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Proposal of New Operator in Four-Dimensional Wave Equation

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Abstract: *Four-dimensional equation of a progressive wave is proposed to express wave-criterion in four-dimensional world. Moreover in this equation a new mechanical operator is obtained.*
Keywords*- Three and Four-Dimensional Wave Criteria, Relativistic Mechanics, Progressive Gravitational Wave.*

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I. Introduction

It is already known that three-dimensional equation of a progressive wave is $d^2\psi/dx^2+ d^2\psi/dy^2+ d^2\psi/dz^2=1/u^2.d^2\psi/dt^2$; where ψ is wave amplitude and u is the velocity of wave. But when a progressive wave moves in four-dimensional nature, then it can obviously obey four-dimensional wave equation. Here four-dimensional formulation of a progressive wave can be drawn to deduce the reality of this wave in four-dimensional world.

II. Formation of Operator-Relation

In four-dimensional generalization, it is written that $x_1=x$, $x_2=y$, $x_3=z$ and $x_4=ict$. In terms of differentials, $dx_1=dx$, $dx_2=dy$, $dx_3=dz$ and $dx_4=icdt$. From operator representation, $d/dx_1=d/dx$, $d/dx_2=d/dy$, $d/dx_3=d/dz$ and $d/dx_4=1/ic.d/dt$.Now taking square in both sides, $d^2/dx_1^2=d^2/dx^2$, $d^2/dx_2^2=d^2/dy^2$, $d^2/dx_3^2=d^2/dz^2$ and $d^2/dx_4^2=1/i^2c^2.d^2/dt^2$. By addition, $d^2/dx_1^2+ d^2/dx_2^2+ d^2/dx_3^2+ d^2/dx_4^2=d^2/dx^2+ d^2/dy^2+ d^2/dz^2-1/c^2.d^2/dt^2$. This is the desired operator-relation.

III. Foundation of Wave Equation

If the amplitude of a progressive wave is ψ; then multiplying in both sides of above operator-relation by ψ, it is obtained that $d^2\psi/dx_1^2+ d^2\psi/dx_2^2+ d^2\psi/dx_3^2+ d^2\psi/dx_4^2=d^2\psi/dx^2+ d^2\psi/dy^2+ d^2\psi/dz^2-1/c^2.d^2\psi/dt^2$. This is the required wave-relation.

From three-dimensional wave equation, it is written that $d^2\psi/dx^2+ d^2\psi/dy^2+ d^2\psi/dz^2=1/u^2.d^2/dt^2$ or $d^2\psi/dx^2+ d^2\psi/dy^2+ d^2\psi/dz^2-1/u^2.d^2/dt^2 =0$. In case of light wave, the relation is $d^2\psi/dx^2+ d^2\psi/dy^2+ d^2\psi/dz^2-1/c^2.d^2/dt^2 =0$; where c is the velocity of light. Thus by putting the above value, the four-dimensional wave equation is $d^2\psi/dx_1^2+ d^2\psi/dx_2^2+ d^2\psi/dx_3^2+ d^2\psi/dx_4^2=0$.

IV. Suggestion for New Operator

The above wave equation be considered as the following form: $[d^2/dx_1^2+ d^2/dx_2^2+ d^2/dx_3^2+ d^2/dx_4^2]\psi=0$. Let it be assumed that $d^2/dx_1^2+ d^2/dx_2^2+ d^2/dx_3^2+ d^2/dx_4^2=\Diamond^2$=a new mechanical operator in relativistic mechanics. So $\Diamond^2\psi=0$. This is the modified form of four-dimensional wave equation of a progressive wave.

V. Conclusion

In course of discussion, it is discussed that the progressive wave which moves with a velocity equals to the velocity of light can obey the above wave equation. In this respect, gravitational wave is mentioned here. According to general relativity, gravitational energy is carried by gravitational waves. These waves move with the velocity of light. Thus the wave equation of a progressive gravitational wave is $\Diamond^2\psi=0$. This relation can express the reality of progressive gravitational waves.

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