On the principle of relativity in the electrodynamics

D.L. Khokhlov

Sumy State University, R.-Korsakov St. 2,
Sumy 40007, Ukraine
E-mail: khokhlov@cafe.sumy.ua

Abstract

It is shown that the principle of relativity in the electrodynamics is equivalent to the postulate of invariance of the speed of light. Equation for this postulate is invariant under the Galilei transformation. Then the principle of relativity in the electrodynamics specifies the Euclidean space and the universal time.

The principle of relativity is a milestone in the foundations of physics. It reads that an observer in any inertial frame cannot reveal the motion of the frame while performing the physical experiments in this frame. In the Newtonian mechanics, the principle of relativity may be enunciated as invariance of laws of the Newtonian mechanics under the Galilei transformation. The following statement is valid that the principle of relativity, the Galilei transformation, specifies the Euclidean space and the universal time in the Newtonian mechanics.

Equations of electrodynamics, Maxwell-Lorentz equations, are not invariant under the Galilei transformation. This raises a question about the validity of the principle of relativity in the electrodynamics. Einstein developed the theory of special relativity [1] on the basis of two postulates, the principle of relativity (invariance of Maxwell-Lorentz equations) and the postulate of invariance of the speed of light in all inertial frames. From this Einstein obtained the Lorentz transformation which leaves Maxwell-Lorentz equations invariant. According to Einstein, it is the Lorentz transformation specifies the space and time. This leads to replacement of the Euclidean space and the universal time by the space-time of Minkowski.

The postulate of invariance of the speed of light in all inertial frames means identity of the scales of length and time in all inertial frames provided an observer measures these scales in his own frame. This postulate is expressed as $l/t = c$. The above equation is invariant under the Galilei transformation. Then the postulate of invariance of the speed of light requires the Euclidean space and the universal time.

The postulate of invariance of the speed of light is independent of Maxwell-Lorentz equations. This postulate gives the invariant speed of light which enters in Maxwell-Lorentz equations. The validity of the postulate of invariance of the speed of light means that an observer in any inertial frame cannot reveal the motion of the frame while performing electromagnetic experiments in this frame. Given the postulate of invariance of the speed of light invariance of Maxwell-Lorentz equations is not needed to enunciate the principle of relativity in the electrodynamics. Then the principle of relativity in the electrodynamics is equivalent to the postulate of invariance of the speed of light. Thus the principle of relativity in the electrodynamics as the postulate of invariance of the speed of light specifies the Euclidean space and the universal time.

From the above consideration it follows that the Lorentz transformation yields the relativistic effects in the electrodynamics but do not specifies the space and time. Then the relativistic effects pertain only to the dynamical parameters of the electromagnetic field.

References

[1] W. Pauli, *Theory of Relativity* (Pergamon, New York, 1958).