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EVENTISM AND POINTISM

CONTENTS

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1. Introduction

The domain of contemporary physics consists of two different classes of objects: a) physical objects — point events (shortly — events), elementary particles (and their aggregates), and fields; b) spatio-temporal objects — space-time points (shortly — points), moments, space points, and their corresponding sets: space-time, time and physical space.

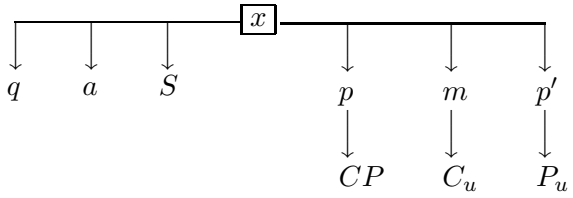
If objects of some kind (physical or spatio-temporal) are treated as individuals, i.e. nonsets, then it is possible to define the remaining kinds of objects from both above-mentioned classes. In this way one can construct two alternative monistic ontologies of physics: *eventism* founded on events, and *pointism* founded on points. It is also possible to establish a dualistic ontology of physics, based both on events and points treated as individuals.

In this paper these three ontologies are presented with particular emphasis on some extreme versions of monistic ontologies. I shall compare them considering both their respective advantages and difficulties and trying to justify my own choice of eventistic ontology.

2. Point-Eventism (EP)

It can also be called: *eventistic monism* or *physical monism*. It is represented by the diagram depicted below, in with x, y, z, stand for events, S — for the set of all events, a — for particles, q for physical fields, p — for points, m for moments, p' — for space points, CP — for space-time, C_u for relative time, P_u for relative space (u refers to some inertial reference system).

Diagram of **EP**:



$\longrightarrow$ direction of defining

The theses of **EP** are as follow:

EP1. Events are the only individuals.

EP2. Every spatio-temporal object is a (set-theoretical) set founded on events; thus points, moments and space points are specific sets of events, i.e. set-theoretical parts of S.

EP3. Every physical object except events is a (set-theoretical) set founded on events; particles and fields are some sets of events, i.e. set-theoretical parts of S.

EP4. Every empirical object is an event or a set founded on events; it is a consequence of the theses: **EP1**, **2**, **3**.

The thesis **EP2** follows from eventistic definitions: 1. of *points* as abstraction classes of the relation of space-time coincidence K in the set S; 2. of *moments* as abstraction classes of the simultaneity relation R_u in the set S; and 3. of *space points* as abstraction classes of the co-location relation L_u in the set S. It also follows from the definitions of: CP — as the set of all points, C_u — as the set of all moments, and P_u — as the set of all space points.

The thesis **EP3** follows from two **EP**-claims: 1. elementary particles (and their aggregates) are things, i.e. time- and space-extended, time continuous and causally connected sets of events; 2. physical fields are things-like objects, time- and space-extended although they are not time-continuous and not causally connected sets of events. The definitions of things and other objects are given in [Augustynek, 1991].

Remark. The following difference between particles and fields is even more important. In the case of a particle properties which characterize it (*mass*, *charge* etc.) are attributed to the whole particle-set of events (resp. to its time cross-section which is also a set of events). In the case of a field (every) value of the physical magnitude which characterizes this field is attributed to the single event which is a member of this field-set of events, i.e. different members have usually different values. For example a definite mass is a property of a particle-set (of events), but a definite value of intensity of electromagnetic field is a property of a particular event, which is a member of this field-set (of events). Accordingly a field is a structure $\langle q, f \rangle$ where q is a set of events and f is a function which maps the set q into the set of

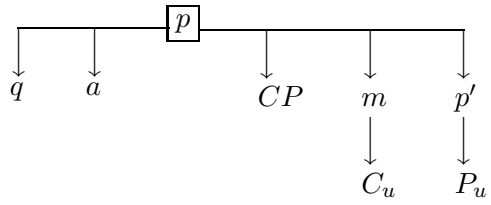
values of a magnitude A which characterizes the field in question; i.e. we have $f : q \to A$.

The eventistic reduction of spatio-temporal objects (see the right branch of the **EP**-diagram), amounts to the so-called *relationism* concerning the nature of space-time (the opposite view is known as *substantivalism*). Relationism in a natural way leads to an eventistic reduction of the physical objects (see the left branch of **EP**-diagram), and thus to EP.

3. Pointism (PK)

The name is my own invention. This doctrine can also be called *point monism* or *spatio-temporal monism*.

Diagram of **PK**:



The theses of **PK** are as follow:

PK1. The only individuals are points.

PK2. Every spatio-temporal objects except points is a (set-theoretical) set founded on points; in particular moments and space-points are specific sets of points, i.e. set-theoretical parts of CP.

PK3. Every physical object except events is a (set-theoretical) set founded on points; in particular particles and fields are some sets of points, i.e. set-theoretical parts of CP.

PK4. Every empirical object except events is a point or a set founded on points. It is a consequence of theses **PK1**, **2**, **3**.

The thesis **PK2** follows from the definitions: 1. of *moments* as abstraction classes of the simultaneity relation R_u in the set CP and 2. of *space points* as abstraction classes of the co-location relation of L_u in the set of CP. It

follows also from the definitions: of CP — as the set of all points, of C_u — as the set of all moments and of P_u — as the set of all space points.

The justification of the thesis **PK3** is more complicated, because pointism is an ontology *in statu nascendi*. To this end, a supporter of pointism should define things as space- and time-extended temporally continuous and causally connected sets of points, which requires that points enter into causal relation. This assumption is explicitly made e.g. by H. Field [1980]. The pointistic thing-like objects should be defined as such sets of points which are space- and time-extended but not endowed by temporal continuity and causal connectivity.

Since particles are things and fields are thing-like objects (defined as above), then we can treat these assumptions as a justification of the thesis **PK3**.

Another, more profound difference between particles and fields, similar to one pointed out in the case of **EP**, is the following one: In the case of a particle a property which characterizes it is attributed to the whole particle-set of points (resp. to its time cross-section). In the case of field (every) value of the physical magnitude which characterizes this field is attributed to the single point which is a member of this field-set of points. Accordingly a field is a structure $\langle q, f\rangle$, where q is a set of points and f is a function which maps the set q into the set of values of a magnitude A which characterizes the given field, i.e. we have $f : q \to A$.

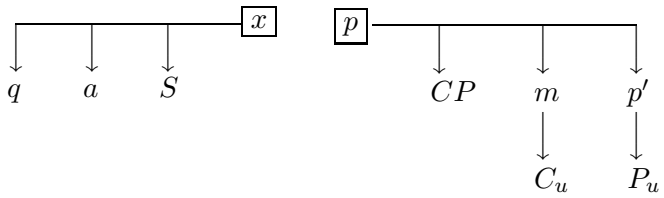
Remark. Two fields based on the same set of points q differ due to the difference in the corresponding functions: $f : q \to A$ and $f' : q \to B$ (where $A \neq B$); in other words they differ with respect to their characteristic magnitudes.

The pointistic reduction of spatio-temporal objects (see the right branch of the **PK**-diagram) comprises the so-called *substantivalism* concerning the nature of space-time (the opposite view is known as *relationism*). The above-mentioned pointistic conception of a field, as defended by H. Field and other authors constitutes, according to its adherents, a serious reason for the acceptance of substantivalism. I believe that it suggests more. Namely, a pointistic reduction of all physical objects, not only fields but also particles (see the left branch of **PK**-diagram). Therefore suggest global pointism. Note that R. Carnap in his earlier works (cf. Carnap [1929] and [1947]) indicated a possibility to represent particles and fields as some sets of space-time points characterized by some physical properties and magnitudes.

4. Dualism (DUA)

Strictly speaking: *physical-spatio-temporal dualism*. The view is represented by the following diagram:

Diagram of **DUA**



Clearly, this diagram is the combination of the left branch of the diagram for **EP** and of the right branch of the diagram for **PK**.

The theses of **DUA** are as follow:

DUA1. The only individuals are events as well as points.

DUA2. All spatio-temporal objects (except points) are sets founded on points. In particular, moments and space points are specific sets of points, i.e. set-theoretical parts of CP.

DUA3. Physical object which are not events are sets founded on events. In particular, particles and fields are specific sets of events, i.e. set-theoretical parts of S.

DUA4. Every empirical object is an event or a set founded on events, or a point or a set founded on points. It is a consequence of theses **DUA1**, **DUA2** and **DUA3**.

The thesis **DUA2** is the same as the thesis of **PK2** and it follows from pointistic definitions: of moments, space points, CP, C_u and P_u.

The thesis **DUA3** is the same as the thesis **EP3** and it follows from the assumption that particles are eventistically defined things, and fields are eventistically defined thing-like objects.

The dualism has to answer the question concerning the nature of the relation between events and points. Notice that theses **DUA1**, **2**, **3** do not suffice to answer this question.

Our experience suggests that *every event occurs at some point*, therefore the additional statement:

DUA5 $\bigwedge x \bigvee p\, Z(x,p)$, where Z is the relation of occurrence of x at p.

The question arises whether the dual statement: $\bigwedge p \bigvee x\, Z(x,p)$ has also to be accepted, i.e. whether at *every point occurs an event*? Two alternative answers are *a priori* possible: the first affirmative:

DUA6´ $\bigwedge p \bigvee x\, Z(x,p)$,

and the second: **DUA6″** which assumes neither **DUA6´** nor its negation:

DUA6″ $\bigvee p \bigwedge x \sim Z(x,p)$.

The claim **DUA6´** is characteristic for so-called *symmetrical dualism*, whereas **DUA6″** characterizes an asymmetrical dualism. The last version of dualism should, I think, be attributed to Newton.

Despite the monistic character of **EP** the question concerning the relation between events and points also arises for it. However, in **EP** both statements: $\bigwedge x \bigvee p\, Z(x,p)$ and $\bigwedge p \bigvee x Z(x,p)$ immediately follow from **EP2**. On the other hand, in **PK** the above question does not arise, for in that ontology there is no place for events.

It is clear from the above presentation that substantivalism can be incorporated not only into the monistic ontology — as in the case of pointism — but also into the dualistic ontology. Indeed, for relationism is very natural to treat it as a *prolongation* of eventism. On the other hand, the version of dualism in which points are defined by events (relationism), and at the same time physical objects are defined by points (the left branch of **PK**), seems to be a nonsense — in this case points appear both as individuals and as sets of events!

5. Extreme Eventism (EPE)

In the above presented ontology of **EP** the space-time relations (such as K, R_u, L_u and also R and L) are essential: they are used in eventistic definitions of space-time objects and of physical objects. Therefore, although according to **EP** every object is really physical, it is an event or a set founded on events, in these objects we have to do with something spatio-temporal treated as their *part* with respect to these relations.

From a point of view of an extreme eventist such a situation is quite unpleasant and therefore should be eliminated. In which way, however? This can and should be done with help of a physicalistic reduction of the

above-mentioned relations, i.e. by formulations of usual definitions of these relations by means of some strictly physical relations.

This idea, which started with Leibniz and still has supporters, is restricted to constructions of causal definitions of the temporal relations, exactly to a definition of the relation W (absolutely earlier) by means of causal relation H (which is asymmetric). They are both determined in the set S of all events. This is the *causal theory of time* and often it is expressed by the modal formula:

$$\bigwedge x \bigwedge y\,[W(x,y) \equiv \Diamond H(x,y)]$$

The success of the attempts of physicalistic reduction of the entire set of spatio-temporal relations would amount to the implementation of the program of **EPE**, the program of *reduction of space-time* to matter. The extant efforts at implementation of that program encounter however a very serious scepticism among philosophers of physics.

6. Extreme Pointism (PKE)

In the above presented ontology of **PK** physical relations, such as for example causal relation (which comprises all physical interactions), are essential. They are used in pointistic definition of things, in particular of particles. Moreover, from the view of **PK** physical properties of particles as well as physical magnitudes which characterize physical fields are also important. Therefore, although according to **PK** every object is spatio-temporal, a point or a set founded on points, in dealing with these objects we have to work with something physical taken as their *part*.

An extreme pointist is, for sore, not satisfied with this situation. Therefore he tries to implement the program of reduction of physical relations and properties to some strictly spatio-temporal relations and properties.

Hume may be considered the originator of the approach under consideration, due to his attempt to construct a temporal definition of causality. He tried to define causal relation by means of the relation of temporal precedence. As a matter of fact, the question as to the adequacy of this Humean approach is a question still discussed.

Ideas of extreme pointism have been given some reinforcement from physics. The General Theory of Relativity showed an immediate connection between the gravitational field and the curvature of space-time, which

sometimes is interpreted as showing that the gravitational field is just the curved space-time.

This gave a rise to many attempts at geometrization of other physical fields and properties of particles. In particular, J. A. Wheeler has introduced his idea of *geometrodynamics* (cf. [Wheeler 1962]). According to it all fields and particles are build from an *empty* space-time, in other words, *matter is reduced to space-time*. However, ten years later Wheeler gave up that program (see. [Misner, 1972]). Also many philosophers who had been fascinated with geometrodynamics followed him in that retreat.

Remark. Of course, the extreme pointism (**PKE**) differs from the developed physical structure of geometrodynamics. However the essence of both conceptions is in principle the same.

7. Comparison

The three ontological systems outlined above have one property in common: physical objects (particles and fields) and spatio-temporal objects (moments, space points etc.) defined by means of corresponding individuals (events, points) are treated here as set-theoretical sets grounded on some individuals.

Now, one can ask: why we have to work with set-theoretical but not mereological sets? My answer is: in **EP** and **DUA**, where at least some individuals are point-events, is not possible to define mereologically such physical objects as, for example, particles and fields, i.e. as mereological wholes or sets of events. Particles and fields cannot be mereological sets of events because they are space-and time-extended whereas (events) are not. Hence, the space-time extended objects cannot consist of space-time non-extended objects. The point-events are *logical* but not mereological atoms. Therefore, point-events should be considered as elements of set-theoretical sets but not mereological ones.

Similarly, in **PK** where individuals are space-time points, one also cannot define in mereological terms other physical objects. Indeed, particles and fields cannot be mereological sets of points, for the former are space-time extended but the latter are not such. Also, the points are *logical* but not mereological atoms; hence they can be elements of set-theoretical sets only.

Similar considerations concern spatio-temporal objects. In every of the above discussed ontological systems moments and space points are set-the-

oretical sets — of events in **EP** and of points in **PK** and **DUA**, for the following two reasons: The first, moments are space-extended, whereas space points are time-extended. Therefore, they cannot be mereological sets of events or points. The second, moments and space points are relative, whereas individuals are absolute. Thus only points can be space-time individuals.

Spatio-temporal objects such as space-time (CP), time (C_u) and physical space (P_u) can also be treated in the ontologies under consideration as set-theoretical sets of appropriate elements. This is in accordance with contemporary physics, where CP, C_u, and P_u are treated as set-theoretical sets, and all properties (metrical, topological etc.) attributed to them in physics are considered to be properties of the corresponding set-theoretical sets. However, we have here something more: the extended space-time CP cannot mereologically consist of non-extended points, the extended time C_u cannot consist of time-non-extended moments, and finally the extended space P_u cannot consist of space-non-extended space points.

Remark. The properties: *space-time extension* of CP, *time extension* of C_u, and *space extension* of P_u can easily be defined by means of appropriate relations: $\bar{K}$ (determined in CP), $\bar{R}$ (determined in C_u) and $\bar{L}$ (determined in P_u).

8. Physical World and Space-Time

This problem is analyzed in my recent paper [Augustynek, 1992]. Now I shall consider it in a broader perspective of the spectrum of ontologies under discussion: **EPE**, **EP**, **DUA**, **PK** and **PKE**. In each of them space-time is defined as the set of all points. Of course, it is equipped with specific space and time relations. This characterisation is consistent with contemporary physics.

In each of these ontologies the physical world is defined as the set-theoretical set of such physical objects as: events, elementary particles (and their aggregates) and physical fields. This general approach also is again consistent with contemporary physics.

According to eventism **EP** the physical world is the set S of event-individuals; particles and fields are set-theoretical parts of it. However, points also are some set-theoretical parts of S. CP is the set of all points, therefore it is an *emanation* of the physical world, i.e. a superstructure over S. Consequently, it is not existentially independent of S (see [Augustynek 1992]).

Extreme eventism **EPE** postulates the reduction of time and space relations to some strictly physical relations. Such physicalization deprives the space-time of all vestiges of its autonomy attributed to it in, for example, **EP**. In **EPE** *space-time is reduced to matter*.

According to dualism **DUA** the physical world is the set of all events-individuals, whereas particles and fields are its set-theoretical subsets. The space-time, CP, is however the set of points which also are individuals: and moments and space points are specific subsets of CP, i.e. its set-theoretical parts. The physical world S and space-time CP constitute thereby two different universes which are existentially independent of one another.

According to pointism **PK** space-time is the set CP of all points-individuals; moments and space points are some set-theoretical parts of CP. Also, the physical objects: particles and fields (equipped with special physical properties) are some specific sets of points, and thus set-theoretical parts of CP. The physical world is therefore some *emanation* or set-theoretical structure over the space-time CP. It is not existentially independent of CP. In fact, CP is the only existentially independent component of reality.

Extreme pointism **PKE** postulates the reduction of physical relations and properties of particles and fields to some space-time relations and properties. In that approach the physical world is deprived of any degree of autonomy relative to space-time. In consequence *matter is reduced to space-time*.

9. Evaluation

From the view-point of the present state of physics and also of its evolutionary trends, the extreme ontologies of the Leibnizian **EPE** and the Wheelerian **PKE** cannot be accepted (cf. [Earman 1972]). It remains possible, however, that in the future new facts and theories of physics would justify one of these extreme position. Today only three ontologies are worthy to be considered seriously: eventism **EP**, dualism **DUA** and pointism **PK**.

Up to my mind, the physical space-time dualism is unacceptable. I cannot envisage a reality which would consists of two different and mutually independent parts which are bounded together. Such a *division* of reality heeds a special explanation. Also, although that dualism is not in contradiction with contemporary physics, it is in some collision with that evolutionary trend in physics which leads to unification of different fields and different kinds of particles. Finally, I am a supporter of relationism (see [Augustynek 1992]), while substantivalism is an essential part of dualism.

I do not agree with pointism either. I do not think that physical world is some *emanation* of space-time, it seem to be an absurd. The defeat of geometrodynamics is also a serious evidence against it.

Moreover, I think that **PK** has a serious formal defect. Within **EP** it is possible to define points as some sets of events. That is admissible in the view of the Theory of Relativity. According to **PK** events are not individuals and it is possible to define them as some sets of points, namely as singleton-points equipped with some property (i.e. like: $x = \{p, F\}$). In the light of the Theory of Relativity such a definition however is a nonsense. According to Relativity point-events are individuals, not sets.

In consequence, I remain on the side of eventism. It has a few advantages which strongly appeal to me. I think that this ontology accords better than any other with contemporary physics and particulary with Theory of Relativity. There is very serious argument against relationism. It refers to empty and meaningful solutions of equations of gravitational field. I do not ignore that argument, however, trying to show why it is not fatal for eventism (cf. [Augustynek 1992]).

In accordance with **EP** I think that space-time is a kind of some *emanation* of physical world which has some autonomy. I.e. space-time relations are not reducible to usual physical relations, like causal and nomological relations. Of course, that autonomy does not rule out some connections between spatio-temporal and physical relations. The recognition of the said irreducibility distinguished a version of **EP** ontology which I prefer from its extreme version.

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