

SUPER QUANTUM MECHANICS AND RELATIVITY

EINSTEIN'S EQUATION

DEFINITION

IN PHYSICS, THE EINSTEIN TENSOR G IS DEFINED AS

$$G = R - \frac{1}{2}gR,$$

WHERE R IS THE RICCI TENSOR, g IS THE METRIC TENSOR AND R IS THE SCALAR CURVATURE. IN COMPONENT FORM, THE PREVIOUS EQUATION READS AS

$$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R.$$

GENERAL RELATIVITY

THE EINSTEIN TENSOR ALLOWS A COMPACT EXPRESSION OF THE [EINSTEIN FIELD EQUATIONS](#):

$$G_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}.$$

USING GEOMETRIZED UNITS, THIS SIMPLIFIES TO

$$G_{\mu\nu} = 8\pi T_{\mu\nu}.$$

EINSTEIN COSMOLOGICAL FORM

THE TENSOR T IS DEFINED AS

$$T = \begin{pmatrix} \Lambda & 0 & 0 & 0 \\ 0 & -\Lambda & 0 & 0 \\ 0 & 0 & -\Lambda & 0 \\ 0 & 0 & 0 & -\Lambda \end{pmatrix}$$

WHERE Λ IS CALLED THE 'COSMOLOGICAL CONSTANT'. THIS AMOUNTS TO GIVING EMPTY SPACE AN ENERGY DENSITY EQUAL TO Λ AND PRESSURE EQUAL TO $-\Lambda$, SO THAT $\rho + 3P$ FOR THE VACUUM IS -2Λ . ON SIMPLIFYING WE GET

$$\frac{3\ddot{R}}{R} = -\frac{1}{2}(\rho + 3P - 2\Lambda), \quad (4)$$

WHERE ρ AND P ARE THE ENERGY DENSITY AND PRESSURE DUE TO MATTER. IF WE TREAT MATTER AS WE DID BEFORE, THIS GIVES

$$\frac{3\ddot{R}}{R} = -\frac{k}{2R^3} + \Lambda.$$

THUS, ONCE THE UNIVERSE EXPANDS SUFFICIENTLY, THE COSMOLOGICAL CONSTANT BECOMES MORE IMPORTANT THAN THE ENERGY DENSITY OF MATTER IN DETERMINING THE FATE OF THE

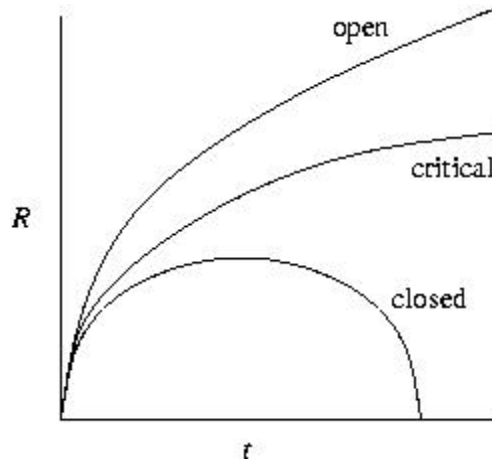
UNIVERSE. IF $\Lambda > 0$, A ROUGHLY EXPONENTIAL EXPANSION WILL THEN ENSUE. THIS SEEMS TO BE HAPPENING IN OUR UNIVERSE NOW.

COSMOLOGICAL CONSTANT

EINSTEIN INTRODUCED THE COSMOLOGICAL CONSTANT LAMBDA IN ORDER TO AVOID THE UNIVERSE EXPANDING. THE COSMOLOGICAL CONSTANT DOES NOT PREDICT THE FATE OF THE UNIVERSE. IT HAS NOT BEEN WELL INTERPRETED.

FOR A BODY EXPANDING THIS LAW WILL GIVE LAMBDA TO BE POSITIVE AND FOR CONTRACTING BODY LAMBDA WILL BE NEGATIVE. FOR A STATIC BODY LAMBDA IS ZERO.

OF THE UNITY OF PHYSICS. SINCE ``WHATEVER GOES UP MUST COME DOWN -- UNLESS IT EXCEEDS ESCAPE VELOCITY," THE SOLUTIONS OF THIS EQUATION LOOK ROUGHLY LIKE THIS:



SO, THE UNIVERSE STARTED OUT WITH A BIG BANG! IT WILL EXPAND FOREVER IF ITS CURRENT RATE OF EXPANSION IS SUFFICIENTLY HIGH COMPARED TO ITS CURRENT DENSITY, BUT IT WILL RE COLLAPSE IN A 'BIG CRUNCH' OTHERWISE.

BIG BANG

EVEN THOUGH RELATIVITY COULD PREDICT THE BIG BANG THERE ARE QUESTIONS.

****THIS MODEL DOES NOT FIT EXACTLY INTO THE BIG BANG. THERE IS NO PROOF THAT THE UNIVERSE STARTED FROM ZERO. IT DOES NOT PREDICT THE FATE OF THE UNIVERSE EITHER.

JUST LIKE THE COSMOLOGICAL CONSTANT IT DOES NOT SAY WHAT WILL HAPPEN EXCEPT TO GIVE IFS.

SUMMARY AND COMMENTS

COSMOLOGICAL CONSTANT

EINSTEIN INTRODUCED THE COSMOLOGICAL CONSTANT LAMBDA IN ORDER TO AVOID THE UNIVERSE EXPANDING. THE COSMOLOGICAL CONSTANT DOES NOT PREDICT THE FATE OF THE UNIVERSE. IT HAS NOT BEEN WELL INTERPRETED.

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SUPERSTRING

IN STRING THEORY MATTER AND GRAVITY ARE BOTH DESCRIBED BY VIBRATIONS OF ONE DIMENSIONAL STRING. THIS IS UNIFIED GEOMETRICAL THEORY OF NATURE WHICH WAS THE DREAM OF EINSTEIN.

CURVATURE

FIRW COSMOLOGIST OBSERVED THREE MAIN CURVATURES WHICH ARE LISTED RESPECTIVELY AS NEGATIVELY CURVED, FLAT, AND POSITIVELY CURVED.

DENSITY

WHICH ONE OUR UNIVERSE CORRESPONDS TO, DEPENDS ON ITS DENSITY.

LESS THAN A CRITICAL VALUE AND THE GEOMETRY IS CURVED, AND UNIVERSE RAPIDLY EXPANDS FOR EVER. MORE THAN A CRITICAL VALUE AND THE GEOMETRY IS CURVED, OR CLOSED AND THE UNIVERSE LASTS UNTIL IT RE COLLAPSES IN A BIG CRUNCH.

AT THE FLAT VALUE THE UNIVERSE EXPANDS AT JUST THE RIGHT "GOLDBLOCKS" RATE.

DARK MATTER

EINSTEIN'S EQUATIONS FURTHER PREDICT NEGATIVE PRESSURES OR WHAT IS KNOWN AS DARK MATTER.

GRAVITY

THE COSMOLOGICAL CONSTANT OF EINSTEIN CAN BE REPULSIVE. IT CAN PUSH GALAXIES AWAY FROM EACH OTHER. THAT IS GRAVITY ACTS NEGATIVELY.

BIG BANG

EVEN THOUGH RELATIVITY COULD PREDICT THE BIG BANG THERE ARE QUESTIONS.

****THIS MODEL DOES NOT FIT EXACTLY INTO THE BIG BANG. THERE IS NO PROOF THAT THE UNIVERSE STARTED FROM ZERO. IT DOES NOT PREDICT THE FATE OF THE UNIVERSE EITHER.

JUST LIKE THE COSMOLOGICAL CONSTANT IT DOES NOT SAY WHAT WILL HAPPEN BUT IF S.

THE NEXT TWO TABLES GIVE US A COMPARISON BETWEEN SUPER QUANTUM MECHANICS AN RELATIVITY.

DURING EXPANSION

(EG. BIG BANG)

VARIABLE	RELATIVITY	SUPER QUANTUM MECHANICS
DENSITY	LESS THAN A CRITICAL VALUE AND THE GEOMETRY IS CURVED	DENSITY DECREASES FROM INFINITY TO ZERO.
ENERGY	?	ENERGY DECREASES FROM INFINITY TO ZERO.
GRAVITY	THE COSMOLOGICAL CONSTANT OF EINSTEIN $\Lambda > 0$. [GRAVITY CAN BE REPULSIVE.]	GRAVITY INCREASES FROM MINUS INFINITY TO ZERO. IT IS NEGATIVE. IT CAUSES THE UNIVERSE TO ACCELERATE
TIME	RELATIVITY BREAKS DOWN BELOW PLANKS CONSTANT.	TIME INCREASES FROM ZERO TO INFINITY.(QUANTIZATION)

DURING CONTRACTION

(EG. BLACK HOLE FORMATION)

VARIABLE	RELATIVITY	SUPER QUANTUM MECHANICS
DENSITY	MORE THAN A CRITICAL VALUE THE BODY OR UNIVERSE LASTS UNTIL IT RE COLLAPSES IN A BIG CRUNCH.	DENSITY INCREASES FROM ZERO TO INFINITY.
ENERGY	?	ENERGY INCREASES FROM ZERO TO INFINITY.
GRAVITY	THE COSMOLOGICAL CONSTANT OF EINSTEIN $\Lambda > 0$. [GRAVITY CAN BE REPULSIVE.]	GRAVITY INCREASES FROM ZERO TO INFINITY. IT IS POSITIVE AND ATTRACTIVE. IT CAUSES THE UNIVERSE TO RE COLLAPSE.
TIME	RELATIVITY BREAKS DOWN BELOW PLANKS CONSTANT.	TIME DECREASES FROM INFINITY TO ZERO.(QUANTIZATION)