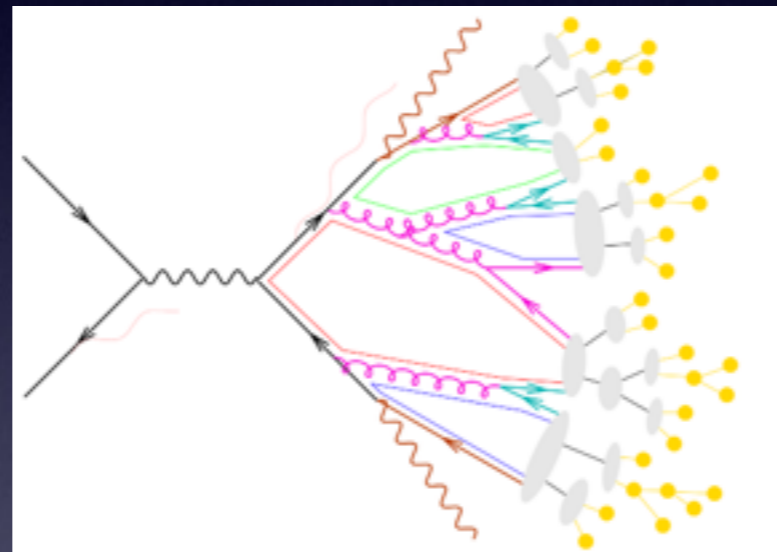


The Role of Symmetry in Creation

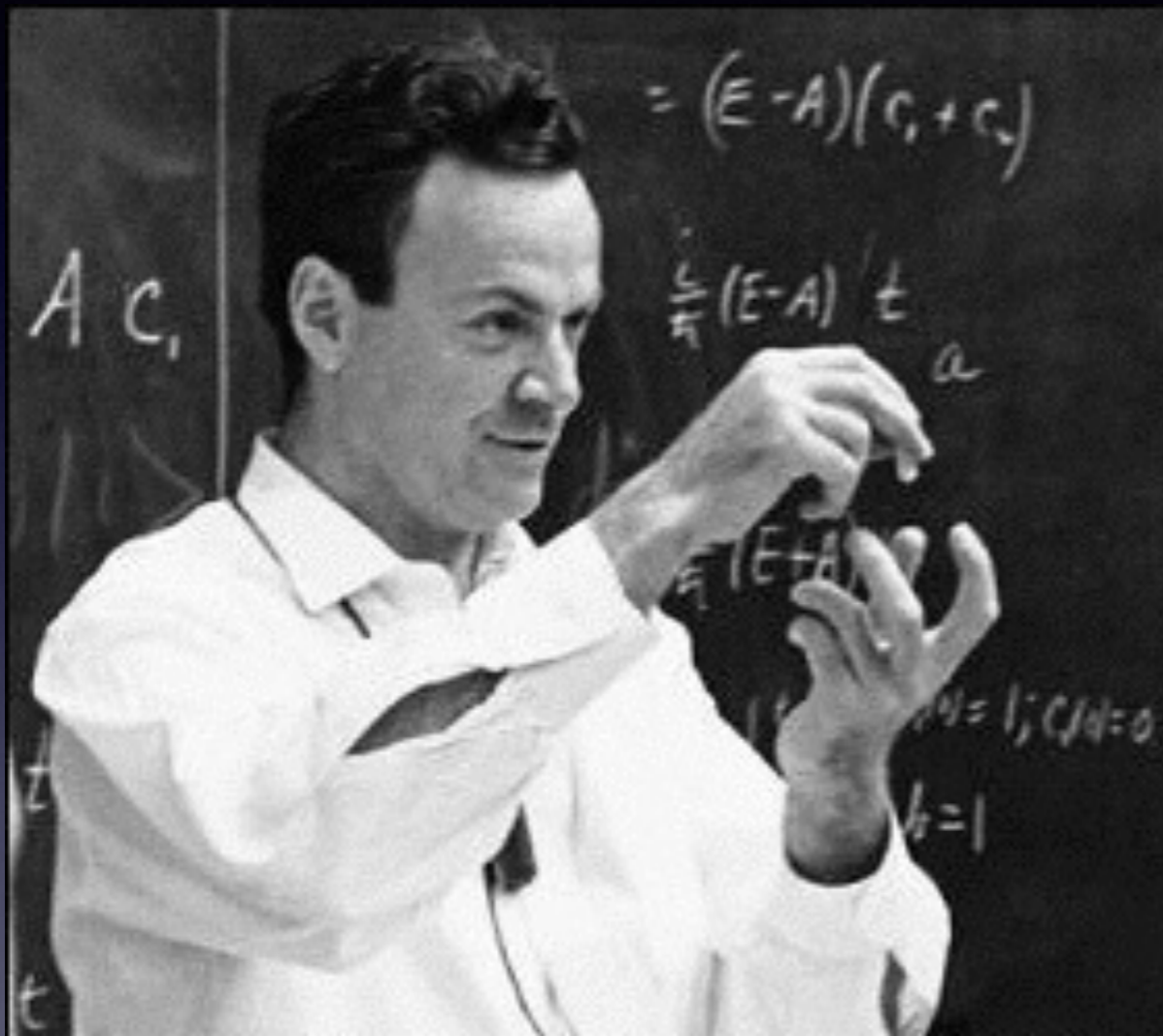


Dr. Jeremy Schnittman (NASA GSFC)

October 11, 2015

Ma Rabu Ma'asecha Series

Yeshiva of Greater Washington—Tiferes Gedaliah



Richard Feynman
1918-1988

American

Nobel in physics 1965

quantum electrodynamics

- Continuous symmetry
- Discrete symmetry
- Symmetry and unification
- Symmetry breaking and complexity

- **Continuous symmetry**
- Discrete symmetry
- Symmetry and unification
- Symmetry breaking and complexity



Emmy Noether

1882-1935

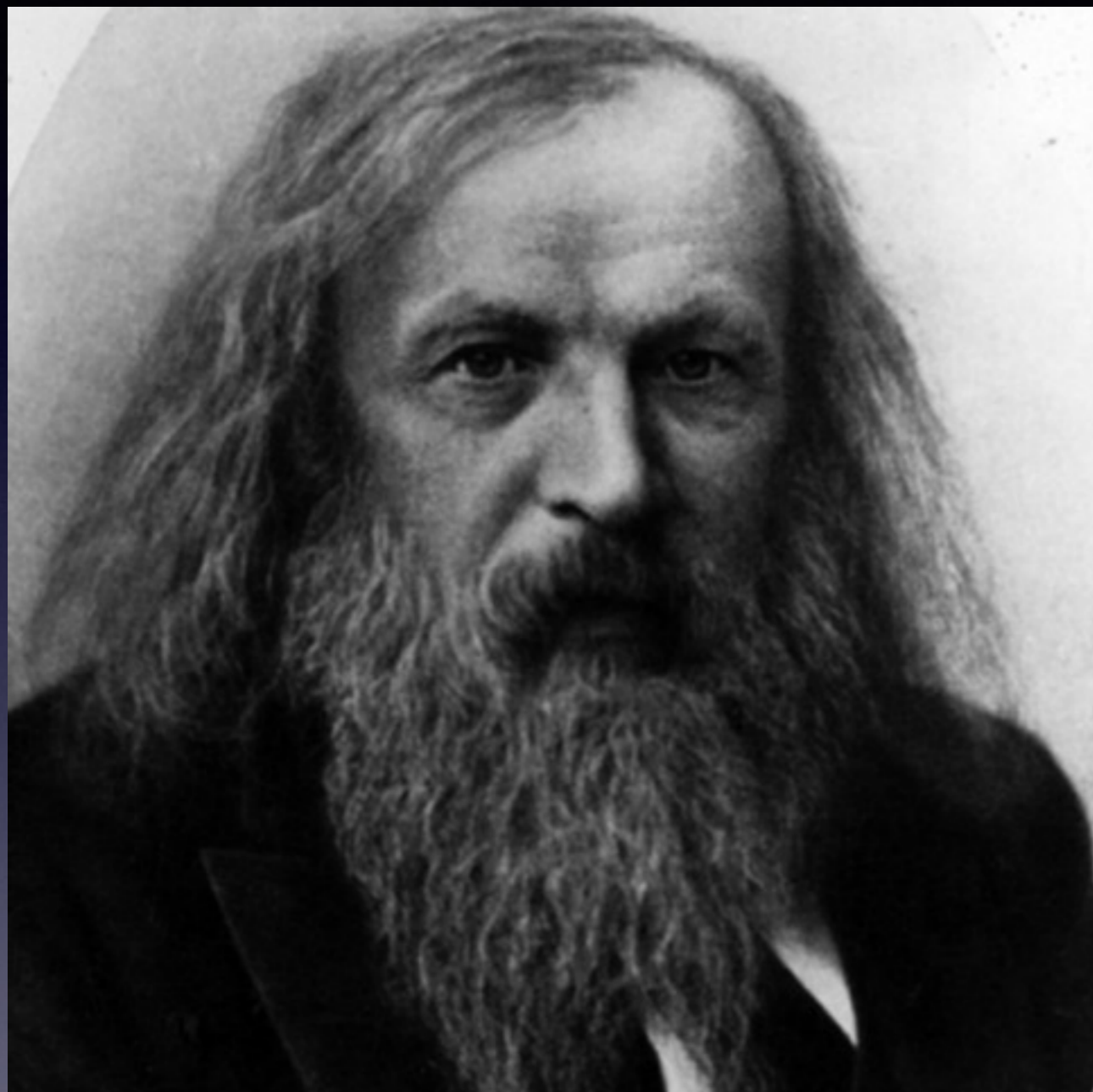
German, American

Noether's theorem

"Most significant creative female mathematical genius of all time" -Albert Einstein

Symmetry	Conservation law
translation in time	energy
translation in space	momentum
rotation in space	angular momentum
gauge transformation	electric charge

- Continuous symmetry
- **Discrete symmetry**
- Symmetry and unification
- Symmetry breaking and complexity



Dmitri Mendeleev
1834-1907
Russian
periodic table

Periodic Table of Elements

based on Mendeleev's Periodic Law

0	I	II	III	IV	V	VI	VII	VIII			
He 4.00	H 1.01	Li 6.94	Be 9.01	B 10.8	C 12.0	N 14.0	O 16.0	F 19.0			
Ne 20.2	Na 23.0	Mg 24.3	Al 27.0	Si 28.1	P 31.0	S 32.1	Cl 35.5				
Ar 40.0	K 39.1	Ca 40.1	Sc 45.0	Ti 47.9	V 50.9	Cr 52.0	Mn 54.9	Fe 55.9	Co 58.9	Ni 58.7	
	Cu 63.5	Zn 65.4	Ga 69.7	Ge 72.6	As 74.9	Se 79.0	Br 79.9				
Kr 83.8	Rb 85.5	Sr 87.6	Y 88.9	Zr 91.2	Nb 92.9	Mo 95.9	Tc (99)	Ru 101	Rh 103	Pd 106	
	Ag 108	Cd 112	In 115	Sn 119	Sb 122	Te 128	I 127				
Xe 131	Ce 133	Ba 137	La 139	Hf 179	Ta 181	W 184	Re 180	Os 194	Ir 192	Pt 195	
	Au 197	Hg 201	Tl 204	Pb 207	Bi 209	Po (210)	At (210)				
Rn (222)	Fr (223)	Ra (226)	Ac (227)	Th 232	Pa (231)	U 238					



Dobereiner's triads

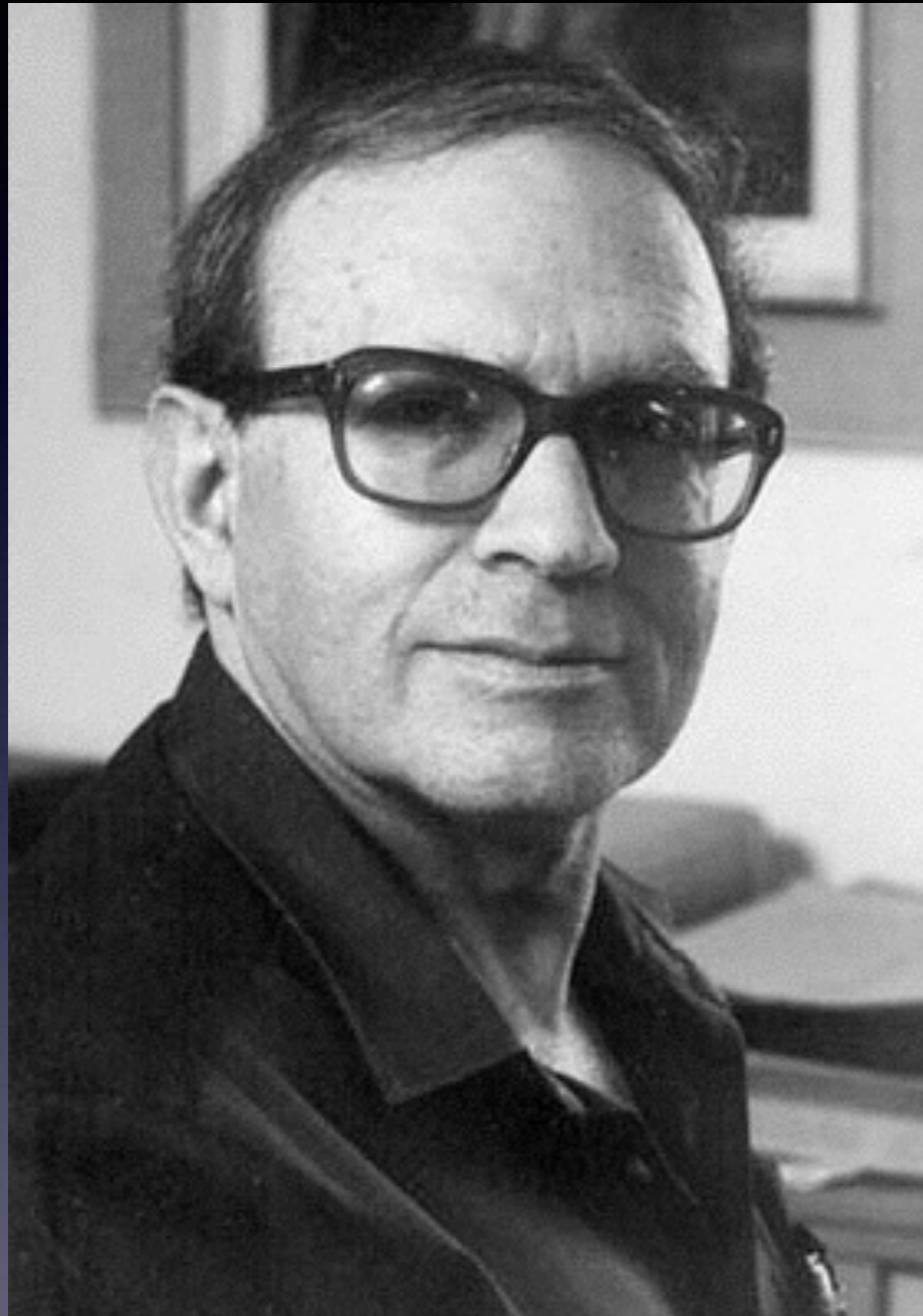


Known to Mendeleev

Lanthanide series

Actinide series

Known to Ancients



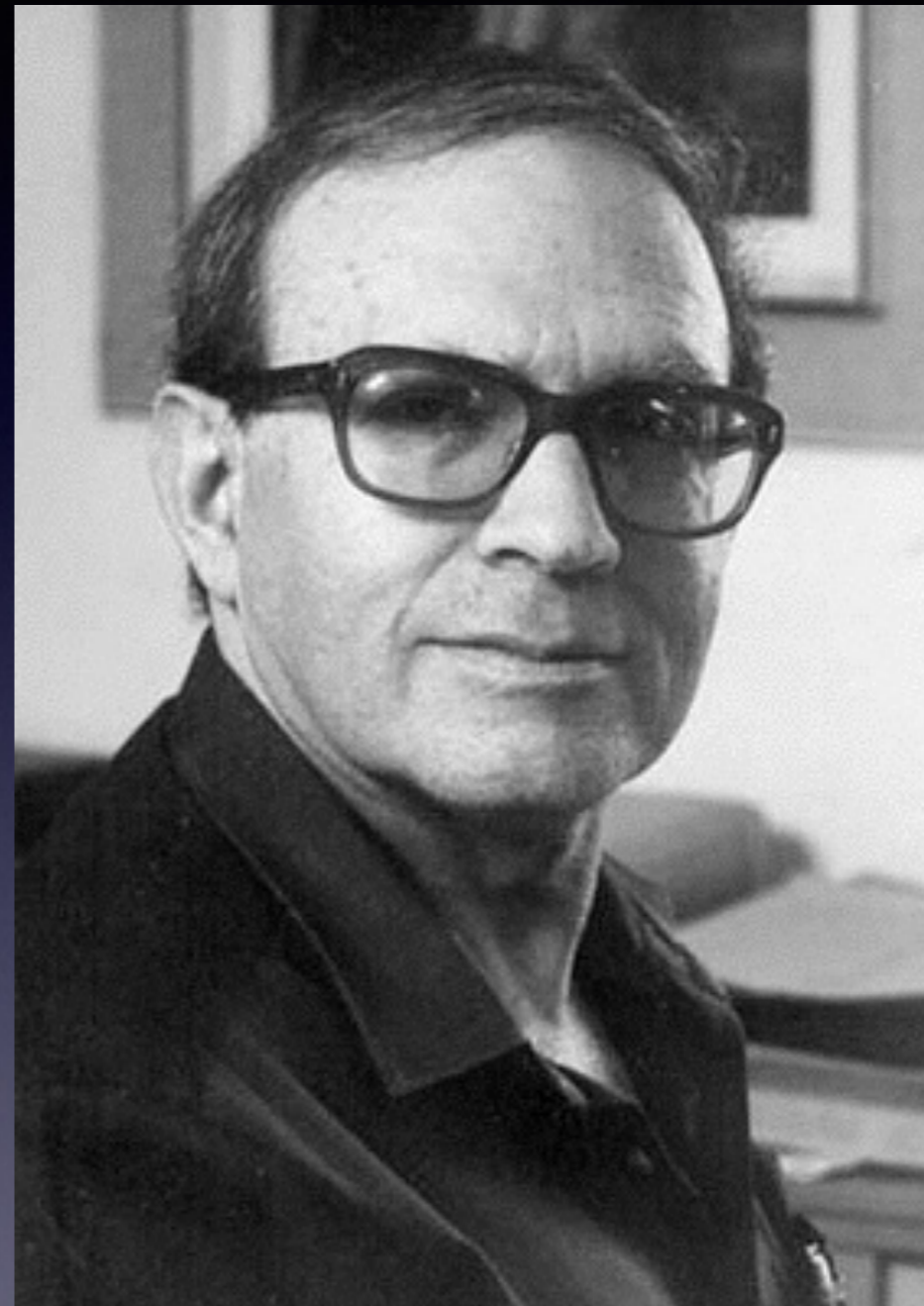
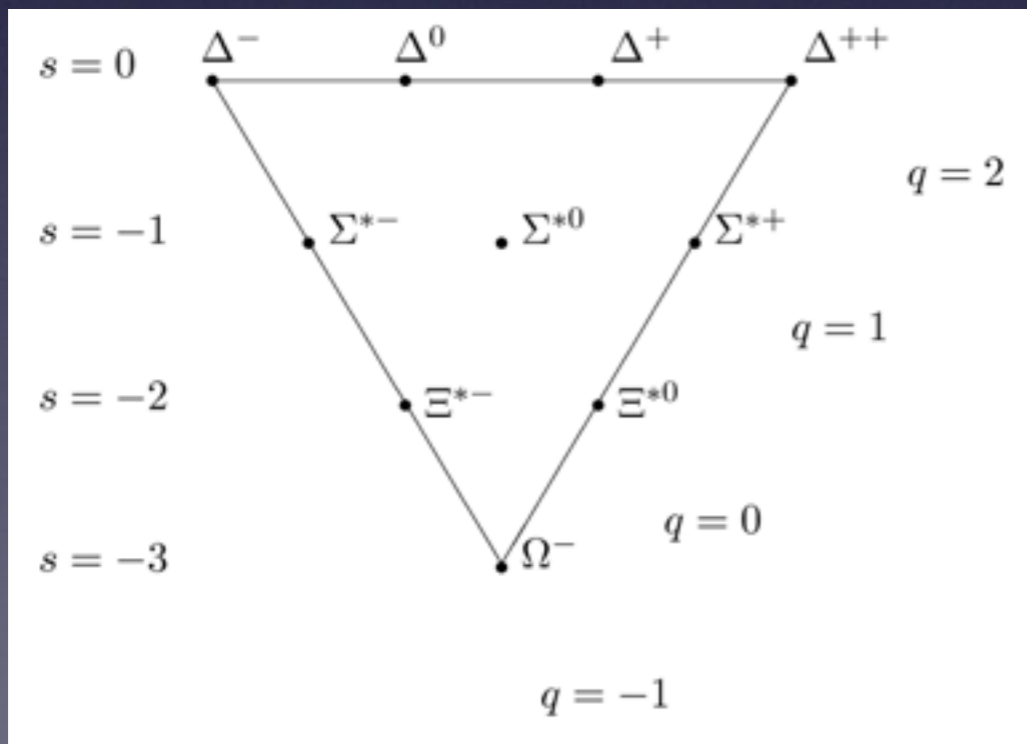
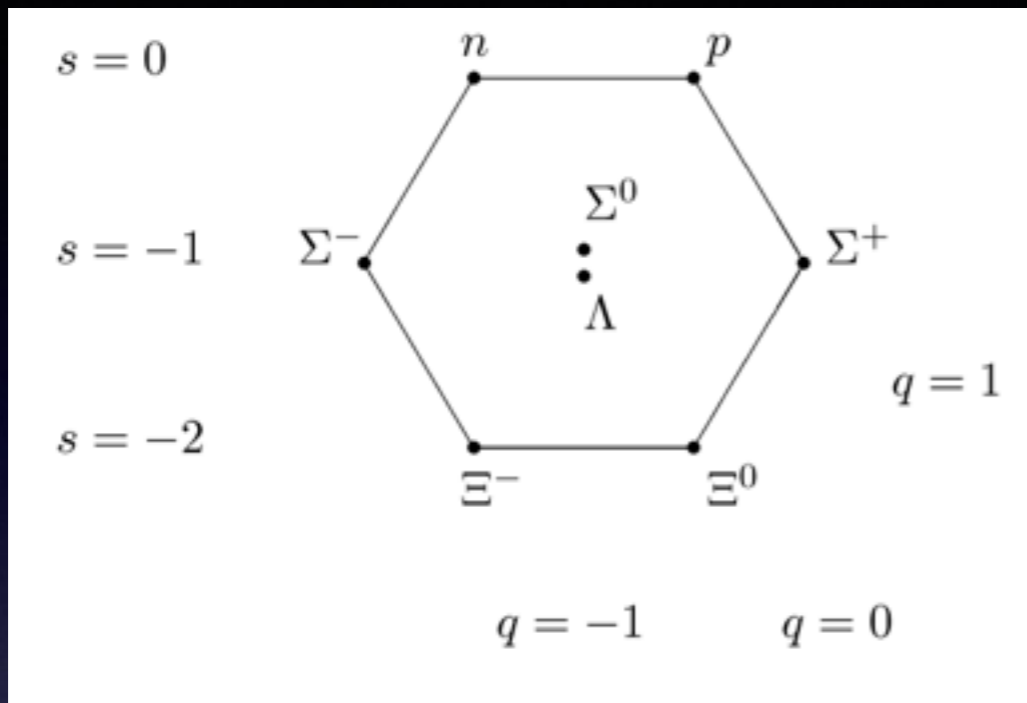
Yuval Ne'eman

1925-2006

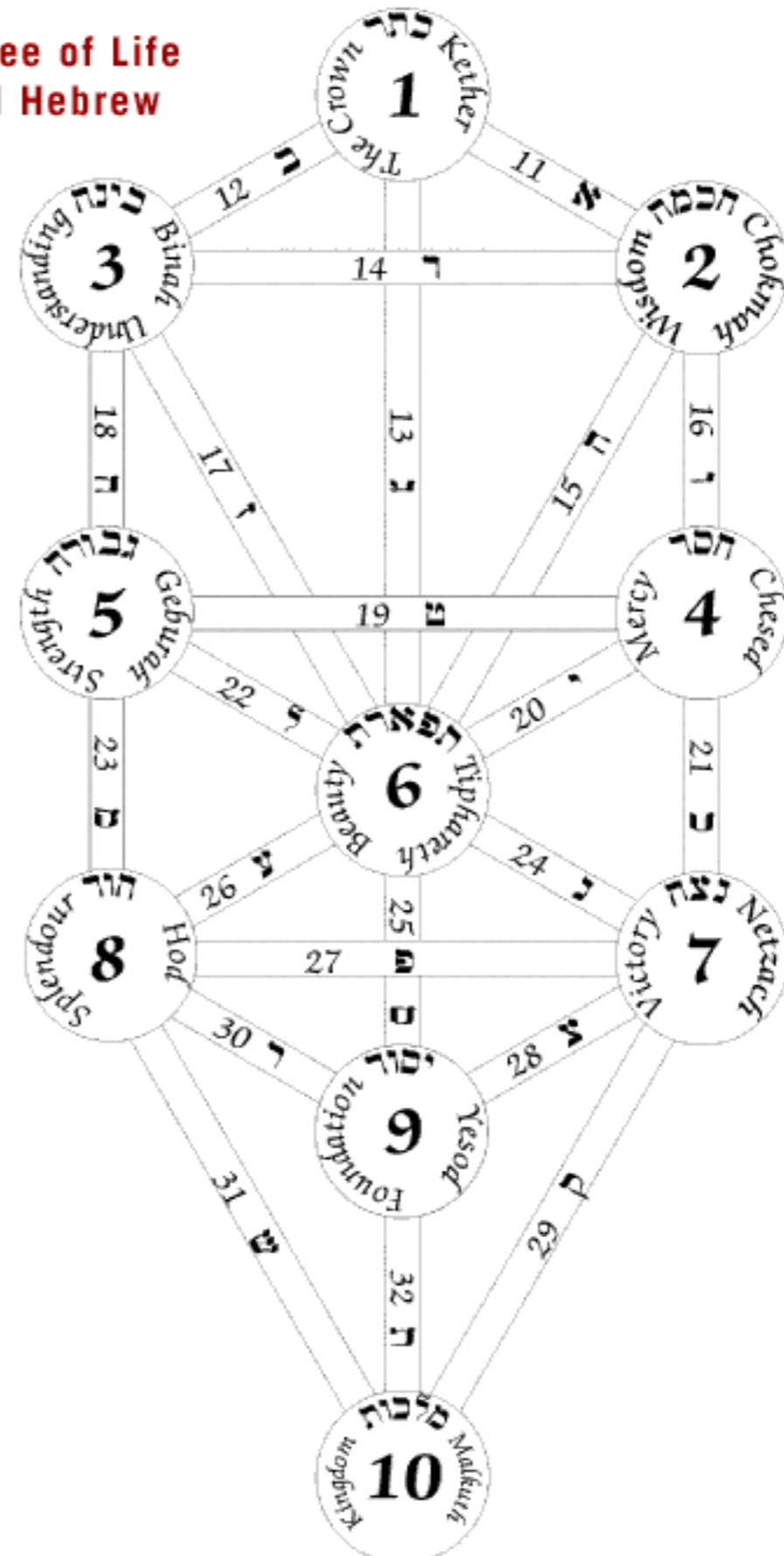
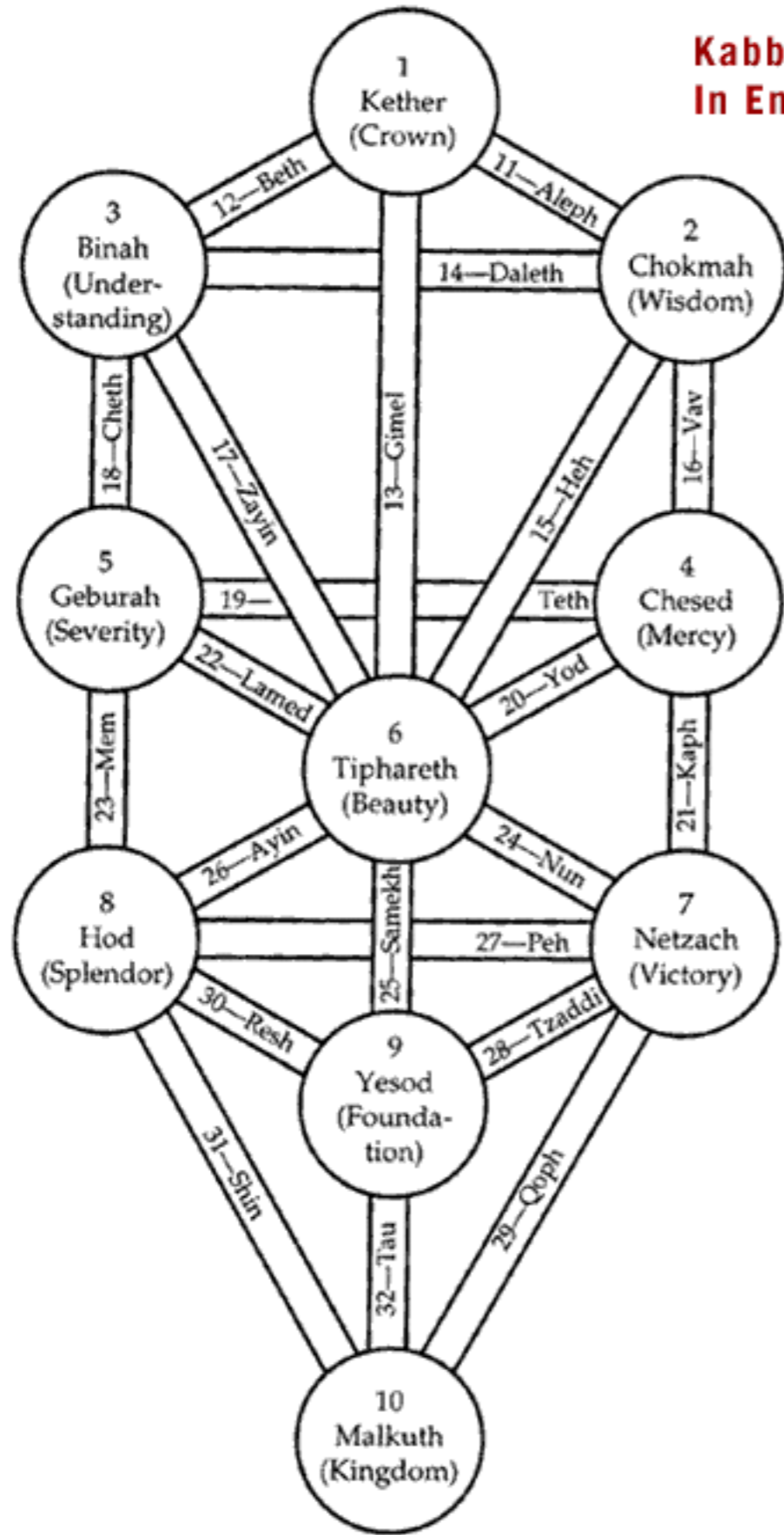
Israeli

Einstein Award 1970

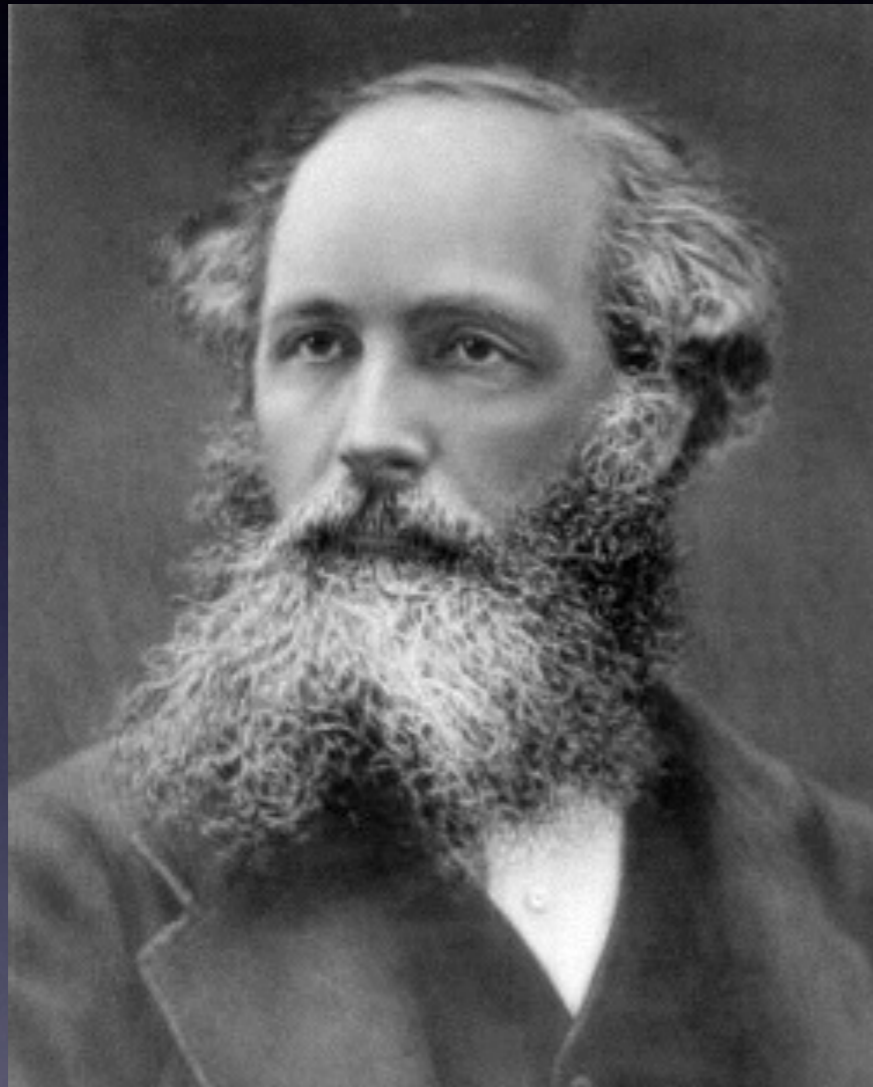
“eight-fold way”



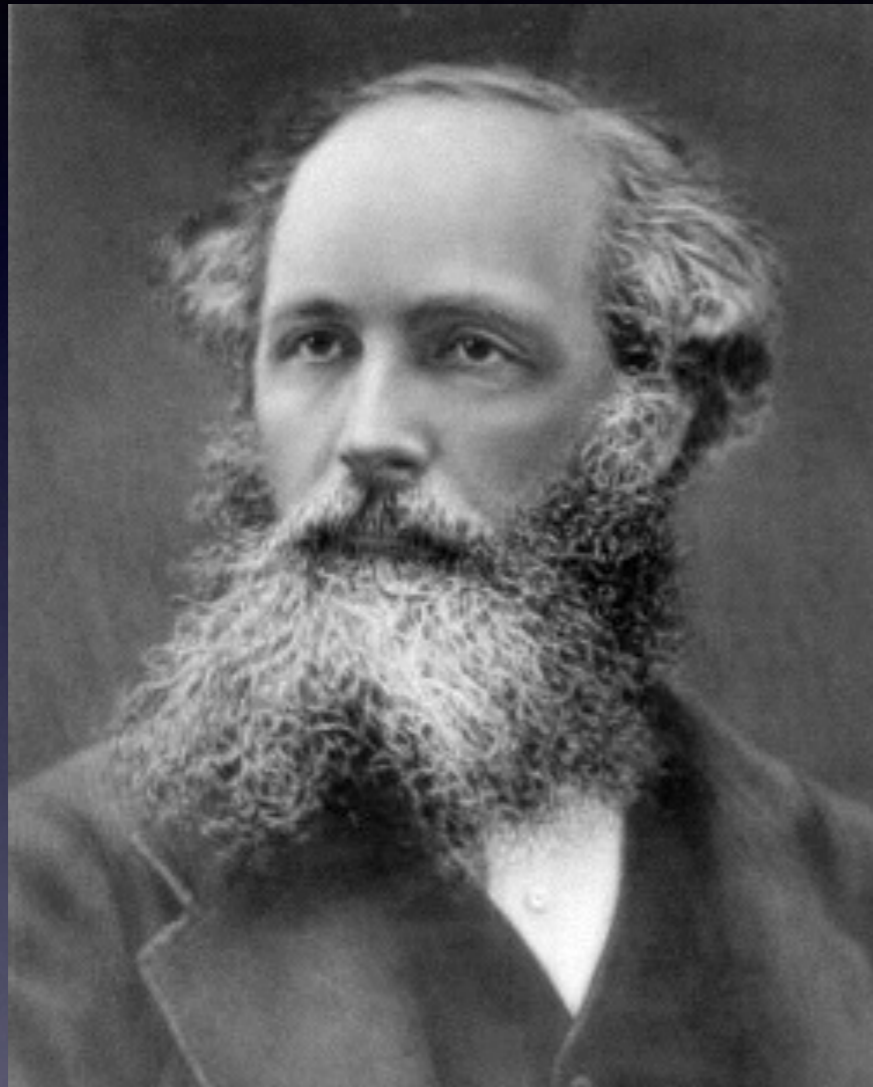
Kabbalistic Tree of Life In English and Hebrew



- Continuous symmetry
- Discrete symmetry
- **Symmetry and unification**
- Symmetry breaking and complexity



James Clerk Maxwell
1831-1879
Scottish
Maxwell's equations

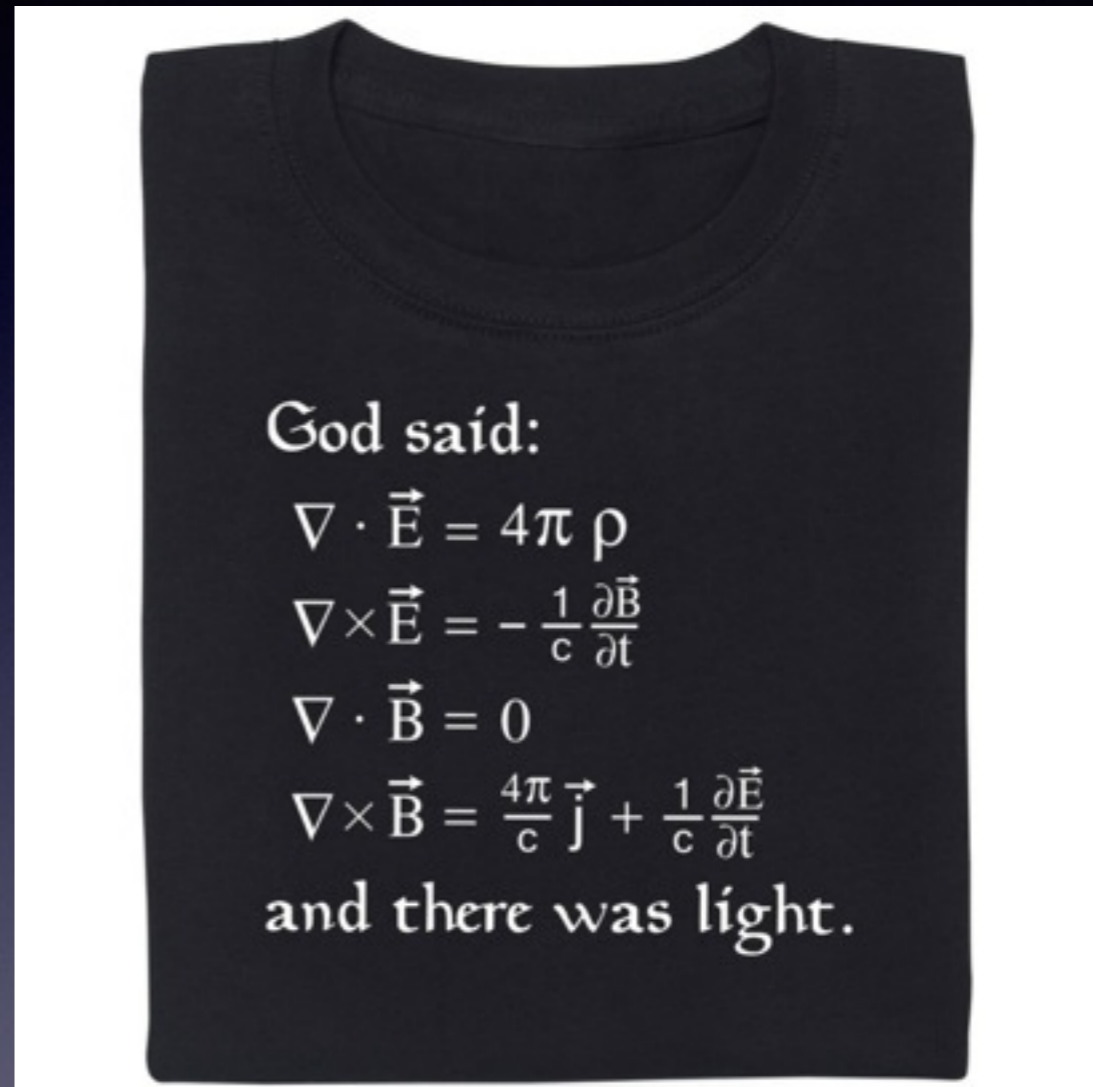
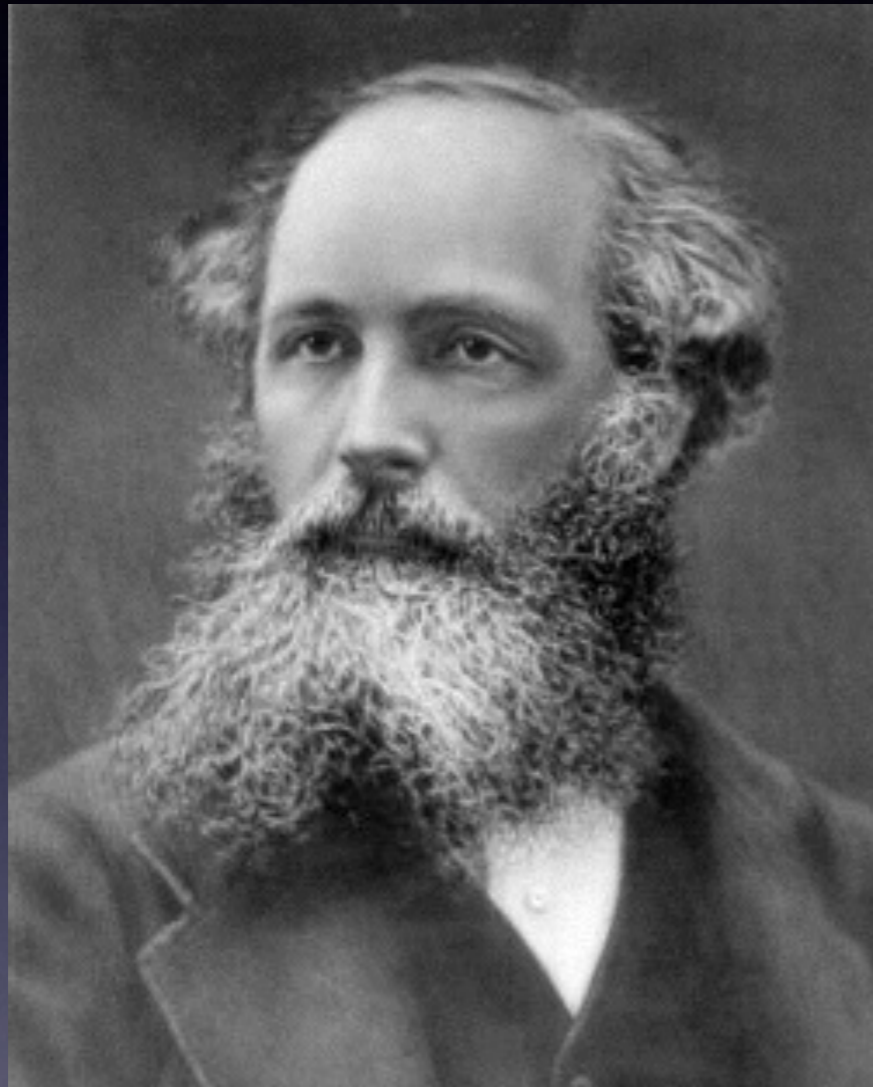


$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}$$





Albert Einstein

1879-1955

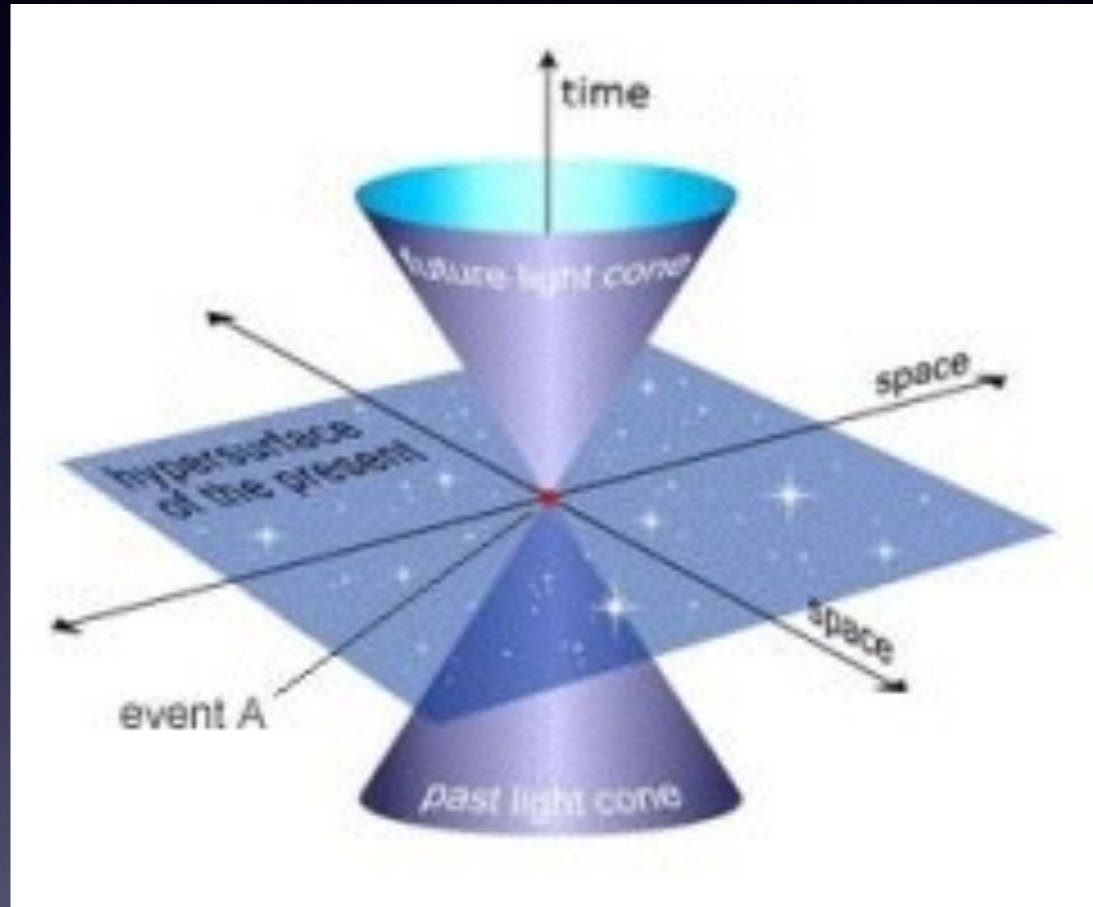
German/Swiss/American

Nobel in physics 1921

theory of relativity

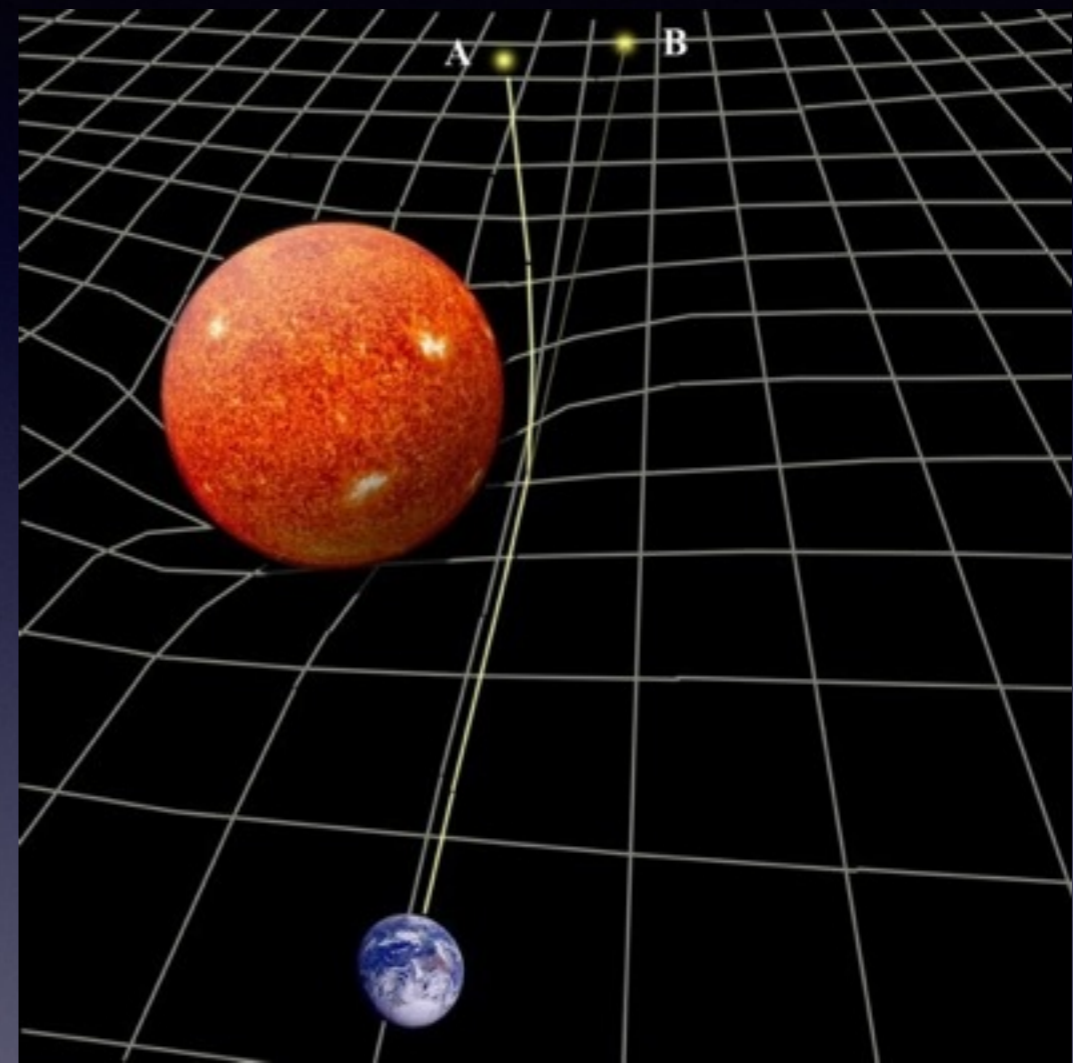
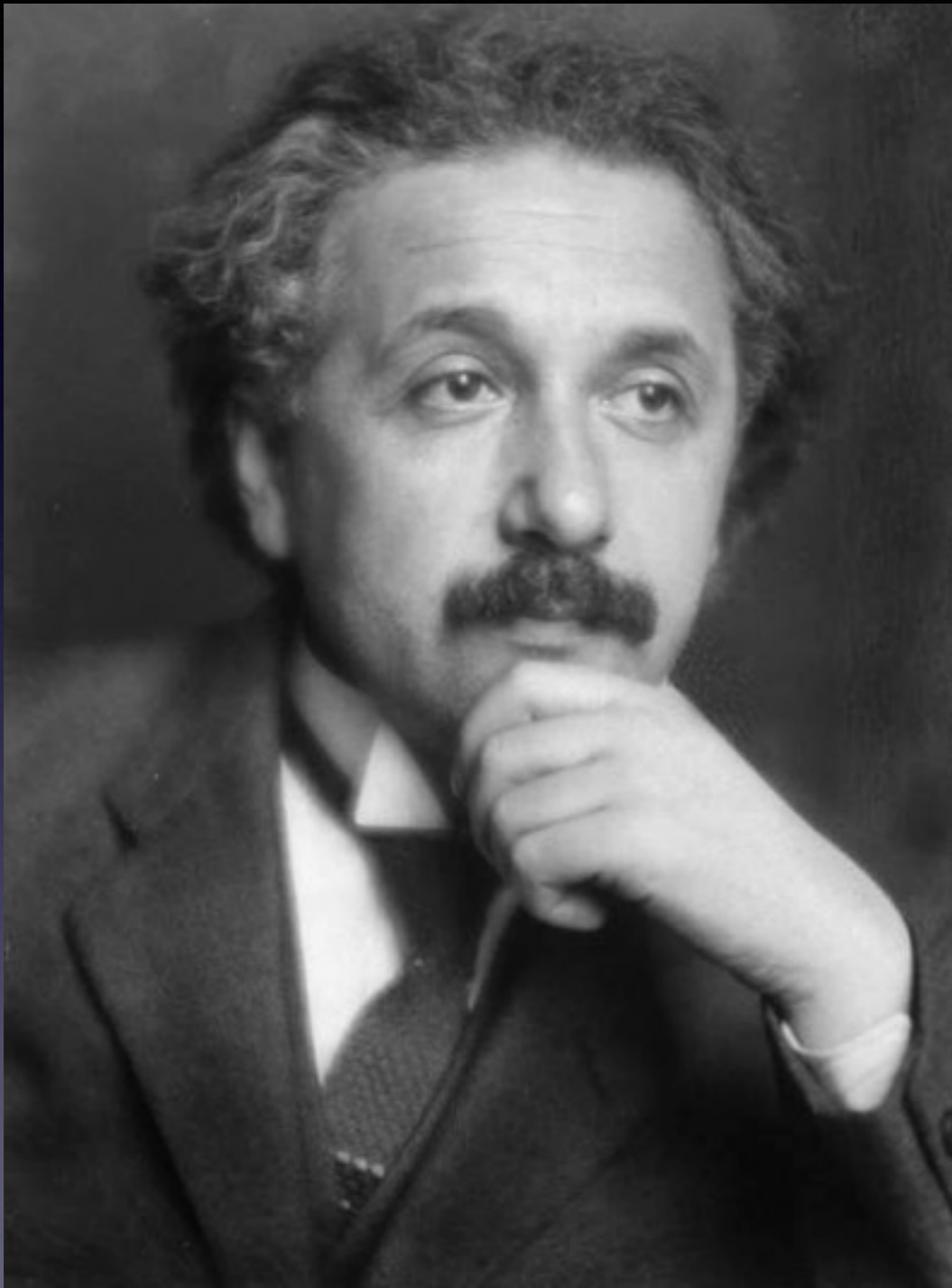


unification of space and time
(1905)

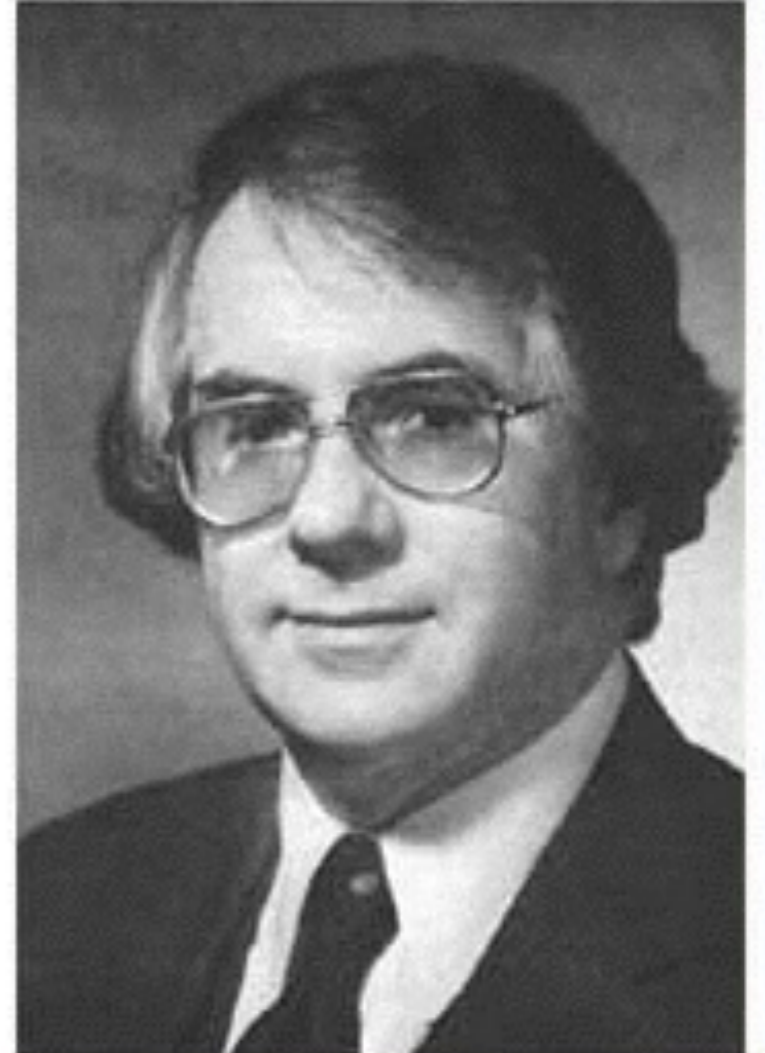
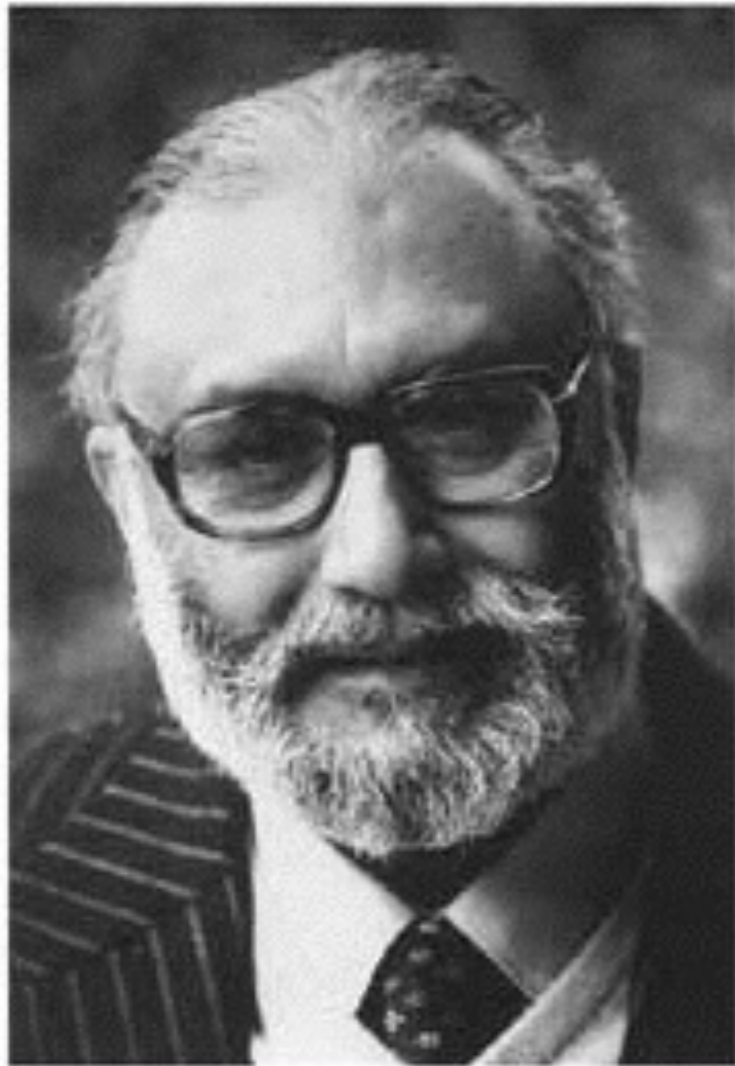


$$\frac{\partial F^{\mu\nu}}{\partial x^\nu} = \mu_0 J^\mu$$

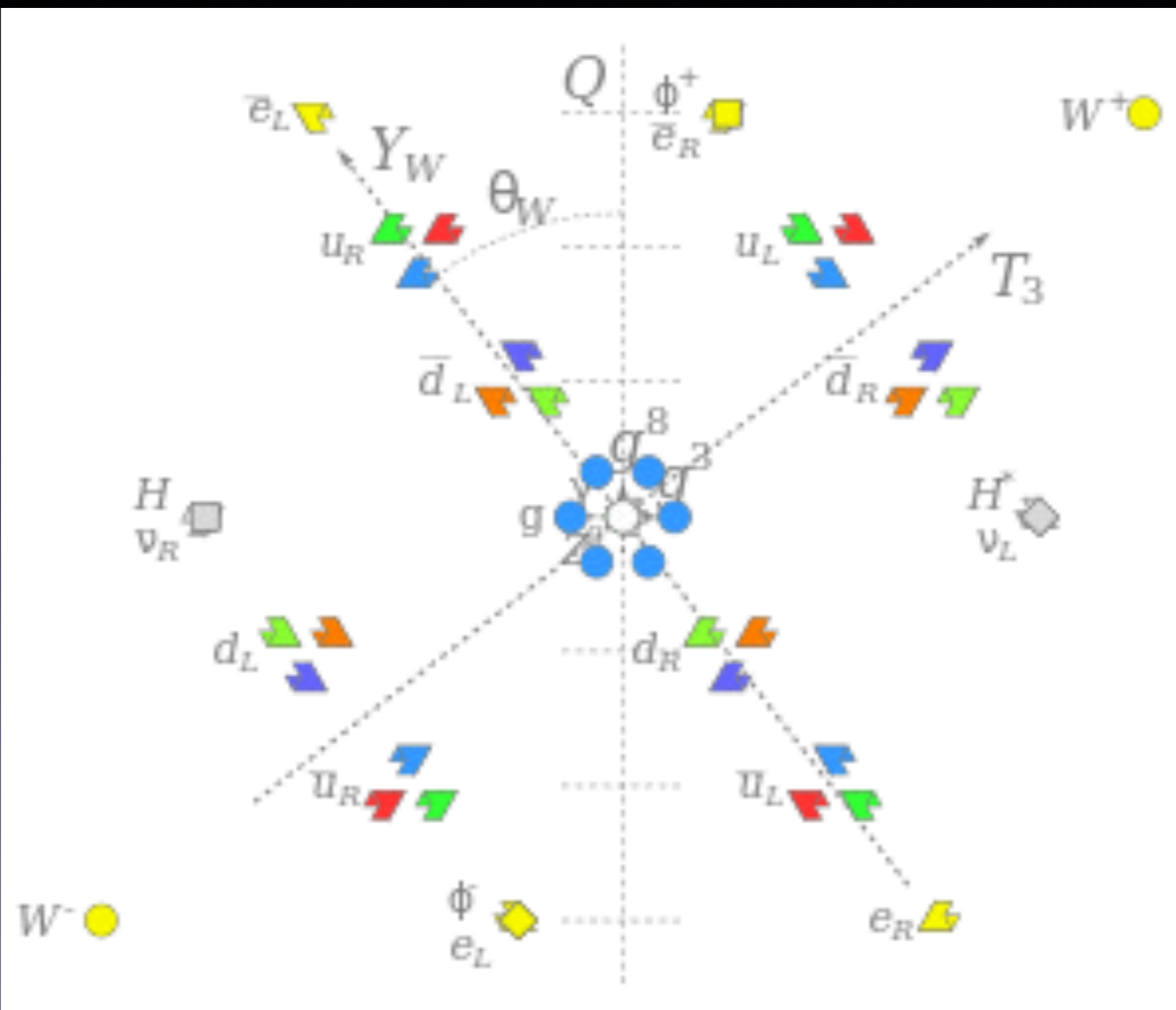
unification of space-time and gravity (1915)

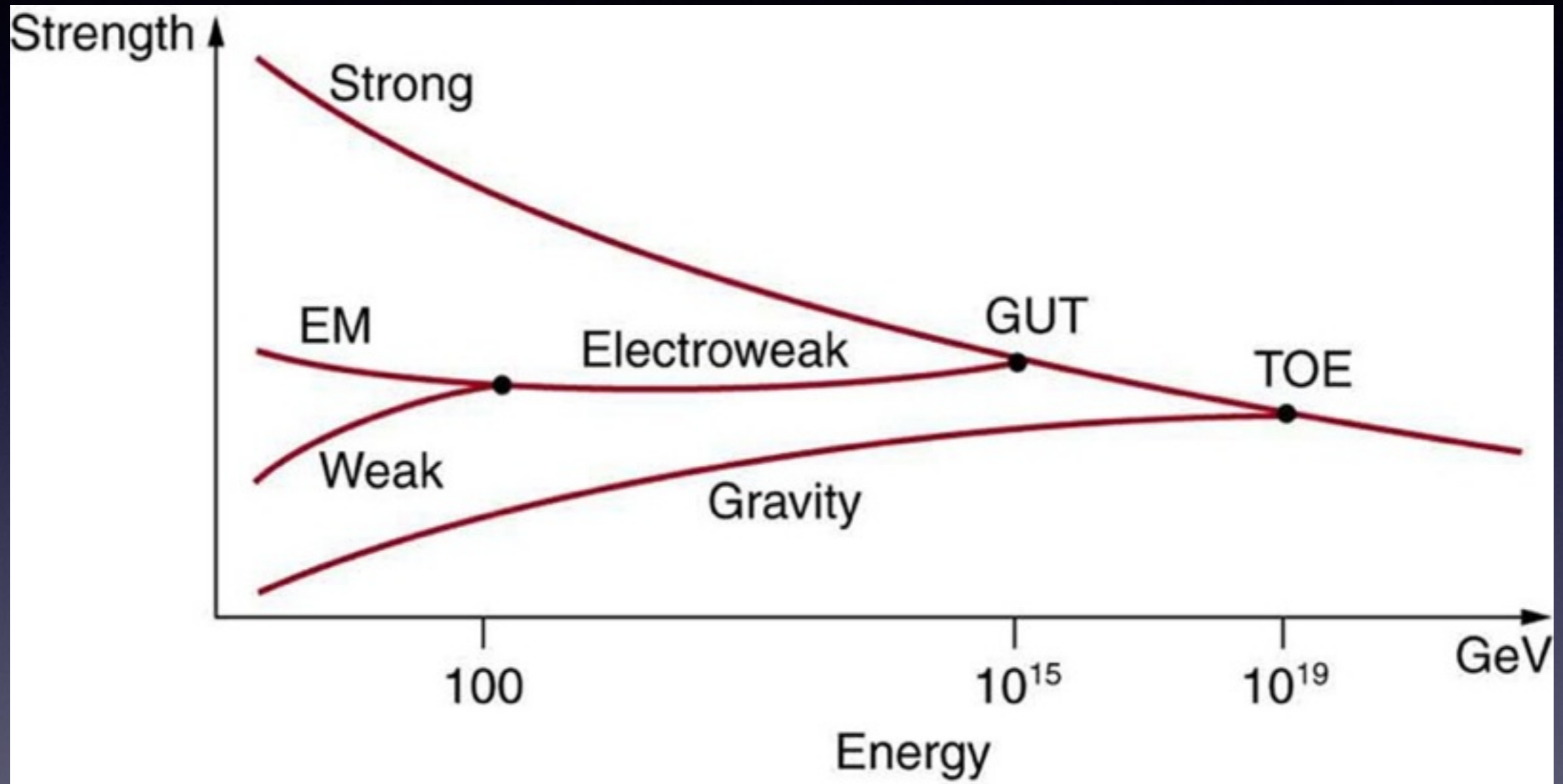


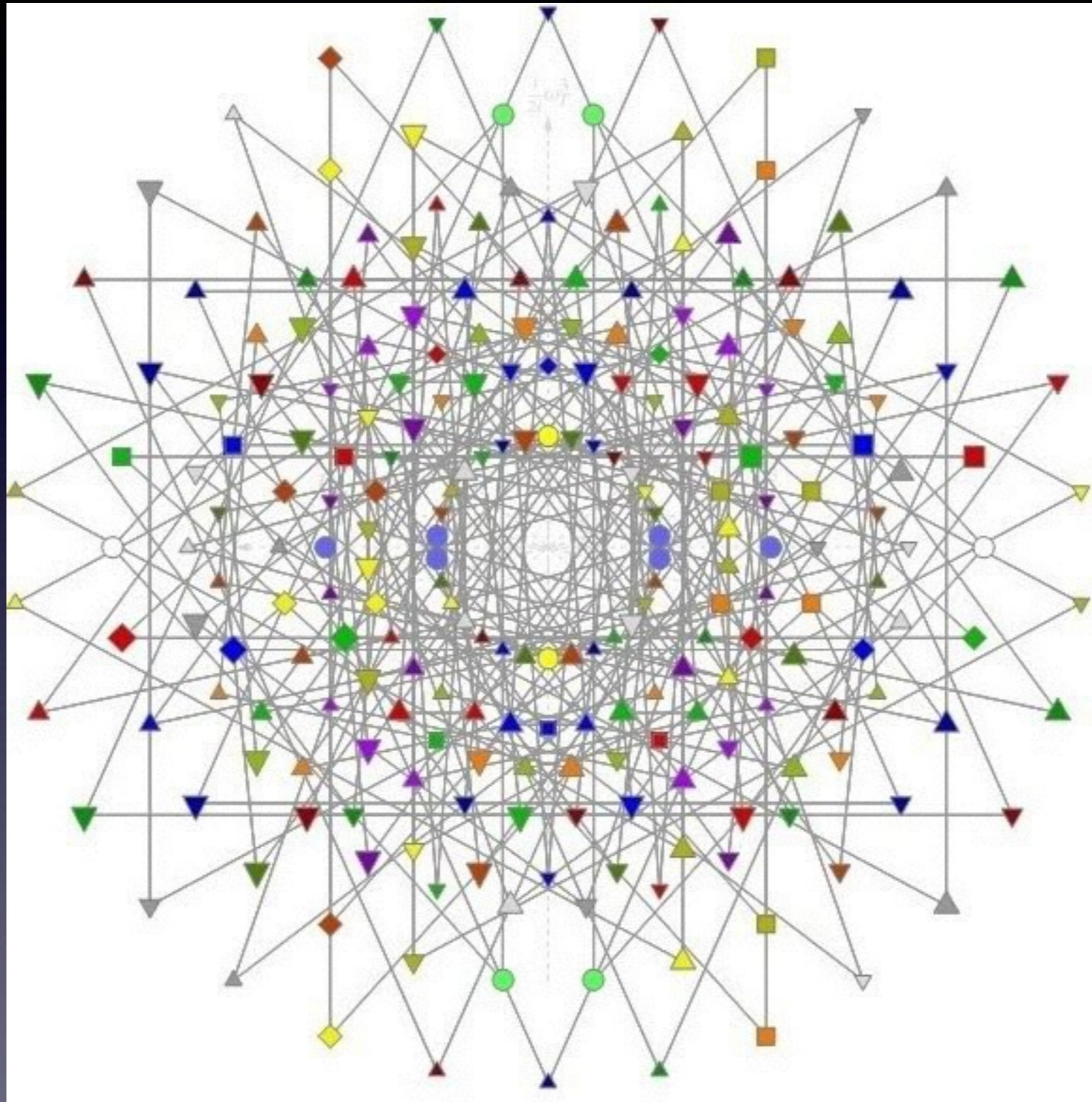
$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = 8\pi GT_{\mu\nu}$$



Abdus Salam, Steven Weinberg, Sheldon Glashow
Nobel in Physics 1979
unified Electromagnetism and Weak nuclear forces

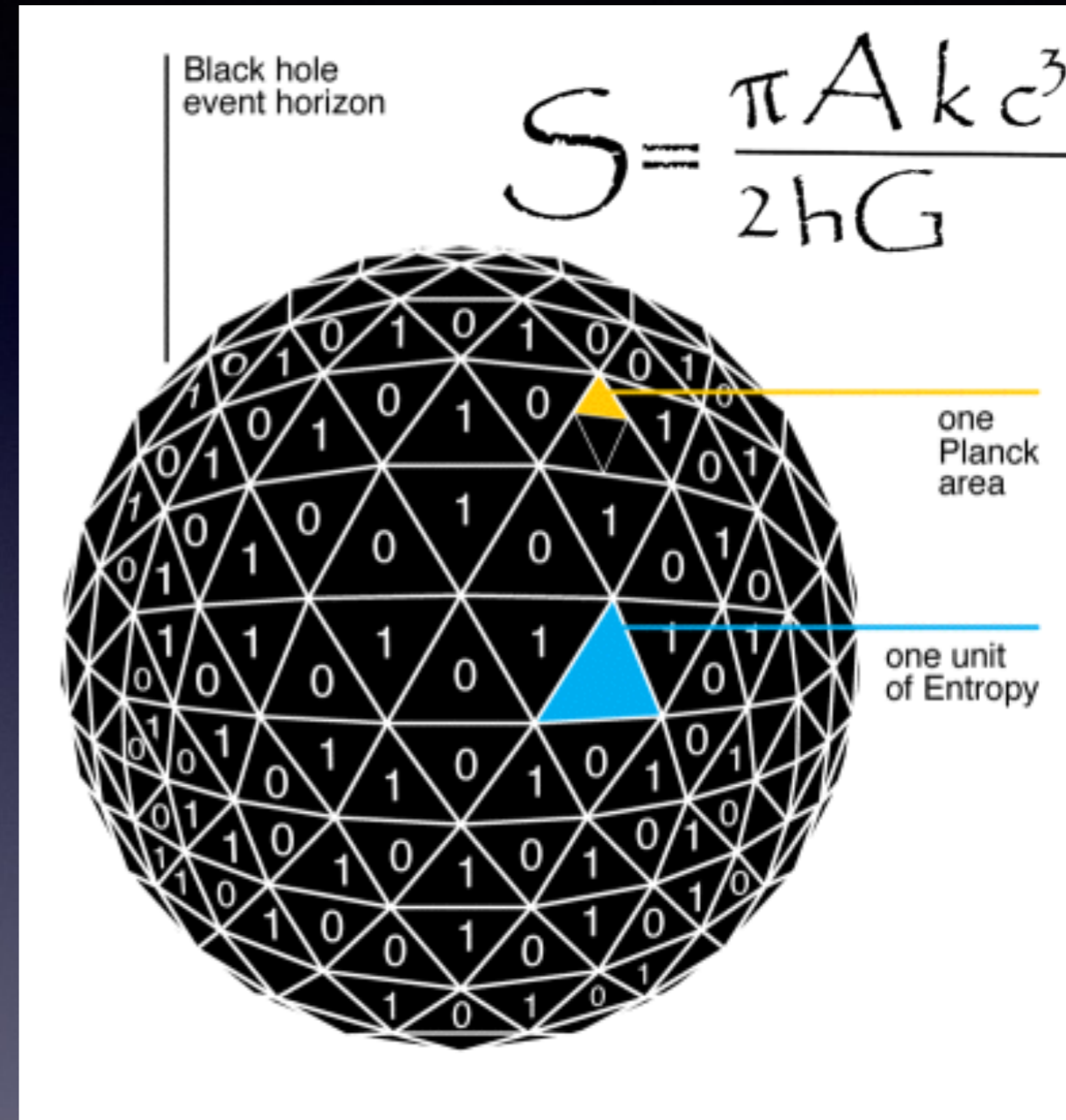








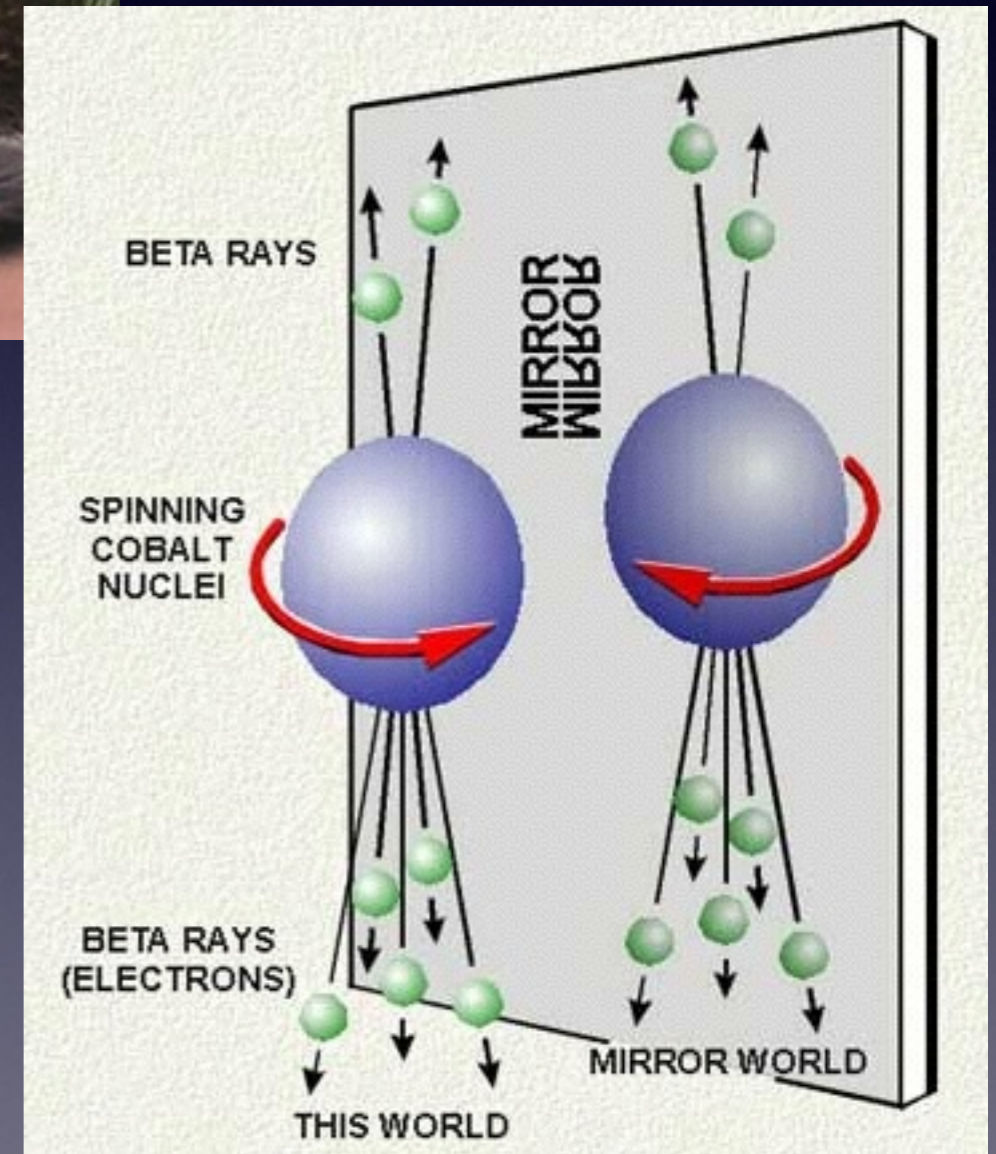
Yaakov Bekenstein
1947-2015
American/Israeli
Einstein prize 2015

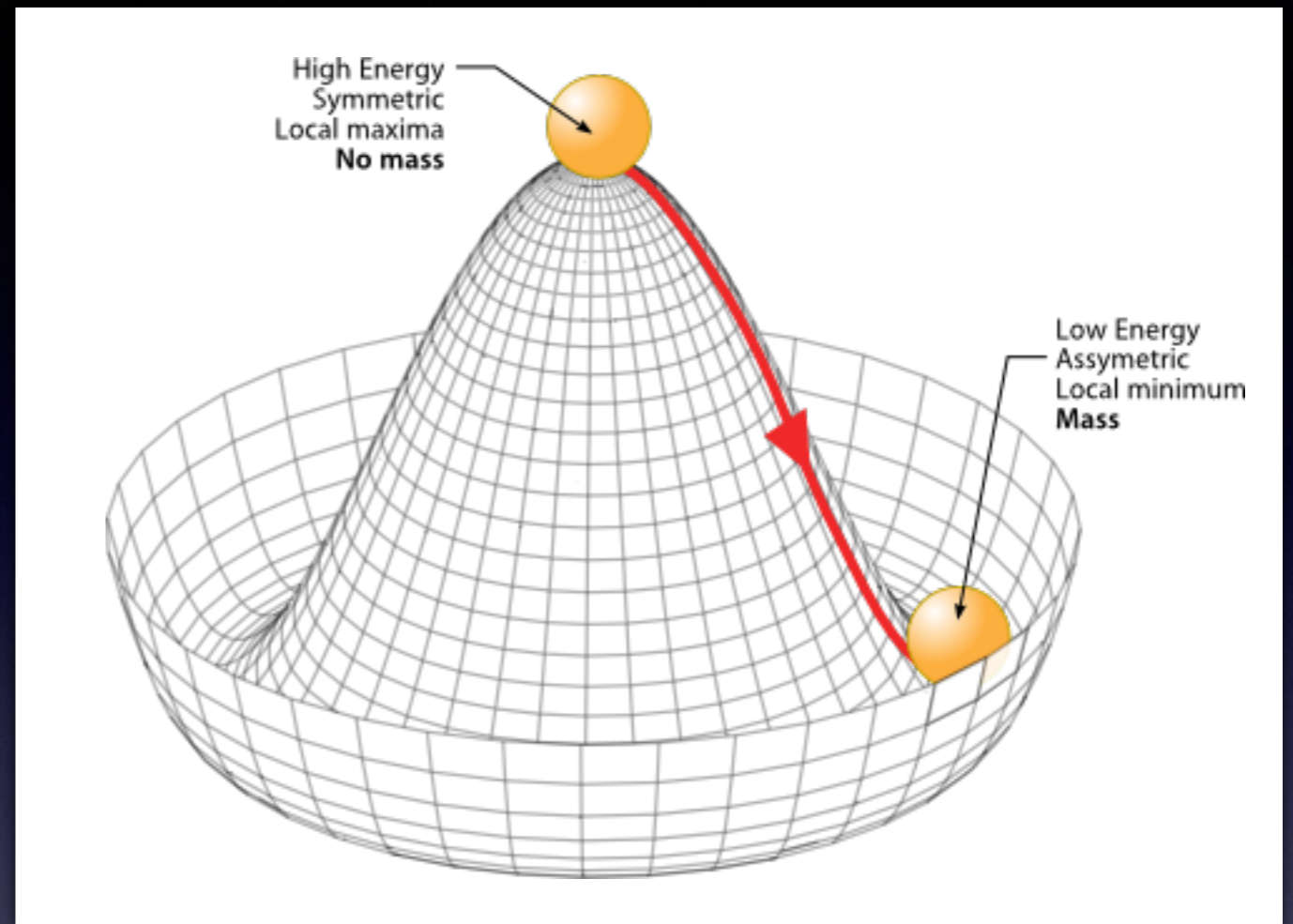


- Continuous symmetry
- Discrete symmetry
- Symmetry and unification
- **Symmetry breaking and complexity**



T.-D. Lee, C.-N. Yang
Chinese/American
Nobel in physics 1957
parity violation





Peter Higgs
1929—
British
Nobel in physics 2013
Higgs boson

