(1)

I AM GOING TO DISCUSS A FEW QUESTIONS:

WHY DO PHYSICISTS WORK ON STRING THEORY?

WHAT IS STRING THEORY?

CAN WE CONNECT STRING THEORY TO PARTICLE PHYSICS?

(1)

ONE BASIC REASON FOR WORKING ON STRING THEORY IS THAT ITS THERE . . .

IT IS THE ONLY KNOWN GENERALIZATION OF STANDARD QUANTUM FIELD THEORY THAT MAKES ANY SENSE

(2)

THE FRAMEWORK OF SPECIAL RELATIVITY PLUS QUANTUM MECHANICS IS SO RIGID THAT IT ALL BUT FORCES QUANTUM FIELD THEORY ON US — AND ESPECIALLY, "RENORMALIZABLE" ONES AT LOW ENERGIES.

THE RIGIDNESS OF THE FRAMEWORK IS ONE OF THE MAIN REASONS PARTICLE PHYSICS MADE SO MUCH PROGRESS IN THE LAST CENTURY

(3)

A BIG IDEA LIKE A CONSISTENT GENERALIZATION OF QUANTUM FIELD THEORY ONLY COMES ALONG EVERY NOW AND THEN

... SO WE HAVE TO TAKE IT SERIOUSLY ...

STRING THEORY, MOREOVER, IS INCREDIBLY RICH – MORE THAN EVEN ENTHUSIASTS TEND TO REALIZE – AND HAS GENERATED AMAZING INSIGHTS ON TOPICS FROM QUANTUM FIELD THEORY TO FOUR-MANIFOLD THEORY. (5)

SUGGESTS ITS ON THE RIGHT TRACK, SINCE I DON'T CONSIDER IT PLAUSIBLE THAT A COMPLETELY WRONG THEORY WOULD GENERATE SO MANY GOOD IDEAS . . . .

IN TRYING TO DEVELOP STRING THEORY PHYSICISTS LEARNED (4)

* IT FORCES GENERAL RELATIVITY UPON US, WHILE STANDARD QUANTUM FIELD THEORY MAKES GENERAL RELATIVITY IMPOSSIBLE

* IT LEADS IN AN A REMARKABLY SIMPLE WAY TO A REASONABLE ROUGH DRAFT OF PARTICLE PHYSICS UNIFIED WITH GRAVITY

(6)

FINALLY, WHERE CRITICS HAVE GOOD IDEAS, THEY TEND TO BE ABSORBED AS PART OF STRING THEORY:

* BLACK HOLE ENTROPY
* HOLOGRAPHY
* NONCOMMUTATIVE FIELD THEORY
* TWISTOR THEORY

(7)

BUT WHAT IS STRING THEORY?

IT MAY WELL BE THAT STRING THEORY IS THE ONLY WAY TO RECONCILE GRAVITY AND QUANTUM MECHANICS (AS WEINBERG SUGGESTED THURSDAY) ... BUT THAT DOESN'T TELL US WHAT IT IS.

(8)

WHAT IS THE CORE IDEA, ANALOGOUS TO THE PRINCIPLE OF EQUIVALENCE IN THE CASE OF GENERAL RELATIVITY?

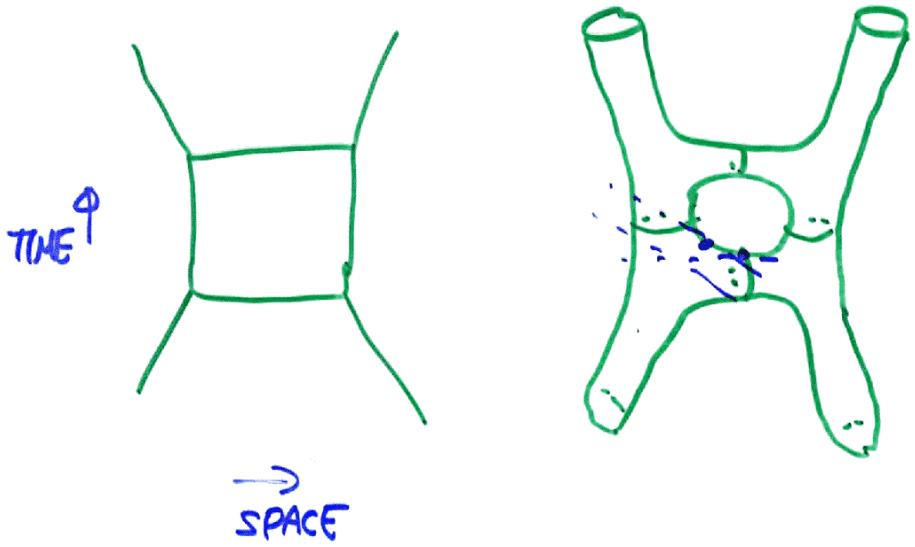
ONE BASIC FACT IS THAT WE DON'T KNOW....

(9)

ONE THING I CAN TELL YOU, THOUGH, IS THAT MOST STRING THEORISTS SUSPECT THAT "SPACETIME" IS AN "EMERGENT PHENOMENON" IN THE LANGUAGE OF CONDENSED MATTER PHYSICS.

10

WE BECAME CONVINCED ORIGINALLY IN THE 1980's:



11

THE FUZZINESS OF THE "EVENT"

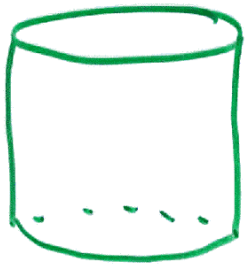
LEADS TO NONCLASSICAL SYMMETRIES ("MIRROR SYMMETRY") AND TRANSITIONS ("TOPOLOGY CHANGE") BETWEEN DIFFERENT SPACETIMES

(12)

IN THE 1980's, THESE WERE OUR BEST CLUES, BUT IN THE 1990's, WE DISCOVERED A NEW SET OF CLUES SUGGESTING THAT "SPACETIME" CAN SOMEHOW BE BUILT OUT OF MATRIX OR GAUGE DEGREES OF FREEDOM

(13)

FOR EXAMPLE, IN THE AdS/CFT CORRESPONDENCE, GRAVITY IN BULK



↑ TIME

IS BUILT FROM GAUGE THEORY ON THE BOUNDARY

(14)

ONCE ONE HAS SUCH A GAUGE/GRAVITY CORRESPONDENCE IN A SPECIAL CASE, ONE CAN MAKE ALL SORTS OF RELEVANT PERTURBATIONS OF THE GAUGE THEORY (AND RELATED CONSTRUCTIONS) SO AN INCREDIBLE VARIETY OF GAUGE THEORIES HAVE A GRAVITATIONAL INTERPRETATION.

(15)

IT IS HARD TO SEE WHERE TO STOP. MAYBE EVERY QUANTUM MECHANICAL SYSTEM HAS A "DUAL" GRAVITATIONAL INTERPRETATION... IN GENERAL STRONGLY CURVED.

THE QUESTION MUST THEN BE TURNED AROUND...

(16)

WHICH QUANTUM MECHANICAL SYSTEMS CORRESPOND TO MACROSCOPIC, SEMICLASSICAL SPACETIME LIKE THE ONE WE LIVE IN?

(17)

PRESUMABLY, WE NOW UNDERSTAND ONLY A FEW FRAGMENTS ...

YET IT IS PLAUSIBLE THAT EVENTUALLY WE'LL MANAGE TO UNDERSTAND WHAT STRING THEORY IS.

(18)

EVEN IF THIS OCCURS, AND IF STRING THEORY IS ON THE RIGHT TRACK, WILL WE BE ABLE TO LEARN HOW TO USE IT TO UNDERSTAND NATURE?

I SUPPOSE THAT DEPENDS ON A LOT OF UNKNOWNS, INCLUDING THE NATURE OF THE ANSWER AND THE CLUES WE ARE ABLE TO GET FROM EXPERIMENT.

(19)

IT WOULD HELP IF "SUPERSYMMETRY," AN IMPORTANT PART OF THE STRING THEORY STORY, IS RELEVANT TO ELECTROWEAK SYMMETRY BREAKING AND CAN BE STUDIED AT ACCELERATORS.