations and they have tried to understand it through both theoretical and empirical analysis.

Speaking at the broadest metaphysical level, the notion of relationality applied to ontological investigation provides an extremely interesting pattern to work with, especially when counterposed to its alternative: substantialism. The contrast between relational and substantialist ontology is in fact strongly connected to the core of many different research areas (metaphysics of course, but also psychology, political theory, ethics, theology) representing a constitutive aspect in particular within sociological quest.

What I would like to undertake in this paper is a focused analysis on the concept of relationality adopting the viewpoint of my specific academic field, the philosophy of physics, on the background of social network analysis. I will mainly focus on the attempt of showing the inconsistency of the metaphysical question concerning the ontological primacy between substances and relations through the notion of 'substance-relation identity', analyzing the notion of relationality emerging from theoretical physics, in particular quantum mechanics, with a final 'causal' interpretation of the classic categories through which such concept is usually studied.

The metaphysical question imposed by the friction between substantialist and relational thinking is posed at both ontological and logical level, asking whether substances or relations are more fundamental. The basic claim of a relational ontology is simply that the relations between substances are more fundamental than the substances themselves, whereas in substantivist ontology substances are primary and relations derivative[1].

Later on I will try to argue that the question about ontological foundation might not be the most appropriate in order to understand the connection between entities and their relations; there is indeed some confusion in the literature about relational ontology for the key idea of relation is nearly intangible. The first difficulty lays on the variety of relations, which seems to make the category untraceable. Even focusing on a single field of study the problem of complexity remains, for instance if we assume physical relations to be the simplest to analyze: classic-mechanical collisions, ordinary fields, relativistic thermodynamics and quantum entanglement show such a diversity in relations - and correspondent entities - that even a unified physical theory of relation seems to be unachievable, and this philosophical issue becomes more relevant as soon as we take into account multiple areas of research. Relations in fact very often express moral value, at an anthropological level; it is rather evident that the construction of a philosophical theory of relation able to embrace at the same time fundamental physics and morality is anything but simple.

What I have said so far is strictly connected to the latest paradigm-shift in sociology, which consists of the idea that the kind of ontology underlying social phenomena is relational ontology. Especially since Mustafa Emirbayer's "Manifesto for a Relational Sociology" (1997)[2], relationality has been described as the ontological foundation of the social world, primarily constituted rather by relations among 'actors' than by actors themselves. This relational perspective was actually introduced by some of the founding fathers of sociology, such as Karl Marx and Georg Simmel, but during the last few decades, as Emirbayer reminds us in his article, it has become the predominant approach within the study of social networks and social structures, e.g. Harrison White, Andrew Abbott, Margaret Somers.[3]

[1] The term 'substance' primarily used within metaphysical contexts, has two main semantic equivalents usually related respectively to physical and sociological domain: 'entities' and 'actors'.

[2] Emirbayer (1997)

[3] *Ibidem*

In order to describe the sociological concept of relationality, it would be useful to evoke the philosophical focus on 'action' proposed by John Dewey and Arthur F. Bentley (also examined in Emirbayer 1997). They distinguished between three different kinds of action: self-action, inter-action and trans-action.[4] Entities in self-action "act in their own power" apart from all the others; entities in inter-action are "balanced […] in causal interconnection" between each others; in trans-actions instead, "systems of description and naming are employed to deal with aspects and phases of action, without final attribution to 'elements' or other presumptively detachable or independent 'entities', 'essence' or 'realities', and without isolation of presumptively detachable 'relations' from such detachable 'elements'".[5]

According to Emirbayer's analysis, self-action and inter-action correspond to the 'substantialist' sociological perspective, whereas trans-action instantiates the 'relational' approach in sociology[6], where entities, as we have said, are not conceived as something ontologically independent of, or logically antecedent to, the relations they establish; on the contrary, substances acquire their ontological status within their relations. Generally speaking, the transactional view has been the main path followed by modern sociology, reflecting the logic behind social network analysis, which conveys the following idea: a social networks is 'actors plus relations'.

The sociological relational model seems to be consistent and coherent at a theoretical level, although it introduces a system not easy to translate into empirical terms; however, such theoretical framework is not devoid of any blind-spot. If relations determine actors, the emerging question is what determines relations; and it is obvious that if we do not want to fall back in substantialism and we apply the same relational logic, we would have to face the problem of an infinite regression. How to get out of this loop is surely less obvious.

Let us then approach this impasse from a different angle, hoping that some metaphysical insights will be prompted by the analysis of 'relationality' through the viewpoint of theoretical physics. I will start this digression by describing the friction between two different classic space-time theories, partially connected to the problem of metaphysical realism and anti-realism. The most interesting aspect of such debate, for the purposes of this discussion, is the comparison between the two metaphysical postures within the notion of 'dependency'. From this point of view, realism and anti-realism do not confront each other on the plane of pure existence but on its manner. Assuming some form of existence, the question is whether the way in which entities exist depends on an interaction -relation- with another system; in other words whether it is possible to speak of a substance with absolute existence and independent of any external factor to it (realism), or whether the manner in which it manifests itself is constantly linked to some relation between the entity and a knowing subject, or any other entity in general (anti-realism). In this sense, we can declare a 'relative antirealism', that is defined by the range of the mode of existence and not existence itself.

A very interesting example obtained by the history of modern physics, which may help in understanding this last nuance of the debate in further detail, consists of the diatribe on space between Newton and Leibniz. In his famous "Philosophiae Naturalis

[4] Dewey & Bentley (1949)
[5] *Idem*, p. 108
[6] Emirbayer (1997), p. 287

Principia Mathematica", Newton defended what is called the concept of 'absolute' space, according to which it has an absolute existence beyond and outside the relations between objects. Newton considered space as a three-dimensional container in which God arranged the material universe at the moment of its creation, which implies that space is what it was before there was any material object. The main reason that prompted Newton to perceive space as an absolute was to distinguish the difference between absolute and relative motion; the latter is the movement that an object has with respect to another, while absolute is the movement of an object with respect to the absolute space itself, understood as a system of universal reference.[7]

Leibniz, however, did not agree at all with the Newtonian absolutist conception; he believed that space did not have any independent nature of the objects, but rather it was precisely defined by the totality of the spatial relations between objects. This relational interpretation implies the impossibility of identifying an absolute reality of space independently from other entities; on the contrary, entities are specially defended only through their relations.[8] At first glance, Newton's substantialist vision may seem more reasonable, probably because it is closer to the common sense of the idea of space that we all have, like a volume containing objects; but nevertheless, Leibniz's theory had a very interesting argument. It demonstrated that the idea of absolute space went against the sound logic of the Principle of the Identity of Indiscernible.

In this demonstration, Leibniz proceeds by reduction to the absurd, initially acknowledging the truth of the Newtonian assumption, proving the contradiction in a second excerpt: imagine two different universes, each containing the exact same objects. In the first universe each object occupies a particular position in absolute space; in the second universe each object has been transferred to a different position in absolute space. There would be no way to distinguish these two universes. We cannot observe the position of an object in absolute -infinite- space, as Newton himself admitted; we can only observe the positions of the objects relative to each other, and these remain unchanged since all the objects have been moved to the same extent. There is no observation or experiment that could ever reveal to us whether we live in the first or second universe.

I believe this peculiar example from classical physics represents a good instantiation of the juxtaposition of substantialist and relational views in a different area of interest, but it does not really allow us to look at the problem of the connection between entities and relations under a new light; the danger of regression would in fact be reiterated, maintaining 'ontological priority' at the core of the quest. What is needed is a radical change in the paradigm substance-relation, able to break the counterposition loop and create symmetry between the system components, in a way that the one can be perfectly reduced to the other. If such a shift is possible, we should look for it taking a further step into the territory of non-classical physics: quantum mechanics.

This physical theory describes the behaviour of microscopic matter, radiation and their interaction, seen as a composition of undulatory and particle phenomena [wave-particle duality]. Despite their highly philosophical characterization, I will have to avoid an exhaustive definition of some of the fundamental principles of quantum physics, such as entanglement and superposed states, since their complex formalism would go beyond the purpose of this second digression. However, it would be relevant

[7] Newton (1686/1999)
[8] Leibniz (1686/2003)

for our discussion to identify two general key concepts, 'indeterminism' on one side and 'dependency' on the other. The former represents the intrinsic impossibility at a microscopic level to determine through the measurement the complete state of a system,[9] of which probability turns out to be a constituent element. This is not a probability linked to cognitive instrumental limits, as in thermodynamics, whereas it appears to be an inescapable property of the system, as a founding element of its own ontological status. According to a strictly realist interpretation, therefore, this 'ontological probability' represents an intrinsic characteristic of the fundamental structure of the nature of the microscopic world.

The latter expresses the fundamental dependency between physical systems and their mutual ineradicable influence: quantum mechanics reveals a relational aspect of microscopic reality that does not permit the definition of the physical properties of a system in a determined and independent manner from another. The measurement of these properties in this sense, as an interaction between systems, takes on a decisive role. This is the direction that the Copenhagen interpretation moves in, regarding in particular the treatment of electrons and their orbital, conceived as a space of possibility where the electron "lives"; the choice by the system of one of the possibilities and the consequent annulment of all the others with regard to its position or velocity, is precisely determined by the act of measurement, that is, when there is interaction with a second system. The description of this dependency of the state of physical systems is the domain of Schrodinger's equation. The collapse of the wave function ψ, the superposition of all states in which a measurement can be found, is the collapse of the quantum state, that is, the moment when from a cloud of possibilities emerges the only one that defines the subsequent state of the system, as a result of a measurement. This applies to the electron properties as velocity, position and spin. The problem of the interpretation of quantum mechanics takes different forms, depending on the relative ontological weight we choose to assign to the wave function ψ or, respectively, to the sequence of the measurement outcomes.

Since it is not possible to know the precise value of a certain property without disturbing the entity which it is associated with, perhaps it does not make sense to ask whether the system reveals such property before the measurement, beginning with the (reasonable) premise of what one cannot measure may not exist. We should therefore not express a judgment of existence with regards to the property before the interaction with an observer; but what about the entity itself?

The relational interpretation of quantum mechanics, proposed by the physicist and philosopher Carlo Rovelli in the paper "Relational Quantum Mechanics" (1996), provides an extremely interesting answer to this interrogative, which seems to go in the direction of the 'paradigm shift' we were aiming for. 'RQM' treats the state of a quantum system as being observer-dependent, that is, the state is the relation between the observer and the system, such that the physical content of the theory is not represented by the objects themselves, but the relations between them. As Rovelli writes: "Quantum mechanics is a theory about the physical description of physical systems relative to other systems, and this is a complete description of the world".[10] In this sense quantum events, and thus the values of the properties of a physical system, are relational, that is, they do not express properties of the system alone, but rather refer

[9] In particle physics the term 'system' amounts to the term 'entity', defined through physical and mathematical properties, such as position, momentum and spin.

[10] Rovelli (1996)

to the relation between two systems. In such relational view there is no meaning in saying that a certain quantum event has happened or that a property of the system S has taken the value q: rather, there is meaning in saying that the event q has happened, or the property has taken the value q, with respect to the observer-system O.

I believe that 'substance-relation' identity is the conceptual implication of this interpretation. The metaphysical insight suggested by RQM is a perfect correspondence between the notion of 'substance' and the notion of 'relation', establishing the symmetry through which one can be reduced to the other. In the words of the author: "The most difficult key of quantum mechanics is the relational aspect. Electrons do not always exist. They only exist when they interact. They materialize in a place when they collide with something else. [...] This is their only way of being real: an electron is a set of jumps from one interaction to another, and there is nothing outside of that interaction. These fundamental entities don't only exist within relation; they are relation".[11]

Substances have therefore to be conceived as fundamentally relational, and relations as fundamentally substantial, and in this perspective the question about the ontological priority between substances and relations becomes meaningless.

It is curious to notice that something very close to this reductional-relational interpretation of fundamental physics can be traced in a completely different context, namely religion.

The relational ontology entailed by the Buddhist doctrine of pratītya-samutpāda conceives every kind of relation as a potential cause of suffering and therefore a constant occasion for enlightenment, strongly influencing the way in which a Buddhist interacts with the world.[12] I believe it would be useful to focus on this at slightly greater length in order to grasp the essential relational thought underlying this doctrine.

Pratītya-samutpāda proposes a particular metaphysical principle, called 'anatta', according to which substances have no essence in themselves, while are entirely constituted by the set of relations that emerge from the context of pre-existing conditions. It is only such context that defines what an entity is, which is to say that "any given thing is what is solely by virtue of its relation with other things".[13] Compassion, in the original meaning of the Latin verb cum-patere, is the fundamental value instilled by this religious view, which eventually leads to enlightenment, as I have already mentioned.

These considerations direct me to think of the whole problem of substance-relation under the light of a new concept, 'causality', a frame of reference in which reinterpreting the notion of relationality with a weaker ontological commitment than the one entailed by substance-relation identity, but still able to break the counterposition loop on "fundamentality". In other words, the veiled interrogatives consist of asking whether it is possible to give a causal notation to every kind of relation, and consequently which explanatory power a causal theory of relations would have. Such theory should be able to give a causal account to every kind of relations, translating each of the relational qualities into terms of causal connections, and, therefore, introducing a metaphysical equilibrium that would uphold neither a substantialist nor a pure relational ontology, while equally bearing entities and relations

[11] Rovelli (2014), p.105
[12] Harris (1995)
[13] Naess (1985)

within its theoretical framework. Considering the spiritual doctrine mentioned above, and, once again, quantum physics, this speculative step seems to be possible.

At first glance, in the Buddhist principle of anatta, causation does not seem to occur since substances have no own-being; however, pratītya-samutpāda provides for entities to come into being, and such (relational) process requires causes. According to the "doctrine of the two truths", which aims at avoiding a reductionist skepticism on both extremes, entities and causes are real and not real at the same time.[14] This conception accepting 'superposed states' reminds me of the quantum principle of the same name, connected to the notion of indeterminism I have already briefly discussed, which takes us into the final causal analysis of non-classical physics.

When considering classic collisions between macroscopic objects, the emerging view of causation is 'local' (or context-independent) which means that, in order to provide a complete physical description of the phenomenon, the observer does not need to be aware of the context of the experiment, in other words of the events that happen beyond the collision itself. This classical conception of causation cannot explain the bizarre relation of quantum entanglement [technically, non-factorizable, multi-particle superposition; non-technically, in the words of Einstein, "a spooky action at a distance"]. Entanglement in this sense is 'non-local' (or context-dependent), meaning that, in order to give an exhaustive account of its relation, it has to be understood in terms of non-contiguous events. However, non-locality does not represent an ontological problem; on the contrary, the locality is maintained for the instantaneous changes do not affect the physical properties of the systems but solely the knowledge that we have of them; although its non-locality in fact, entanglement does not allow non-local information transfer. This is the reason the philosophical characterization of entanglement does not have to be identified in a sort of mystic communication process between two coupled systems, but rather in establishing space-time relations within wider causal - and more fundamental - relations.

At this point of the discussion, we should finally try to answer the following question: is adopting the 'substance-relation identity' view a good approach to take in a more specific sociological perspective?

I cannot declare myself able to provide a precise response to such interrogative; however, I believe that adopting this metaphysical posture in the analysis of social structures might have some advantages. The subordination of both entities and relations to a dualist network allows us to stop the recursive quest of the ontological primacy between them, and leads to conceive these two fundamental aspects of our experience as the explicate phenomenological manifestation of a more complex, implicate, 'order'.

On the one hand, the moral drawback of a substantialist ontology is that some very important relations convening moral values, such as the one connecting humans and nature through an ecosophical link, are overshadowed; on the other, a relational ontology hides a self-centered tendency to give inadequate importance and credit to the actors among whom social realities are shared.

[14] Eckel (1992)

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