Confronting dilaton-exchange gravity with experiments

H.V. Klapdor-Kleingrothaus\textsuperscript{a}, H. Päś\textsuperscript{a}, U. Sarkar\textsuperscript{b}

\textsuperscript{a} Max-Planck-Institut für Kernphysik, P.O. Box 103980, D-69029 Heidelberg, Germany
\textsuperscript{b} Physical Research Laboratory, Ahmedabad 380 009, India

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Abstract

We study the experimental constraints on theories, where the equivalence principle is violated by dilaton-exchange contributions to the usual graviton-exchange gravity. We point out that in this case it is not possible to have any CPT violation and hence there is no constraint from the CPT violating measurements in the $K$-system. The most stringent bound is obtained from the $K_y - K_s$ mass difference. In contrast, neither neutrino oscillation experiments nor neutrinoless double beta decay imply significant constraints. © 2000 Published by Elsevier Science B.V.

At present we have no indication for the violation of gravitational laws. But some theories like string theory suggest deviations from the usual graviton-exchange theories of gravity. Thus it becomes necessary to find out the extent of applicability of the general theory of relativity. Several experiments were performed to test the equivalence principle [1] for ordinary matter and to test local Lorentz invariance [2,3]. Attempts were also made to test these laws in the neutrino sector [4–6], but these works included only tensorial interactions. In the K-system both tensorial and vectorial interactions were studied by many authors [7].

Recently it has been suggested [8] that string theory may lead to a different kind of violation of the equivalence principle (VEP) via interactions of the dilaton field, which gives an additional contribution to the usual graviton exchange gravity. The resulting theory is of scalar-tensor type (in contrast to purely tensorial VEP discussed previously) with the two particle static gravitational energy

$$V(r) = -G_N m_A m_B (1 + \alpha_A \alpha_B) / r, \quad (1)$$

where $G_N$ is Newton’s gravitational constant and $\alpha_j$ are the couplings of the dilaton field $\phi$ to the matter field of type $j$. This additional contribution may result from a gravitational interaction

$$L = m_1 \alpha_j \phi \bar{\psi}_j \psi_j. \quad (2)$$

The distinct feature of this new contribution are specific couplings of the dilaton field to different matter fields, which violates the equivalence principle. It has been discussed recently whether this feature can be tested in neutrino oscillation experiments [9,10].

Unlike the violation of the equivalence principle through tensorial interactions, in the dilaton-exchange gravity the gravitational basis is always the