Centre for Research in String Theory :

David Berman

Andreas Brandhuber

Sanjaye Ramgoolam

Rodolfo Russo

Bill Spence

Steven Thomas

Gabriele Travaglini

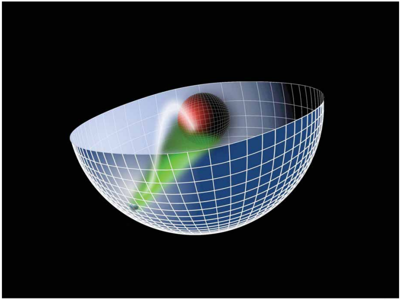
Brian Wecht (new faculty arriving in October)

+ 2 postdocs + 10 graduate students.

String Theory and hidden geometries

Sanjaye Ramgoolam

Queen Mary, Univ. of London



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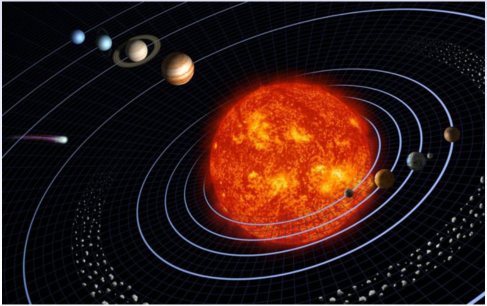
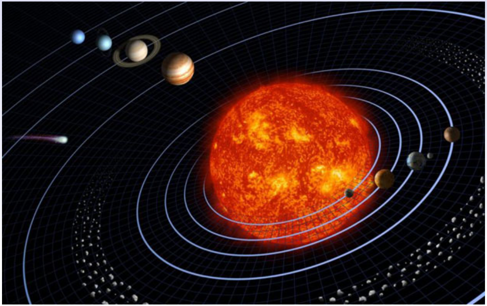


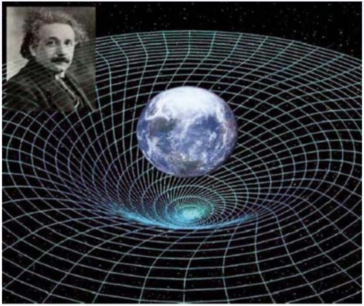
From falling apples to orbiting planets, Newton explained that there is one underlying equation :



From falling apples to orbiting planets, Newton explained that there is one underlying equation :

$$F = \frac{GMm}{r^2}$$

FORCE of gravity $\leftrightarrow$ CURVATURE of Spacetime



Now the key player is the metric $g_{\mu\nu}(t = x_0, x_1, x_2, x_3)$ which describes the curvature of space-time. For each point in spacetime $g_{\mu\nu}$ is a matrix with $\mu, \nu \in 0, 1, 2, 3$.

And the equation is

$$\delta S = 0$$

where

$$S = \int dt dx_1 dx_2 dx_3 R \sqrt{g}$$

There are three other fundamental forces, e.g electromagnetic forces.

These are described with Quantum Electrodynamics - QED -
Quantum $\rightarrow$ uncertainty principle

$$\Delta x \Delta p \geq \hbar$$

The better we know where an electron is, the less we know where it is going.

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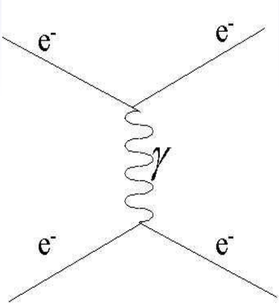
Force is exchange of photons (particles of light).



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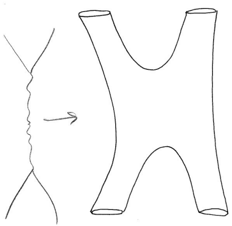
different particles.

Feynman diagram becomes a string interaction diagram



Another example of Hidden geometry :

Unification is possible if :

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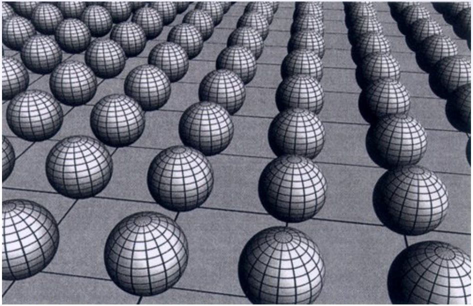
Unification is possible if :

Point $\longrightarrow$ circle

line $\longrightarrow$ cylinder

Feynman diagram $\longrightarrow$ string diagram

80’s : This only works if the space-time is ten-dimensional, i.e in addition to the four we know, there are another six dimensions.



90's : Three major discoveries in string theory.

All three challenging how we think about space-time.

And we are still trying to work through the implications.

Eleventh dimension : M-theory

Build a string universe : 10 spacetime dimensions, and one variable coupling constant.

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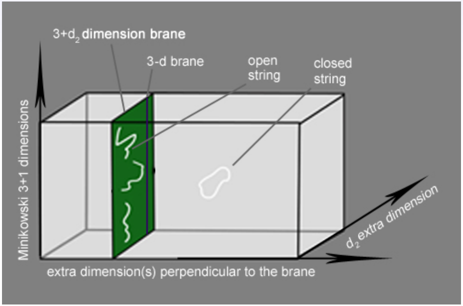
Build a string universe : 10 spacetime dimensions, and one variable coupling constant.

It turns out that this string universe is an 11 dimensional universe (with an extra space dimensions) with no adjustable coupling constant.

Branes

Branes : Alternatively, the world can be a 3-dimensional brane living in ten dimensional universe.

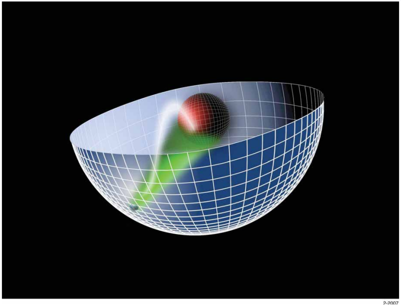


Gauge-String duality.

It was discovered that a 3+1 dimensional world without gravity :
a MATRIX generalization of photon theory

can be physically equivalent

to a theory with strings, branes and gravitons in 10 dimensions.



Some recent themes at QMUL

Generalized geometry in string and M-theory : Berman + student Musaev

Electrons are charged under the 4-vector potential A_μ. Strings : $B_{\mu\nu}$. Membranes of of M-theory : $B_{\mu\nu\lambda}$

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The metric $g_{\mu\nu}$ which describes curvature of space-time, is generalized to a metric in a doubled space – which includes these potentials.

This allows generalizations of the geometries that the six “small dimensions” of string theory can form.

Fuzzy geometry of branes :

$$\Delta X \Delta P > \hbar$$

$$\downarrow$$

$$\Delta X \Delta Y > \Theta$$

(Ramgoolam, Spence, Thomas + students Papageorgakis, Mc Namara)

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(Ramgoolam, Spence, Thomas + students Papageorgakis, Mc Namara)
Fuzzy branes in inflationary models of cosmology
(Thomas, Ward + collaborators in Astro Unit.)

Gauge-string duality : Quantum states to geometries

(Ramgoolam, Russo + students and postdocs Pasukonis, Brown, Turton, Gili , Georgiou, Heslop , Kimura.)

Use the large N Matrix photon theory in four dimensions, to construct the quantum states of branes and strings in the dual spacetime in ten dimensions.

Interface with mathematics

Simple mathematical models of gauge-string duality.

can be found using classical mathematics such as Riemann existence theorem and Schur-Weyl duality which can be used to relate the combinatorics of matrix models (zero dimensions) to that of string worldsheets (in two dimensions)

(Ramgoolam + postdocs/students Jejjala, Rodriguez-Gomez , Pasukonis, Garner and external collaborators Robert de Mello Koch.)

Interface with particle physics

Directions towards particle physics :

Rodolfo Russo : high energy string scattering (with Will Black and external collaborators e.g Veneziano)

Supersymmetry breaking (Rodolfo Russo, Steven Thomas, with students Mc Garrie, Koschade)

Amplitudes : Brandhuber, Spence, Travaglini + postdocs Heslop, Gang Yang, Congkao Wen.

A unification of surprises ?

String theory has given us many surprises :

- Ten dimensions is secretly eleven.
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What is it really telling us about space-time ?