Smoothing (out) Negative Tension Brane

Theoretical Physics Laboratory, RIKEN, Saitama 351-0198, Japan Kin-ya Oda
E-mail: odakin@riken.jp

Recent progress in string theory has revealed that the compactified space is generically warped under the presence of fluxes. In the five dimensional effective field theory, Randall and Sundrum have shown that the warped compactification can generate the large hierarchy between the weak and Planck scales. In this Randall-Sundrum 1 model, the fifth dimension y is compactified on S^1/Z_2: $-L < y \leq L$ and two points y and $-y$ are identified. The gravitational part of the action reads

$$S = M_5^3 \int d^5x \left[\sqrt{-g} \left(\frac{R}{2} - \Lambda_5 \right) - \sqrt{-g^{(4)}} \Big(\lambda_0 \delta(y) + \lambda_L \delta(y - L) \Big) \right], \tag{1}$$

where $g^{(4)}$ is the four dimensional induced metric. To keep the four dimensional cosmological constant Λ_4 at the observed value $\Lambda_4 \lesssim 10^{-120} M_P^4$, where M_P is the four dimensional Planck scale, we need the fine tuning among the five dimensional bulk cosmological constant Λ_5 and the brane tensions λ_0, λ_L:

$$\Lambda_5 = -k\lambda_0 = k\lambda_L < 0, \tag{2}$$

where k is the curvature scale of the five dimensional anti de Sitter space (AdS_5). The UV brane at $y = 0$ has positive tension while the IR brane at $y = L$ has negative. The negative tension object has long been known to be problematic in general relativity. Here we attempt to smooth it out. See [1] for further motivations and discussions.

The following modification of the action:

$$S = M_5^3 \int d^5x \sqrt{-g} \left(\frac{R}{2} - \Lambda_5 \epsilon(y)^2 - \lambda \frac{\epsilon'(y)}{\sqrt{g_{yy}}} \right) \tag{3}$$

provides a way to smooth out our metric to be $g = e^{-2\sigma(y)} dx^2 + dy^2$, where $\sigma(y) = k \int dy \epsilon(y)$ can be an arbitrary function by a proper choice of ϵ. We have checked that this modification can be compatible with the Goldberger-Wise mechanism. Further, the action (3) can be rewritten by the wrong-sign kinetic term for the auxiliary four form field:

$$S = \frac{M_5^3}{2} \int \left(R \wedge *1 + F_5 \wedge *F_5 \right). \tag{4}$$

Implications of these results will be discussed in [1].

Reference

[1] K. Oda, T. Suyama and N. Yokoi, in preparation.