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MATHEMATICAL MODELS OF CLASSICAL ELECTRODYNAMICS

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Abstract. Four mathematical models of classical electrodynamics based on vector fields, tensor spaces, geometric algebras and differential forms are represented in parallel and compared.

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1. Introduction

In December 1865, the great Scottish physicist James Maxwell presented to the Royal Society of London his original paper [11]. Initially Maxwell has formulated his theory in terms of twenty equations. Later, in 1873, he published his next important paper [12], where he reduced his system to twelve scalar equations. The further development showed that even eight scalar equations are sufficient! The main mathematical advantage of his system of equations was that he offered one electromagnetic model which "in principle" discovered all the important natural effects that are related to electromagnetic field theory. The main physical disadvantage of his model was that he thought that for the electromagnetic waves (predicted by him) is necessary of existence a special medium called "ether". Further experiments did not reveal the existence of such "artificial medium". He introduced this concept used analogy with acoustical waves that such a medium is necessary (like air, for example). Nevertheless his mathematical description of the electromagnetic waves was correctly. This was proved experimentally about twenty years after by the gifted German physicist Heinrich Hertz reported in [7].

The main difference between the acoustical waves and the electromagnetic waves is that the first ones are "scalar longitudinal waves", while the second ones are