LETTER

Delta-String—A Hybrid between Wormhole and String

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The flux tube solutions in 5D Kaluza-Klein theory can be considered as string-like objects—Δ-strings. The initial 5D metric can be reduced to some inner degrees of freedom living on the Δ-string. The propagation of electromagnetic waves through the Δ-string is considered. It is shown that the difference between Δ and ordinary strings are connected with the fact that for the Δ-string such limitations as critical dimensions are missing.

KEY WORDS: Wormholes; strings; Kaluza-Klein theory.

1. INTRODUCTION

The difference between point-like particles and strings on the one hand, and Einstein’s point of view on an inner structure of matter on the other hand is that according to Einstein everything must have an inner structure. Even more: at the origin of matter should be vacuum. In string theory a string is a vibrating 1-dimensional object and the string has many different harmonics of vibration, and in this context different elementary particles are interpreted as different harmonics of the string. The string degrees of freedom are the coordinates of string points in an ambient space.

In this paper we would like to consider the situation when the string has an inner structure. The question in this situation is: what will be changed in this

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situation? Definitely we can say that in this situation the string is an object which effectively arise from a field theory and such object has inner degrees of freedom which are not connected with an external space. As a model of such kind of string-like object we will consider gravitational flux tubes. These tubes are the solutions in 5D Kaluza-Klein gravity [1] filled with electric $E$ and magnetic $H$ fields. If $E = H$ we have an infinite tube, if $E \approx H$ (but $E > H$) the length of the tube can be arbitrary long and the cross section can be $\approx l_{Pl}$ ($l_{Pl}$ is the Planck length) [2]. Such flux tube can be considered as a string attached to two Universes or to remote parts of a single Universe. For the observer in the outer Universe the attachment points looks like to point-like electric and magnetic charges (see Fig. 1).

We have to note that similar construction was presented in Ref. [3]: the matching of two remote regions was done using 4D infinite flux tube which is the Levi-Civita - Bertotti - Robinson solution [4], [5] filled with the electric and magnetic fields.

2. GRAVITATIONAL FLUX TUBE

In this section we will describe the gravitational flux tube and why it can be considered as a $\Delta$–string. At first we would like to explain why we use the word $\Delta$ for the super-long and thin gravitational flux tube. The thickness of the gravitational flux tube can be arbitrary small and we choose its in the Planck region. In this case near to the attachment point of the tube to an external Universe the handles of a spacetime foam will appear between this object and the Universe. This is like a delta of the river flowing into the sea, see Fig. 2. This remark allows us to call the super-long and thin gravitational flux tube as the $\Delta$–string. Let us