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Poincaré's Ether: B. What characterizes Poincaré's ether?

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In this paper I discuss Poincaré's solution to the following problem: the principle of relativity is not valid for rotations and we thus can claim for absolute rotation. The principle of relativity was experimentally not valid for uniform rotations, and therefore it lost of its complete validity. Logical conventionalism (the philosophical principle of relativity) also lost of its complete validity. Therefore, since the principle of relativity was not *a priori* completely valid, we could disclose absolute motions with respect to absolute space, or speak of a reality independent of the observer. Poincaré could not accept this. He therefore postulated the ether as a material body in absolute rest. By doing so he felt that the principle of relativity regained its complete validity, because by no experimental means could we disclose absolute space (1908a, p. 567): "it is impossible to escape this impression that the principle of relativity is a general law of nature, that one can never by any imaginable means get evidence of any but relative velocities, and by this I mean not merely the velocities of bodies in relation to the ether, but the velocities of bodies in relation to other bodies".

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Newton: absolute motion and absolute space

According to Newton in his *Principia* (1729, p. 6; an English translation): "Absolute space, in its own nature, without relation to anything external, remains always similar and immovable". Absolute space is necessary for Newton, because according to his conception, God being in all places perceives what happens in the world; and in order to perceive created things, he needs an organ, namely space. Human beings perceive the world using their senses. But if God is to perceive what happens in the world, he must do so in a less indirect way. Newton therefore suggests that all infinite space is God's sensorium. Since God perceives and knows everything (infinite knowledge), infinite absolute space is an organ to omniscience (Alexander, pp. xv-xvi).

Afterwards Newton defines relative space in the following way (1729, p. 6; an English translation): "Relative space is some movable dimension or measure of the absolute spaces […]". According to Jammer (1954, pp. 100-104), Newton's relative spaces are what we call today coordinate systems. All these relative spaces may be moving coordinate systems that move in absolute and immutable space. To Newton, absolute space is a logical and ontological necessity. It is a necessary prerequisite for the validity of Newton's first law of motion, according to which "every body continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it (Newton, 1729, p. 13). Therefore, rectilinear uniform motion requires a reference system different from that of an arbitrary relative space. The reference system in which Newton's first Law holds is an inertial system and it is not uniquely determined. Newton's mechanics is invariant for a translational transformation with constant velocity. Therefore a whole class of reference systems or "spaces" complies with this requirement. He wrote "the motions of bodies included in a given space are the same among themselves, whether that space is at rest, or moves uniformly forwards in a right line without any circular motion" (Newton, 1729, p. 20). This is the mechanical principle of relativity. Therefore for Newton there existed one absolute space and a multitude of inertial systems. How is absolute space to be distinguished from among the multitude of inertial systems? Newton first suggests the hypothesis that the center of the world (the center of gravity of the system composed of the sun, the earth, and the planets) is immovable. According to the Ptolemaic astronomy the earth is fixed in that center while according to the Copernican system the sun is fixed in that center. However they both acknowledge that this center is in absolute rest. According to the principle of relativity this center either is at rest or moves uniformly forward in a straight line. The latter alternative is eliminated by Newton's hypothesis. Therefore the center of the world is at absolute rest in absolute space. This assumption escapes all possibility of experimental or observational verification.

After defining Absolute space, and absolute time (which "flows equably without relation to anything external"), Newton defines Place (1729, p. 6): "Place is a part of space which a body takes up, and is according to the space, either absolute or relative". He then defines motion (1729, p. 7): "Absolute motion is the translation of a body from one absolute place into another; and relative motion, the translation from one relative place into another." According to Newton, absolute space can be determined through the existence of centrifugal forces in rotational motion. Newton implicitly wanted to show that centrifugal forces determined absolute motion, which in its turn determined absolute space.

Poincaré: relative motion and the ether

As opposed to Newton, Poincaré reasoned (1900b, pp. 458-459):

> *There is no absolute space and we only perceive relative movements; however one expresses most often mechanical facts as if there was an absolute space to which they could be referred.*

We need the ether for the purpose of eliminating absolute motion with respect to absolute space. Poincaré eliminates Newton's absolute space by suggesting the ether and concentrates on relative spaces only.

The above quoted claim contains two parts:

1) Poincaré explained in *Science and Hypothesis* that the principle of relativity eliminates absolute space, rest and motion (1902, p. 100):

> *The state of bodies and their mutual distances at any given instant, as well as the velocities with which those distances are changing at that instant, will depend only on the state of those bodies, on their mutual distances at the initial instant, and on the velocities with which those distances were changing at the initial moment; but they will not depend on the absolute initial position of the system nor on its absolute orientation, nor on the velocities with which that absolute position and orientation were changing at the initial instant.*

2) The principle of relativity is imposed upon our mind and any contrary hypothesis is repugnant to the mind. Unfortunately the principle thus formulated does not agree with experiments, because absolute rotation of a body might be clearly shown. But then, why is the principle only true for uniform and rectilinear motion? It should be imposed upon us with the same force for accelerated motion, or at least for a uniform rotation.

Poincaré explained these views in the form of a parable (1902, p. 100): If the sky of some planet was forever covered with clouds, so that we could never see the other stars (Mach's fixed stars cannot be taken into account in this world), we would still be able to conclude that the earth turns round itself. For example, we would be able to perform Foucault's pendulum experiment. However, we could then say: If we say that the earth turns round, it must turn around something. Then we could assume that it turns around with respect to absolute space. If there is no absolute space then the earth cannot turn without turning with respect to something. Poincaré was thus worried (1902, p. 131; my italics): "That does not prevent absolute space – that is to say, *the point to* which we must *refer* the earth to know if it really does turn round – from having no objective existence". Against this Poincaré said (1902, p. 100):

> *Now, here is a fact which shocks the philosopher, but which the physicist is forced to accept.*
> *We know that from this fact, Newton concluded the existence of absolute space. I myself cannot accept this way of looking at it.*

The physicist expresses physics in this way and holds that rotations (i.e. the "mechanical facts") happen as if absolute space existed, because he can formulate a principle of relativity only for rectilinear and uniform motions. In order not to be forced to accept absolute space, the physicist can make a compromise: he can eliminate absolute empty space and retain an all-pervading ponderable body at rest, the ether. He can define all motion with respect to ponderable bodies as relative motions, but formulate the principle of relativity in such a manner that relative motion with respect to the ether can never be disclosed and only relative motions of bodies with respect to other material bodies are detectable (1900b, p. 477; 1902, p. 129): "The motion of some system has to obey the same laws, whether with respect to fixed axes, or to mobile axes carried by a rectilinear and uniform motion".

Like absolute space, the philosopher says that this ether does not really exist; we have invented it. Once it has been invented, everything happens for the physicist as if it existed. We invented the ether in order to explain stellar aberration and to eliminate instantaneous action-at-a-distance interactions. This ether eliminated the need for absolute space when dealing with rotations. Stellar aberration, instantaneous action-at-a-distance and uniform rotation required the ether in the scientific explanation. Poincaré thus retained the ether at absolute rest as a convenient hypothesis but rejected the existence and the convenience of absolute space. I shall explain this from the physical point of view.

If we discover that the motion of the earth influences optical and electrical phenomena, we will be able to reveal absolute motions. It will be therefore necessary to have an ether, because absolute motions cannot take place with respect to empty space, but with respect to something concrete. "Will we ever arrive at it?" Poincaré's answer was negative, because he firmly believed in the principle of relativity (1900a, pp. 1171-1172).

The earth revolves *round the sun* with a velocity of 30 km/sec. However, we notice nothing of this motion; all mechanical events on the earth occur as if this tremendous forward motion does not exist, because during the short period of time of the observation, the earth's motion is practically rectilinear and uniform (Born, 1962, pp. 67-68). This is an enunciation of the principle of relativity in classical mechanics as defined further above (1900b, p. 477; 1902, p. 129). This principle by definition eliminates every possibility of ever discovering absolute motions: it applies to matter alone. Therefore, if Poincaré believed in the principle of relativity, why was he in need of the ether? He approximately gave the following answer:

If Lorentz's electron theory (the electrodynamical theory of electrons immersed in stationary ether, the theory that was the prevailing one until 1905) is true, the principles of mechanics and of relativity do not "apply to matter *alone*" (1900a, p. 1172). This difference should be accessible to experiment. On the other hand, many ether-drift experiments have been performed in order to check whether there is an influence on optical and electrical phenomena of the earth's motion through the ether. The results have always been negative. This confirms the principle of relativity, which applies to matter alone. However, we have performed these experiments because we were not sure (in light of Lorentz's theory) beforehand that the principle of relativity actually applied to matter alone. May be it applied also to the ether using compensations? Indeed such compensations were used to verify *a posteriori* the principle of relativity in Lorentz's theory.

However, if we believe in this last suggestion, we should expect to see improved methods of experimentation giving positive results to the ether-drift experiments. Poincaré thought, "such an experiment is illusory" (1900a, p. 1172).

In this situation we have a choice between two possibilities:

1. We can eliminate the ether and claim that according to the principle of relativity applied to matter alone, we can never reveal absolute motions.
2. On the other hand, we can retain the ether and claim that since the principle of relativity is valid for both matter and ether (using compensations), we can never practically reveal absolute motions, because no improved experimentation method can ever give positive results to ether-drift experiments.

The two possibilities rely on the validity of the basic contents of the principle of relativity.

Rotation of the earth and the ether

I shall now extend Poincaré's reasoning to the rotation of the earth round itself. During the short period of time of the observation the earth's path is not practically rectilinear and uniform. The principle of relativity is no more valid for such motions and therefore we cannot choose possibility number 1). We will thus be able to reveal absolute motions. We thus have to assume the ether so that we will not have to speak of the earth's *absolute velocity* with respect to *absolute space*, but its velocity with respect to the ether. Poincaré explained this in the following sources.

Towards the end of *Science and Hypothesis* he asserted (1902, pp. 242-243): "What we could measure in that way, is not their absolute velocity, but their relative velocity with *respect to the ether*, so that the principle of relativity is safe". In his popular paper, "The End of Matter" Poincaré asserted that (1906, p. 202): "We could know not only the relative motion of the earth with respect to the sun, but also its absolute motion in the ether". In 1902, Poincaré defined velocity with respect to the ether as relative *velocity*. In 1906 he defined it as absolute *motion*. This exactly discloses Poincaré's compromise: rigorously speaking *motion* with respect to an ether at absolute rest is absolute *motion*, however, physically speaking, we say "relative *velocity*," since the ether is a ponderable medium and therefore we can speak of the earth's relative *velocity* with respect to this medium. In his paper, "The Relativity of Space" Poincaré confessed (1907, p. 3):

> *I have myself fallen a victim to the tenacious illusion that makes us believe that we think of an absolute space. I was thinking of the earth's motion on its elliptical orbit round the sun, and I allowed 30 kilometers per second for its*

> *velocity. But its true velocity, this I do not know, I have no means of knowing.*

When Poincaré included this paper in his general book a year later, *Science and Method*, he added a phrase (after the words "true velocity") that did not appear in the original paper (1908b, pp. 98-99): "(I understand, this time, not its absolute velocity, which has no sense, but its velocity with respect to the ether)". Velocity with respect to the ether is relative, while velocity with respect to absolute space is absolute velocity. True velocity is velocity with respect to the ether.

After 1905 Poincaré's idea was taken up by the partisans of the electromagnetic world-picture in order to attack the proponents of Einstein's (special) principle of relativity. One of the leaders of the electromagnetic world-picture was Kaufmann. In a discussion revolving around the merits of each world-view, that was held after Planck's lecture, on the 19th of September 1906, in Stuttgart, Kaufmann asserted that (Planck, 1906, p. 761): "[...] there is an attempt to get rid of the ether which is regarded as unpleasant but we have to return to it in rotation movements, for example in the domain of the obletelness of the heavenly body".

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