Is String Theory Useful?

David Tong
String Theory
STRING THEORY SUMMARIZED:

I just had an awesome idea. Suppose all matter and energy is made of tiny, vibrating "strings."

Okay. What would that imply?

I dunno.

xkcd.com
Some Hard Problems in Physics
Particles that don’t interact
(or interact only very weakly)
What Physicists Understand

“Physics is that subset of human experience which can be reduced to coupled harmonic oscillators”

Michael Peskin
What Physicists don’t Understand

Pretty Much Everything Else
(Particles whose interactions are not small)
How to Proceed…

But sometimes this isn’t possible…
The Quark-Gluon Plasma
High Temperature Superconductors

Diagram A shows the structure of a high temperature superconductor, with unit cell edges labeled and atoms represented by different colors. Diagram B illustrates the temperature-dependent properties, including regions labeled as 'antiferromagnet', 'very strong metal', 'less strong metal', 'messy insulator', and 'superconductivity'. The resistivity of a \( \text{Tl}_2\text{Ba}_2\text{CuO}_6\) single crystal is plotted against temperature, showing a sharp drop at the superconducting transition temperature.
A New Tool
Help from a Surprising Place
Black Hole Entropy

\[ S_{BH} = \frac{A}{4} \]
Implication

We are all two dimensional holograms
Putting this to work

Gravity in $d$ dimensions

\[
\begin{array}{c}
\text{Strongly interacting matter} \\
\text{in (d-1) dimensions}
\end{array}
\]
Putting this to work

Strongly interacting matter in \((d-1)\) dimensions

\[
\begin{array}{c}
\uparrow \\
\downarrow \\
\end{array}
\]

Gravity in \(d\) dimensions
The AdS/CFT Correspondence
(a.k.a gauge/gravity duality)
So is string theory useful?
Preliminary Success: Quark-Gluon Plasma

- Viscosity: \( \frac{\eta}{s} = \frac{1}{4\pi} \)

- Jet Quenching:
Pre-Preliminary Success: Non-Fermi Liquids

under doped  
optimally doped  
over doped

energy

momentum
The Future

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is made of tiny, vibrating "strings".

Okay, what would that imply?

Time to learn condensed matter physics.