

Notes

An alternative to KK Redux:

We want to find a realization of these ideas.

Turns out a useful strategy



SM lives there really happens  $\psi, \psi, A_n, \dots$

also consider closing fluxes long or short  
 you (extension)  $\rightarrow$  asking to whom or not fluxes!

+ gravity in bulk

$\rightarrow$  can be superfluous but sometimes so relevant

$\downarrow$   $g_{\mu\nu}(x) \Rightarrow$  induced metric  $g_{MN}(x) = G_{MN}(x) + \frac{1}{\alpha^2} \frac{dx^M dx^N}{dy^a dy^b}$

$$S_{bulk} = \int d^5x \sqrt{-G} \left\{ -\Lambda + 2M^3 R^5(x) + \dots \right.$$

$$S_{brane} = \int d^4x \sqrt{-g} \left\{ -\mathcal{L}_{matter} + g_{\mu\nu} D_\mu \psi D_\nu \psi + \dots \right.$$

+ SM couplings

Image courtesy of Lisa Randall

**In 1998**, theorists Lisa Randall and Raman Sundrum met in a coffee shop in Boston to discuss how extra dimensions of space would change the predictions of particle theories.

Several months later they began to apply their ideas to one of the most puzzling questions about particles and forces: Why is gravity so much weaker than all other known forces?

For more than 30 years theorists had tried to find an explanation. In 1999, Randall and Sundrum published two revolutionary papers on how to use the concept of extra dimensions in gravity in a new way, boldly claiming in the first paper that "the experimental consequences of this scenario are new and dramatic."

On this page from 1999, with the headline "An alternative to KK redux," Randall laid the groundwork for the second paper, "An Alternative to Compactification." The acronym KK refers to theorists Theodor Kaluza and Oskar Klein and their publications in 1919 and 1926. To obtain physically meaningful quantities, the KK theory requires extra dimensions to be of finite ("compact") size. Randall and Sundrum developed a method to introduce infinite dimensions. The equations here treat the overall universe in five dimensions ("bulk"), while ordinary matter resides in four-dimensional space-time ("brane").

Since being published, the two Randall-Sundrum papers on extra dimensions have ranked among the Top 10 most-cited publications in all of high-energy physics every year. **Kurt Riesselmann**