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Translation:Uniform Rotation of Rigid Bodies and the Theory of Relativity

Uniform rotation of rigid bodies and the theory of relativity.

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In the attempt to generalize the kinematics of relative-rigid bodies from uniform, straight-line translation to any form of motion, we come, on the basis of MINKOWSKI's ideas, to the following approach:

A body is relative-rigid, that is: *it is deformed continuously at any movement, so that (for a stationary observer) each of its infinitesimal elements at any moment has just that Lorentz contraction (compared to the state of rest) which corresponds to the instantaneous velocity of the element's center.*

When (some time ago) I wanted to show me the consequences of this approach, I came to conclusions which seem to show that *the above approach already leads to contradictions for some very basic types of motion.*

Now, BORN in a recent paper[1] gave a definition of relative-rigidity, which includes all possible motions at all. BORN has based this definition – in accordance to the basic idea of relativity theory – not on the system of measurement of a *stationary* observer, but on the (MINKOWSKIan) measure-determinations of, say, a continuum of infinitesimal observers who *travel along* with the points of the non-uniformly moving body: *for each of them in their measure the infinitesimal neighborhood should appear permanently undeformed.*

However, both definitions of relative-rigidity – if I understood correctly – are equivalent. It is permissible, therefore, to point in short to the simplest type of motion, for which the first definition already leads to contradictions: *the uniform rotation about a fixed axis.*

In fact: let a relative-rigid cylinder of radius R and height H be given. A rotation about its axis which is finally constant, will gradually be given to it. Let R' be its radius during this motion for a stationary observer. Then R' *must satisfy two contradictory conditions*:

a) The periphery of the cylinder has to show a contraction compared to its state of rest:

$$2\pi R' < 2\pi R,$$

because each element of the periphery is moving in its own direction with instantaneous velocity $R'\omega$.

b) Taking any element of a radius, then its instantaneous velocity is normal to its extension; thus the elements of a radius cannot show a contraction compared to the state of rest. It should be:

$$R' = R.$$

Note: If we don't want, that the deformation only depends on the instantaneous velocity of the element's center, but also on the instantaneous rotation velocity of the element, then the deformation function must contain a universal dimensionless constant besides the speed of light, or the accelerations of the element's center must be included as well.

St. Petersburg, Sept. 1909.

(Received September 29, 1909.)

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1. M. Born, Die Theorie des starren Elektrons in der Kinematik des Relativitäts-Prinzipes. Ann. d. Phys. 30, 1, 1909. See also in this journal, 10, 814, 1909.

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