

In the Pursuit of Precision

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Biography of Dmitry BARDIN

<http://theor.jinr.ru/~kuzemsky/bardinbio.html>

https://en.wikipedia.org/wiki/Draft:Dmitry_Yu._Bardin

https://ru.wikipedia.org/wiki/Бардин,_Дмитрий_Юрьевич

Dedicated to the memory of Dmitrii BARDIN (1945 – 2017)

I express my deep gratitude to Dima Bardin for his friendship, numerous help and support on many occasions, but the first and foremost for the happiness to be in contact with him during 50 years (1967-2017)

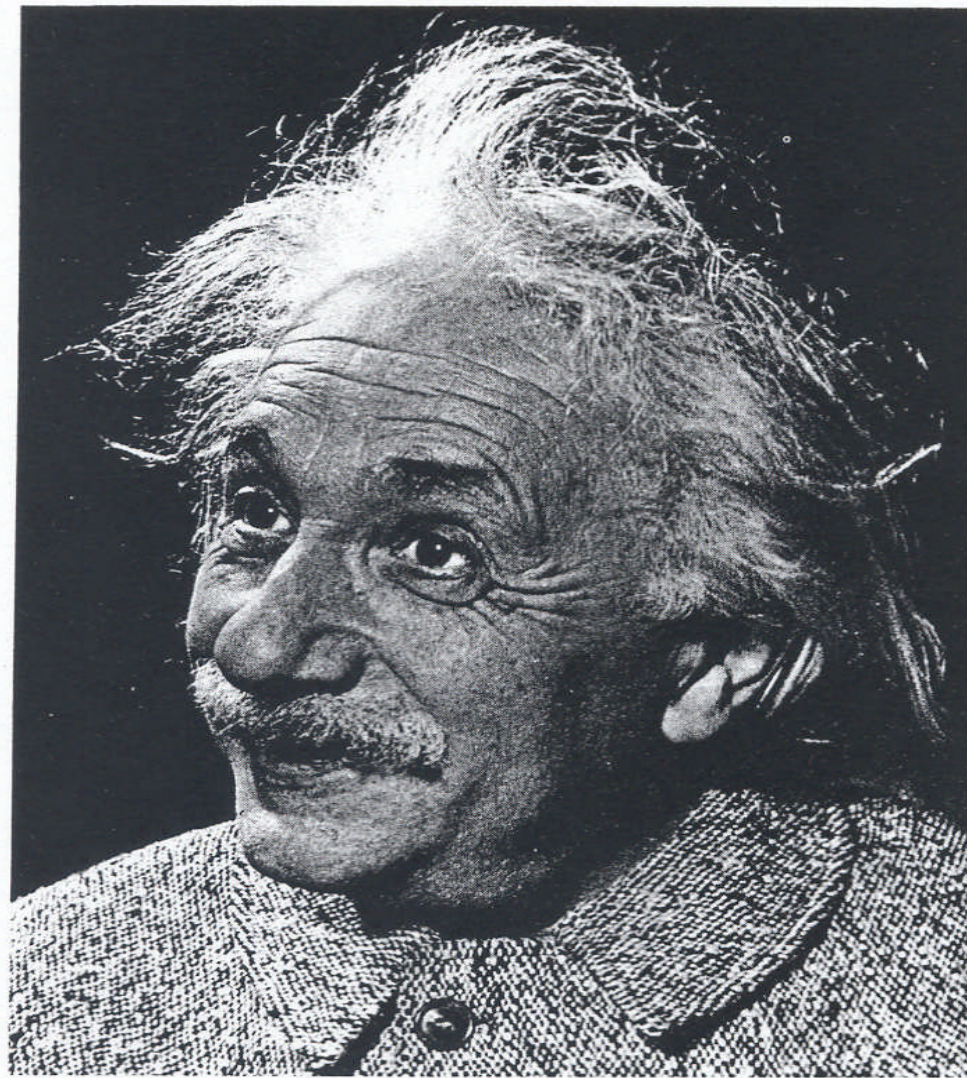


Time Line

- In this talk I would like to share with you some selected recollections and thoughts. I begin with time line:
- 1967-68: MSU, Dubna, Leningradskaya 10
- 1969-73: Room mate (with G. Mitselmacher) Dubna, Jolliott-Curie Str.13
- 1973-1976: Room mate, 2 beds room, Jolliott-Curie Str.13

I do not proffer any sort of memoirs, but only a glimpse into nice personality of Dima Bardin as a
eye-witness

- I testify: Dima was really decent, gentle, kind, friendly, responsible, talented, intelligent and honorable person.
- He had the intelligence of the heart and was very modest and open to communication. He had talent to live in the REAL world and was sensitive to details.
He HAD an Imagination...



*"Imagination is more
important than knowledge"*

Albert Einstein

Synopsis:

- Physics and Mathematics
- Theory and Experiment
- General Principles and Experimental Data
- Complementarity of the Both
- Precision: what is that?

Precision: Long Story

- Babilon math.(1500 B.C.):

Square root 2 = 1.4142135

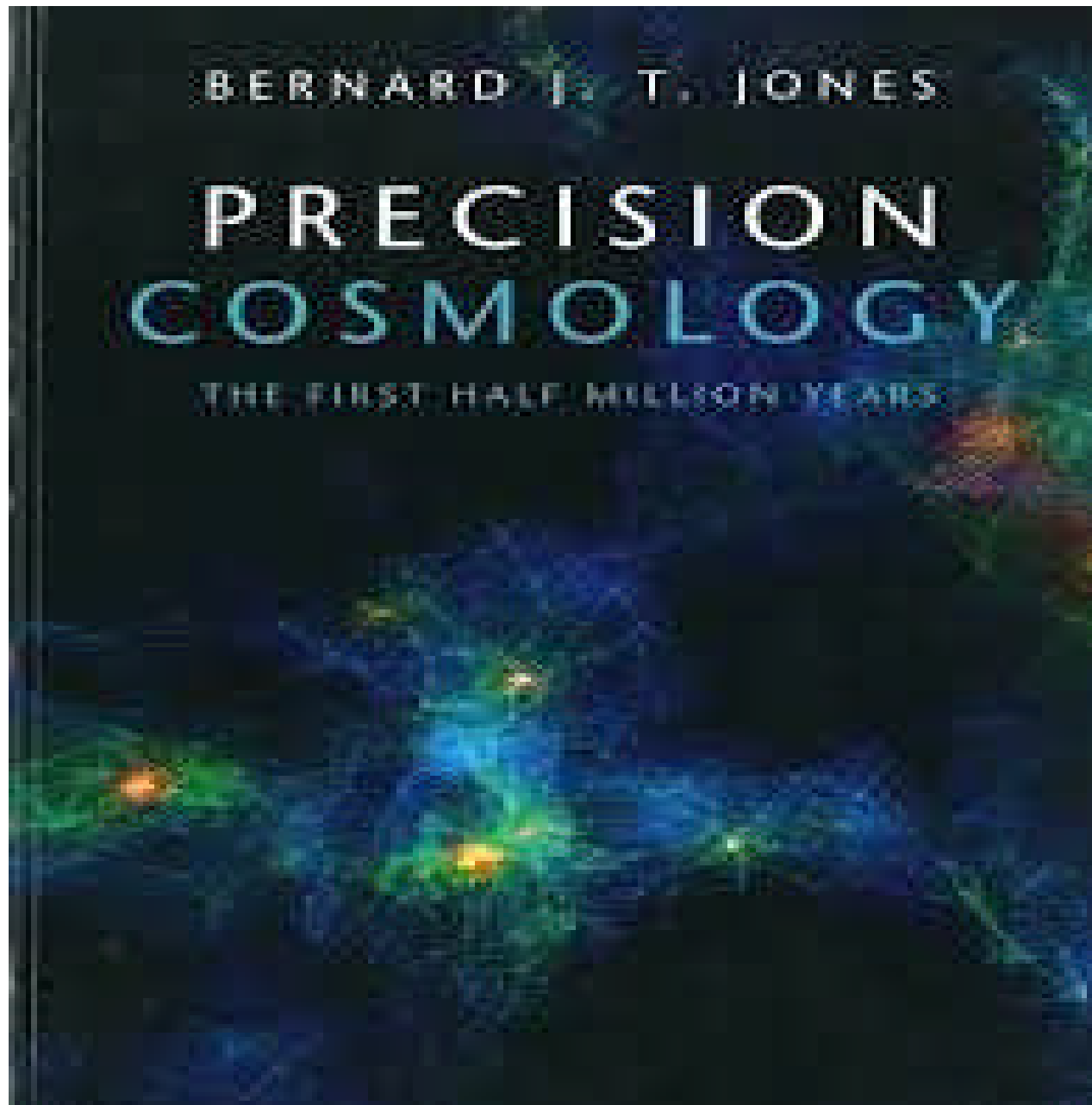
- Modern number: Square root 2 = 1.4142135623730950488...
- Lamb shift – quantum electrodynamics
- Precision Cosmology

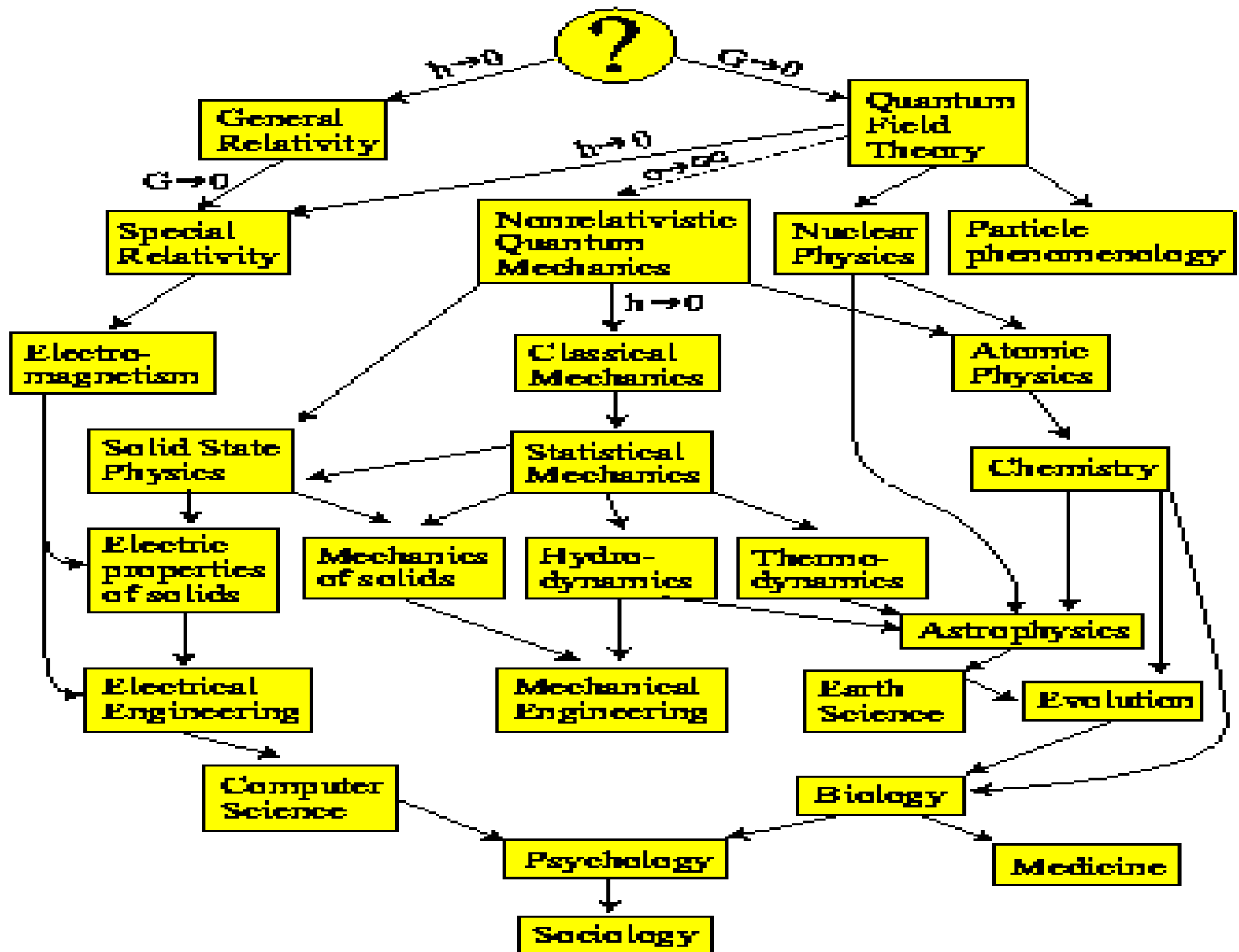


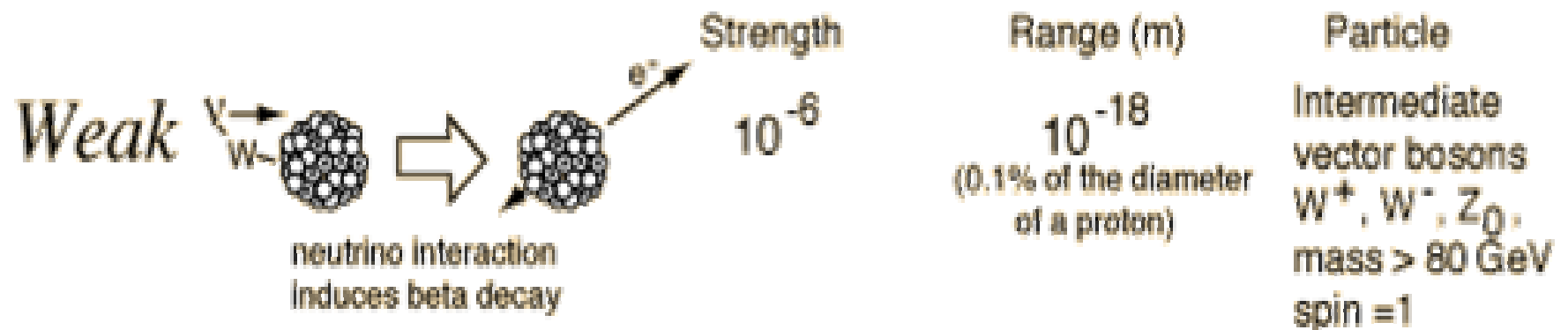
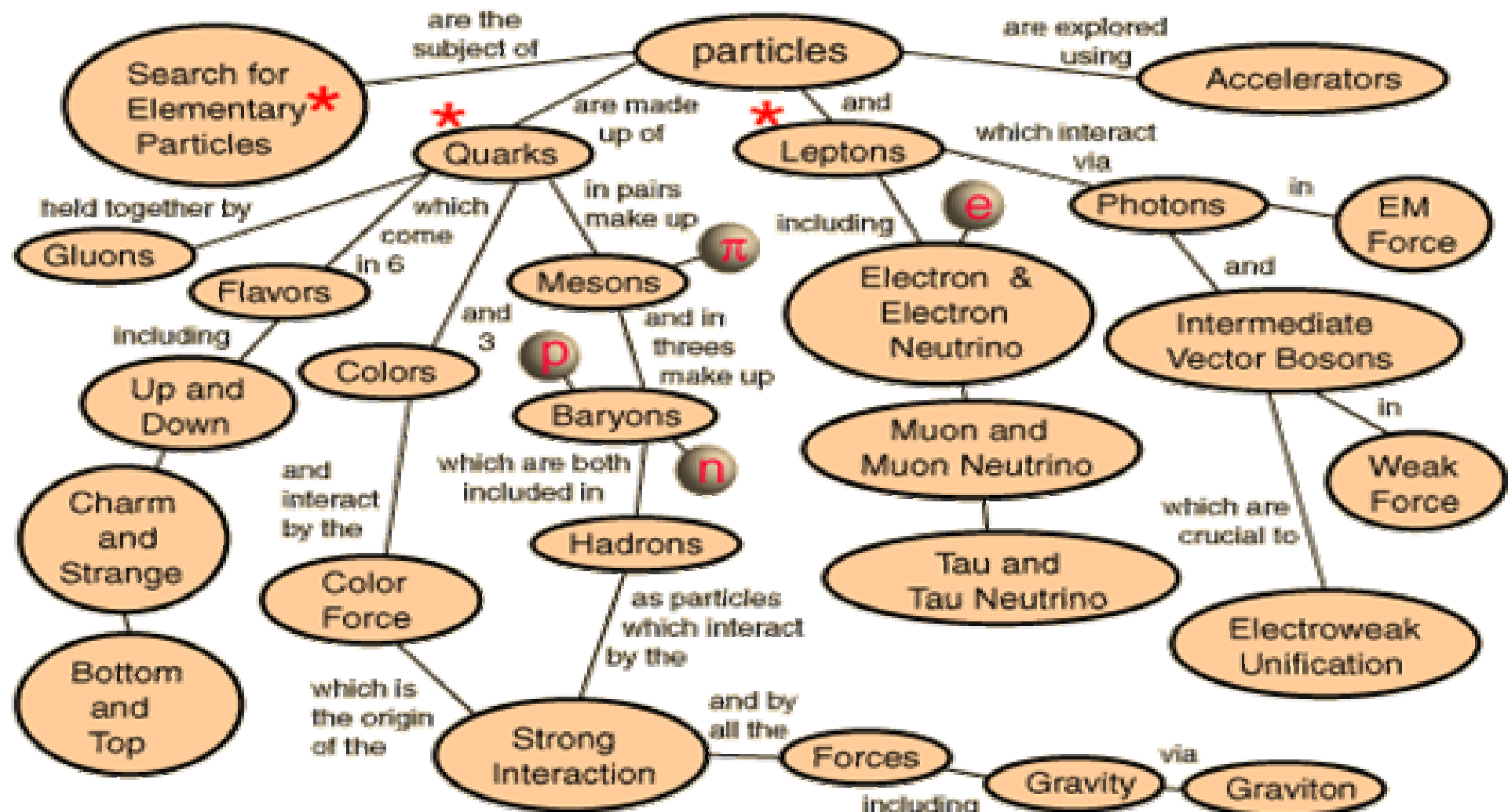
W.E. Lamb (1913 – 2008)

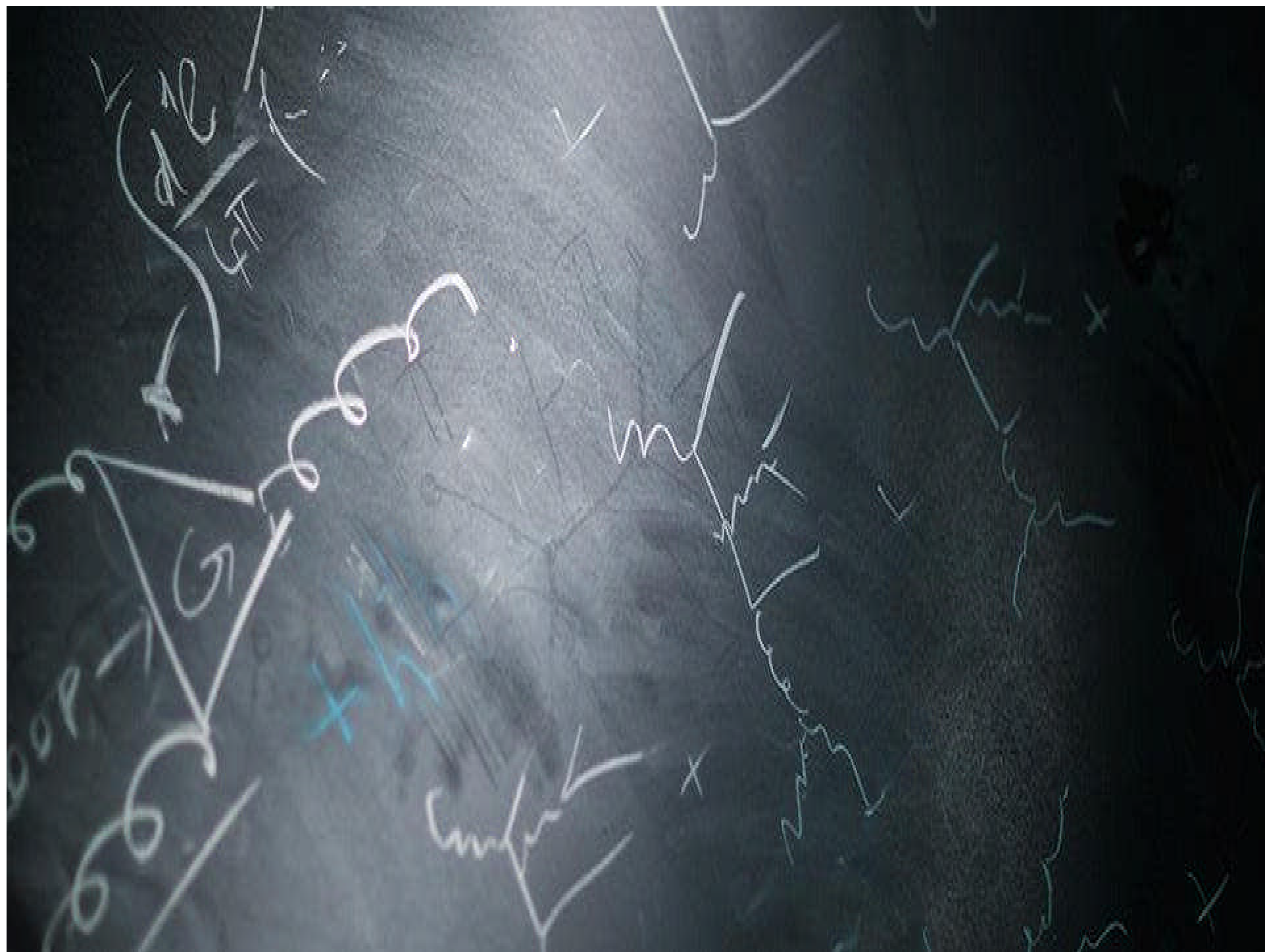
In physics, the **Lamb shift**, named after Willis Lamb (1913-2008), is a small difference in energy between two energy levels $2S_{1/2}$ and $2P_{1/2}$ of the hydrogen atom in quantum mechanics. According to Dirac and Schrodinger theory, *hydrogen* states with the same n and j quantum numbers but different l quantum numbers ought to be degenerate.

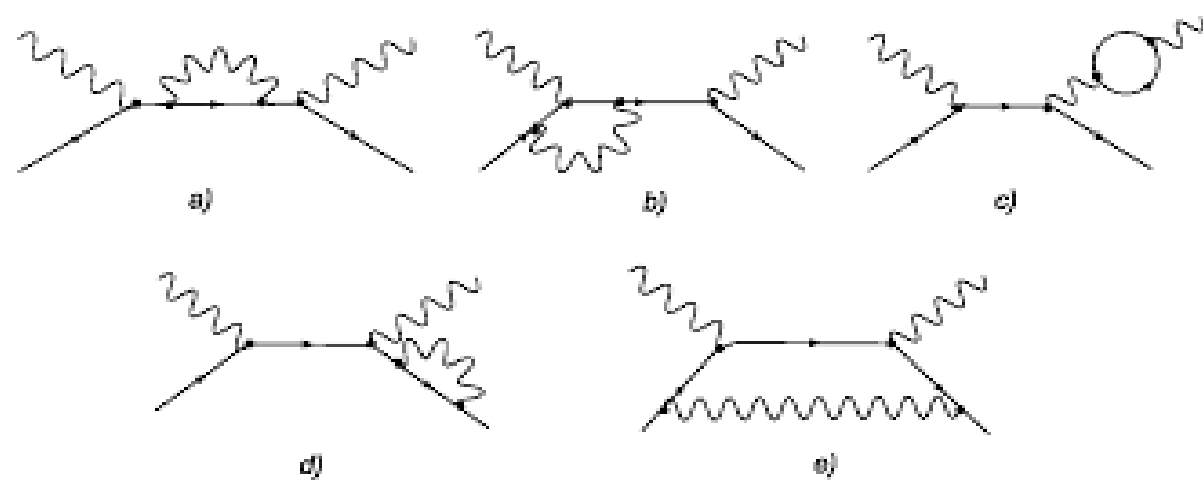
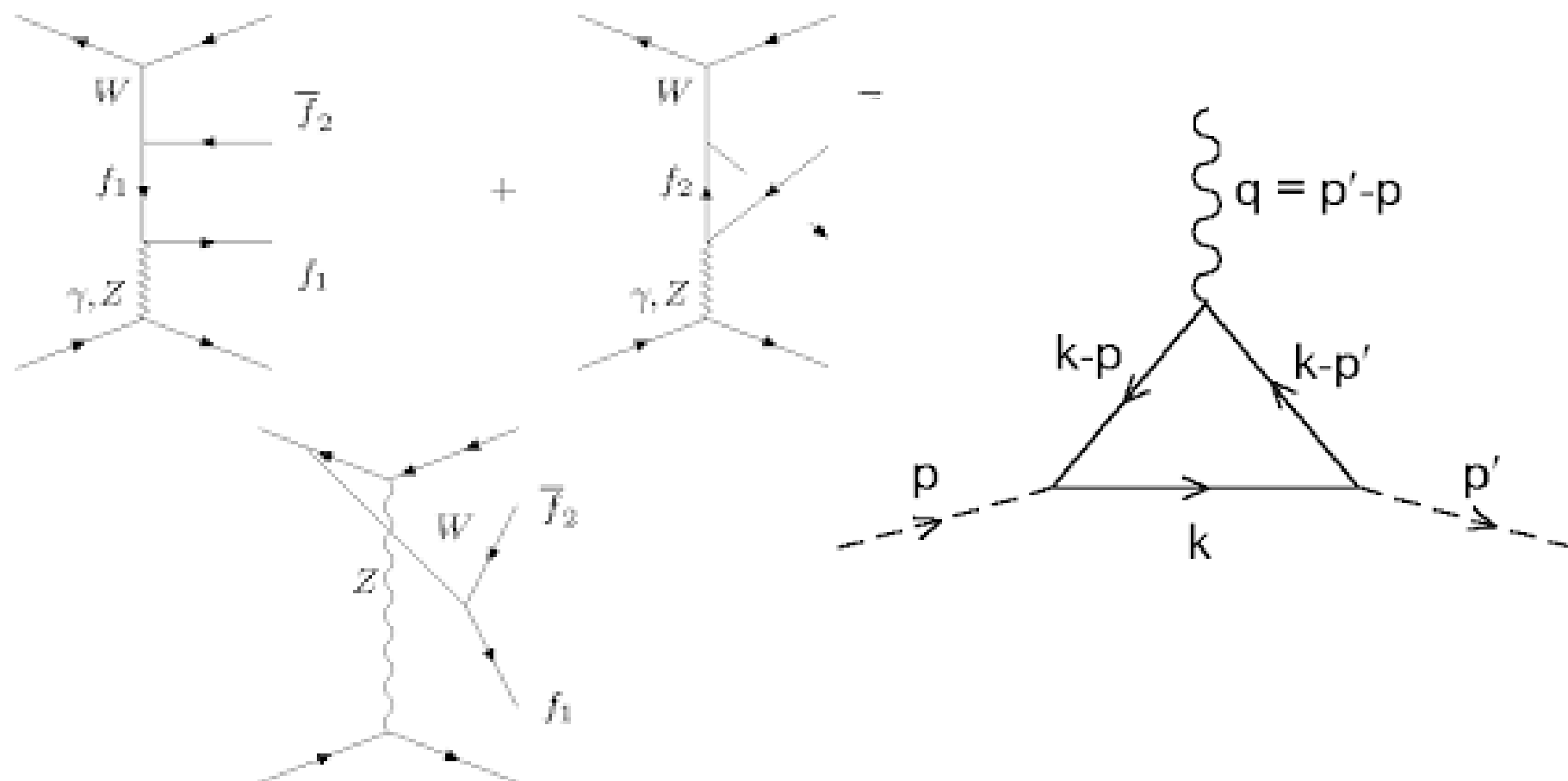
PRECISION COSMOLOGY





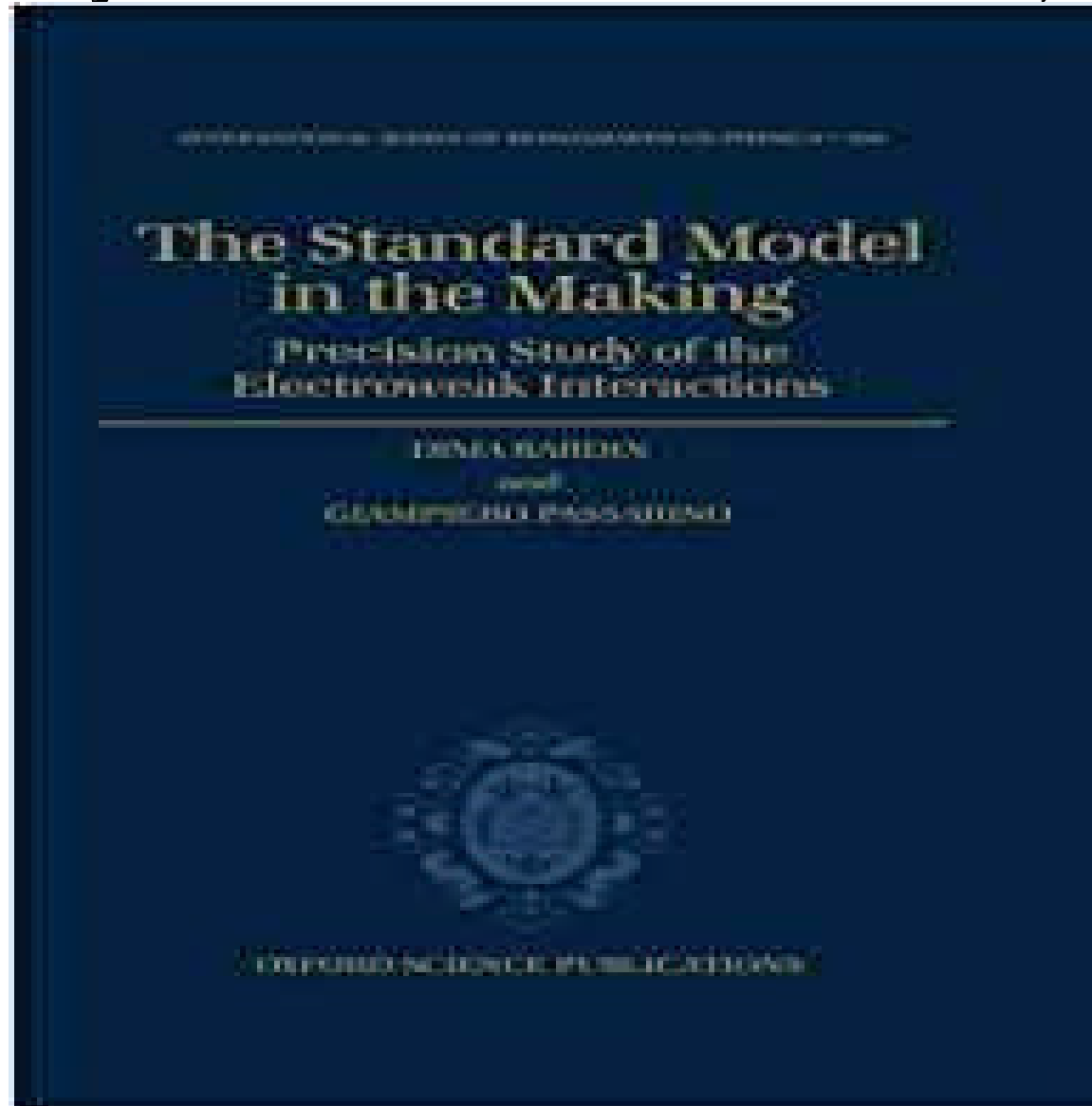






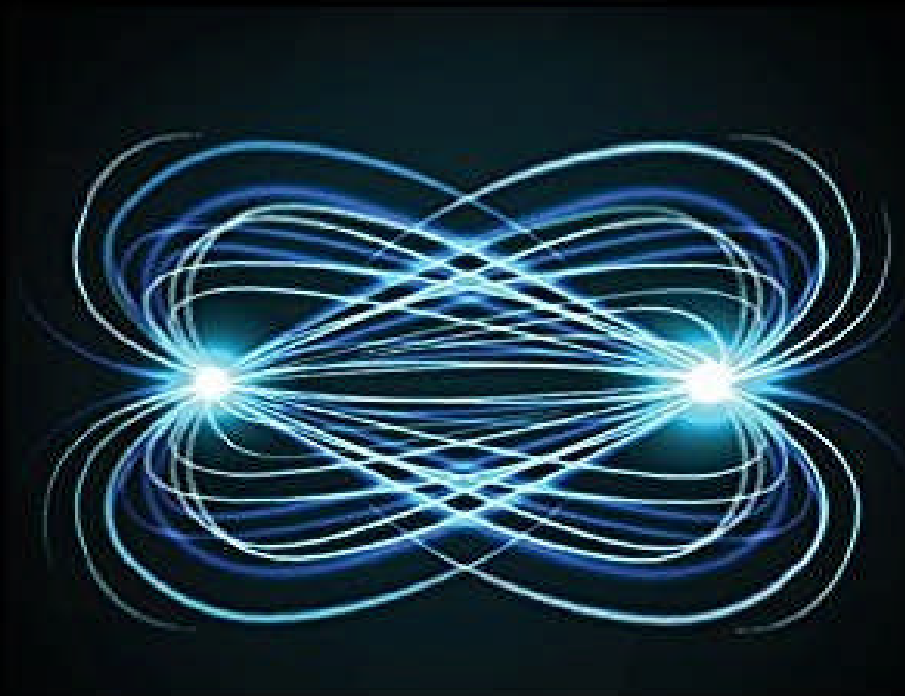
Bardin, Passarino, The Standard Model in the Making.

Precision Study of the Electroweak Interactions, Oxford, 1999



Statistical Mechanics and the Physics of Many-Particle Model Systems

Alexander Leonidovich Kuzemsky



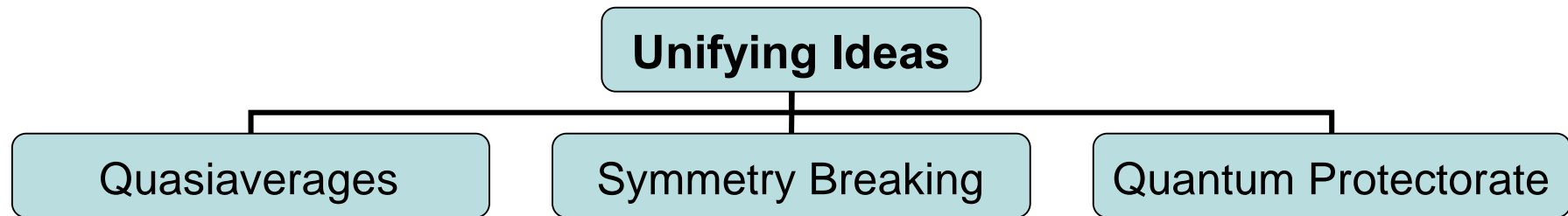
 World Scientific

Variational Principle:

- It was Maupertuis, who wrote in 1774 the celebrated statement:
- Nature, in the production of its effects, does so always by simplest means.



Principles of Symmetry and Physics of Many-Particle Systems





Laughlin R.D.,
D.Pines.

Quantum Protectorate:
a stable state of matter whose generic low-energy
properties are determined by a higher organizing
principles and nothing else.

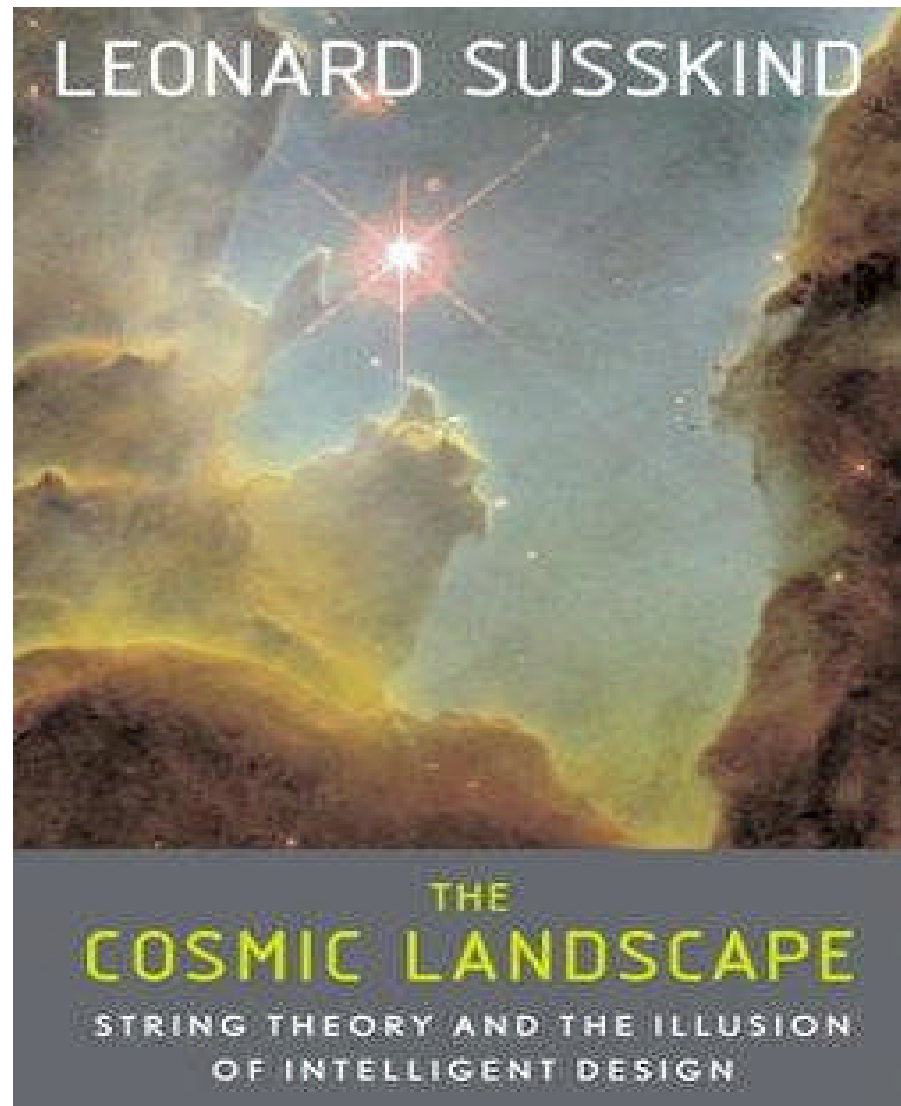
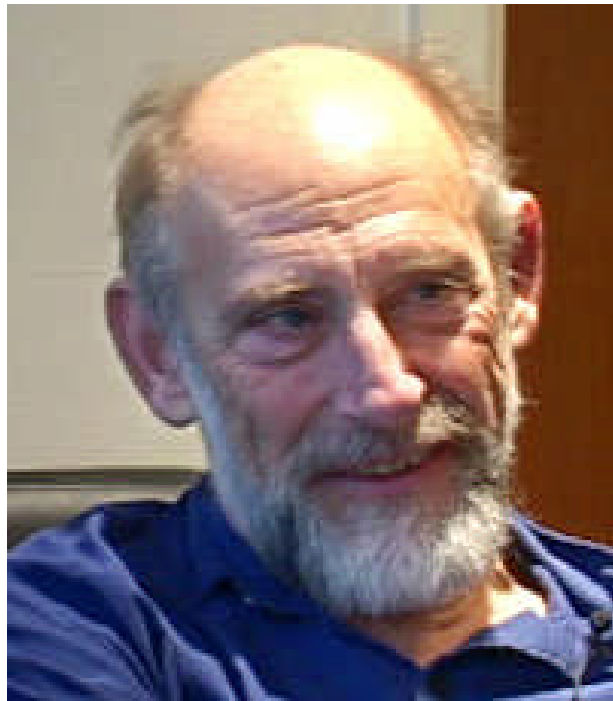
Theory of Everything,
PNAS, Vol. 97, Issue 1, 28
31, January 4, 2000

The **EMERGENCE** – macro-level effect from micro-level causes – is at the heart of the interrelation of reductionism and functionalism.

Laws of Quantum Mechanics

→ Emergence of consequences: superconductivity, magnetism, etc.

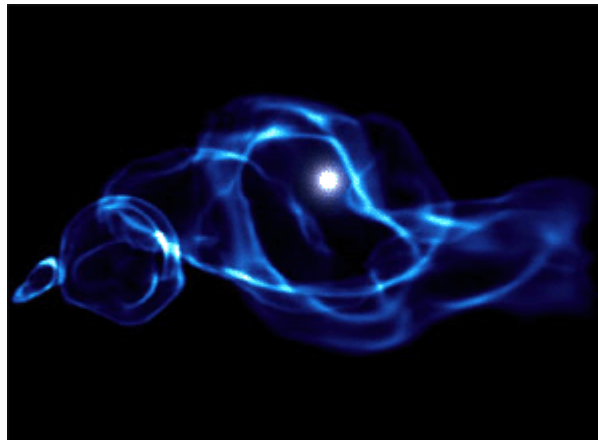
Polemics with Laughlin





F. Wilczek, 2005

**We vehemently suspect
that the world is a
multilayered, multicoloured,
cosmic **superconductor****



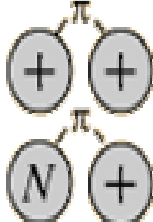
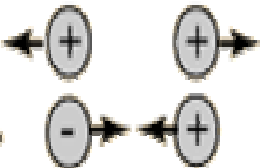

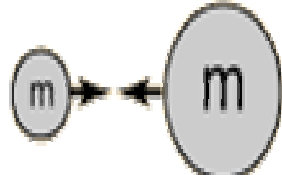
Big Bang Expansion and the Fundamental Forces

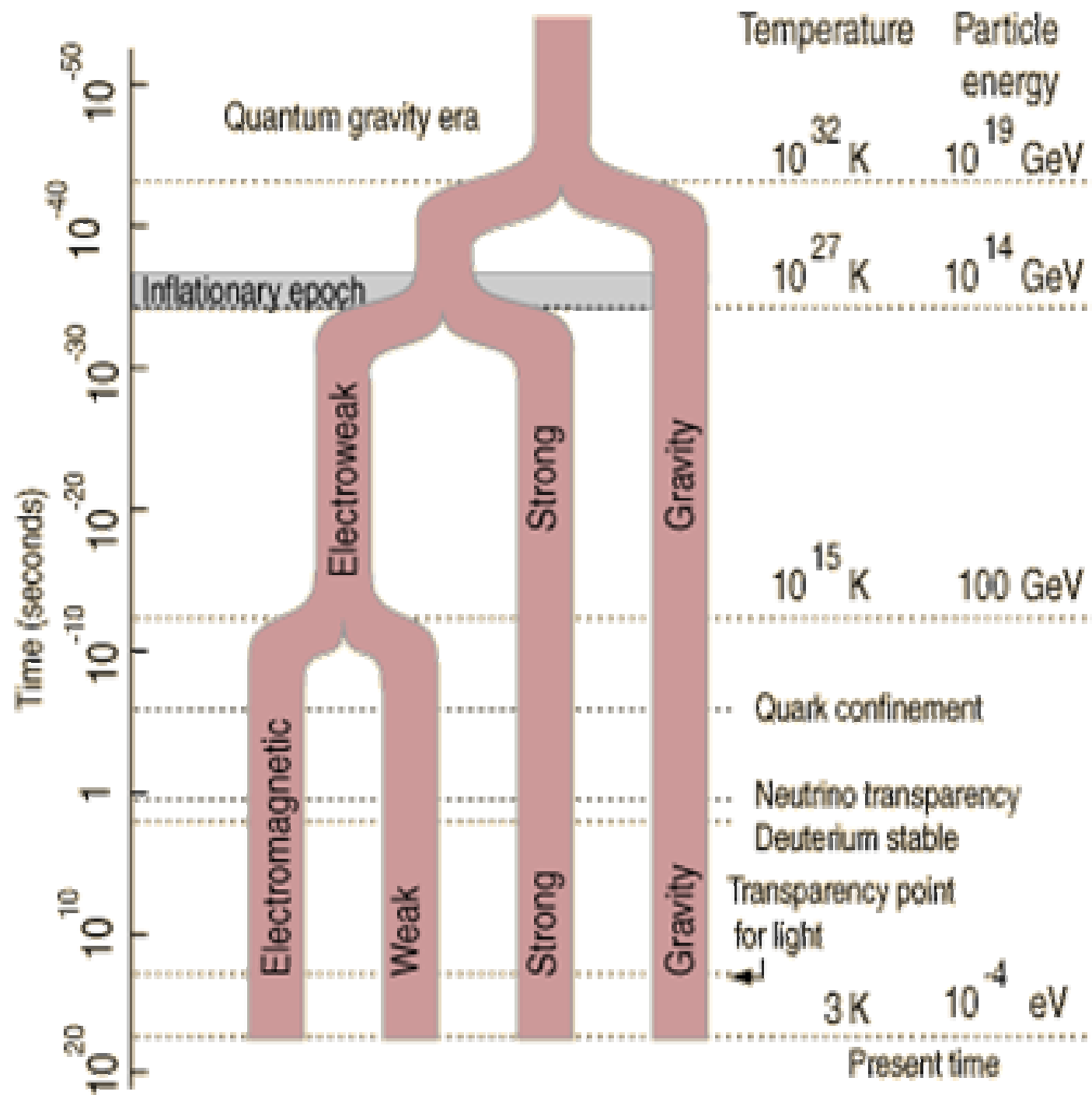
Modeling of the "[Big Bang](#)" expansion of the universe at earlier and earlier times has led to the use of the "[Planck time](#)" of 10^{-43} seconds as a proposed interval during which all the [fundamental forces](#) were unified into a single force.

We believe that the "[spontaneous symmetry breaking](#)" which is presumed to have separated the original force into the four forces which we see operating in the present, low temperature universe. Proposed energies and temperatures associated with each of the symmetry breaks are shown along with a modeling of the time elapsed in the Big Bang model.



Fundamental Forces

<i>Strong</i>		Strength 1	Range (m) 10^{-15} (diameter of a medium sized nucleus)	Particle gluons, π (nucleons)
<i>Electro-magnetic</i>		Strength $\frac{1}{137}$	Range (m) Infinite	Particle photon mass = 0 spin = 1
<i>Weak</i>		Strength 10^{-6}	Range (m) 10^{-18} (0.1% of the diameter of a proton)	Particle Intermediate vector bosons W^+ , W^- , Z_0 , mass > 80 GeV spin = 1
<i>Gravity</i>		Strength 6×10^{-39}	Range (m) Infinite	Particle graviton ? mass = 0 spin = 2



The Standard Model

4

Fermions			Bosons	
Quarks	u up	c charm	t top	γ photon
	d down	s strange	b bottom	Z Z boson
Leptons	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson
	e electron	μ muon	τ tau	g gluon
			Force carriers	
			Higgs* boson	

Source: AAAS

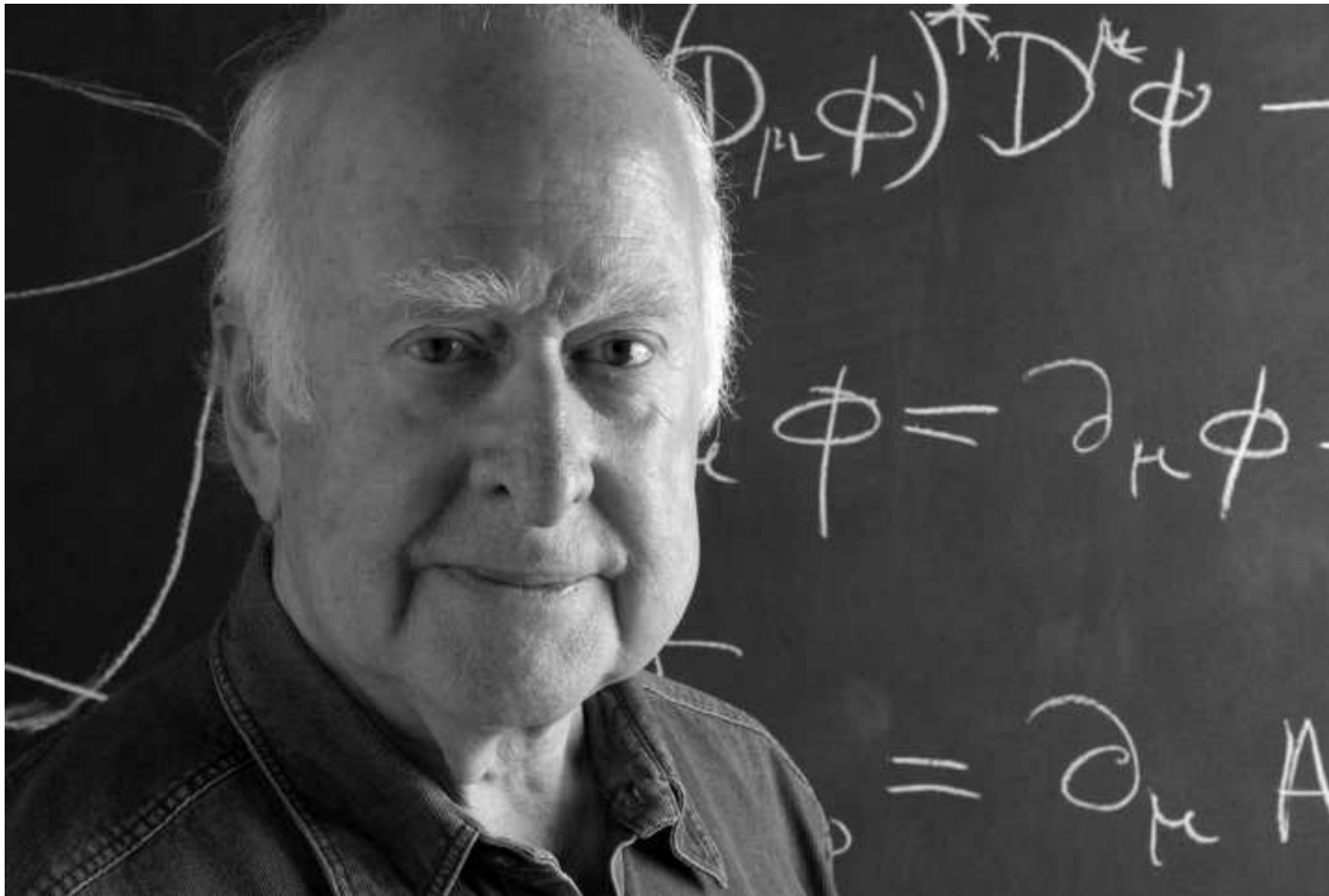
*Yet to be confirmed

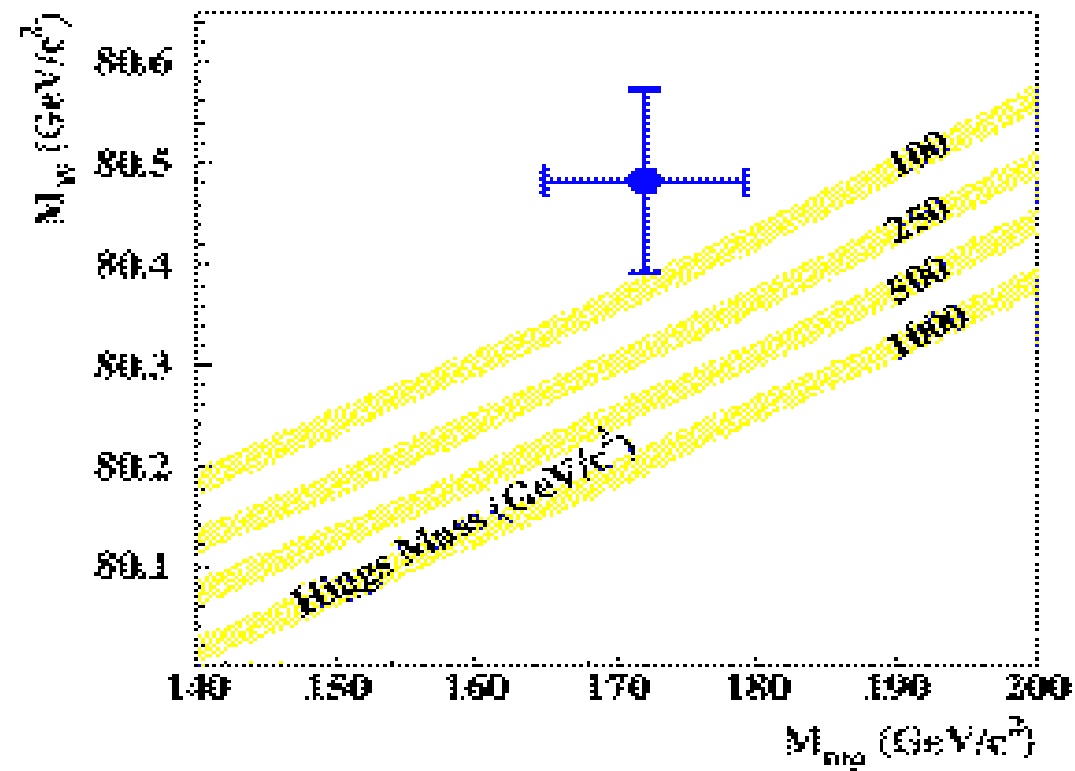
Higgs Fields

The Higgs Fields (after Peter Higgs) are hypothetical scalar fields introduced into **Grand Unified Theories** to maintain gauge invariance for "particles" with "mass". Indeed it is the coupling of the "matter field" ("particle") to the Higgs Field that leads to the thing we call "mass".

There is a Higgs Field for each of the 24 fundamental particles. Each of the fundamental particles is thought of as a bundle of energy of the field. The Higgs Fields are symmetric about their zero points, but the potential has a positive value at this point. Instead the potential is zero at some non-zero value of the field. It is the shape of this potential which enable spontaneous symmetry breaking to occur.

Peter Higgs





Higgs Boson Mass (expected) < 200 GeV



Дмитрий Иванович Блохинцев

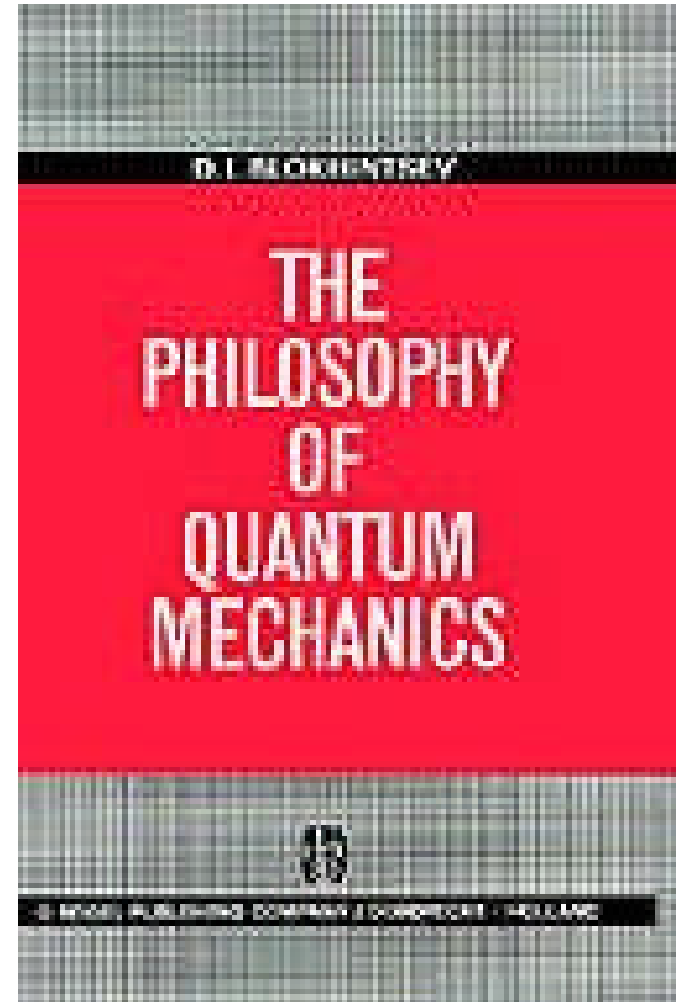
11.01.1908 – 27.01.1979



D. I. Blokhintsev

Blokhintsev

According to Blokhintsev, “The ability of a human being to perceive his surrounding reality is related to the feeling of surprise and admiration in front of the inconceivable beauty and harmony of the world.”



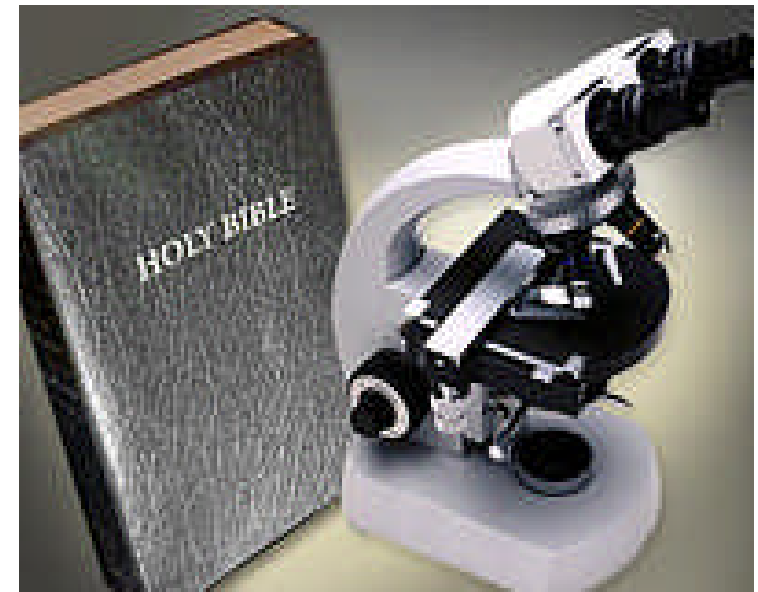
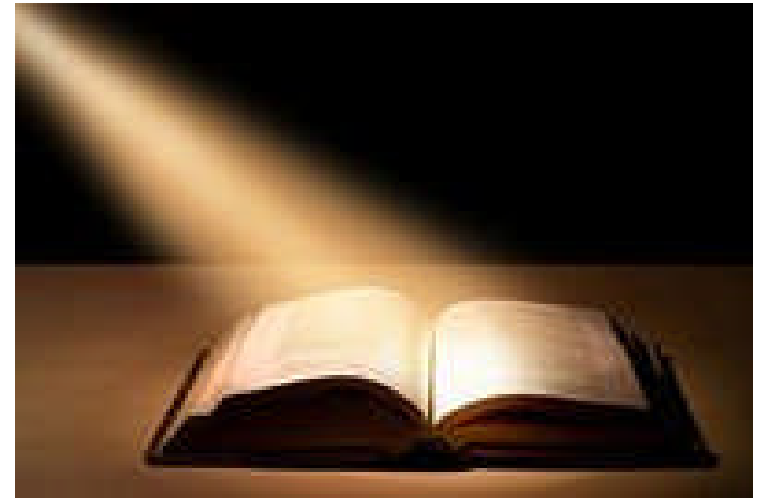
N. N. Bogoliubov

21.08.1909 – 13.02.1992



N. N. BOGOLIUBOV

GOD IS A
MATEMATICIAN...



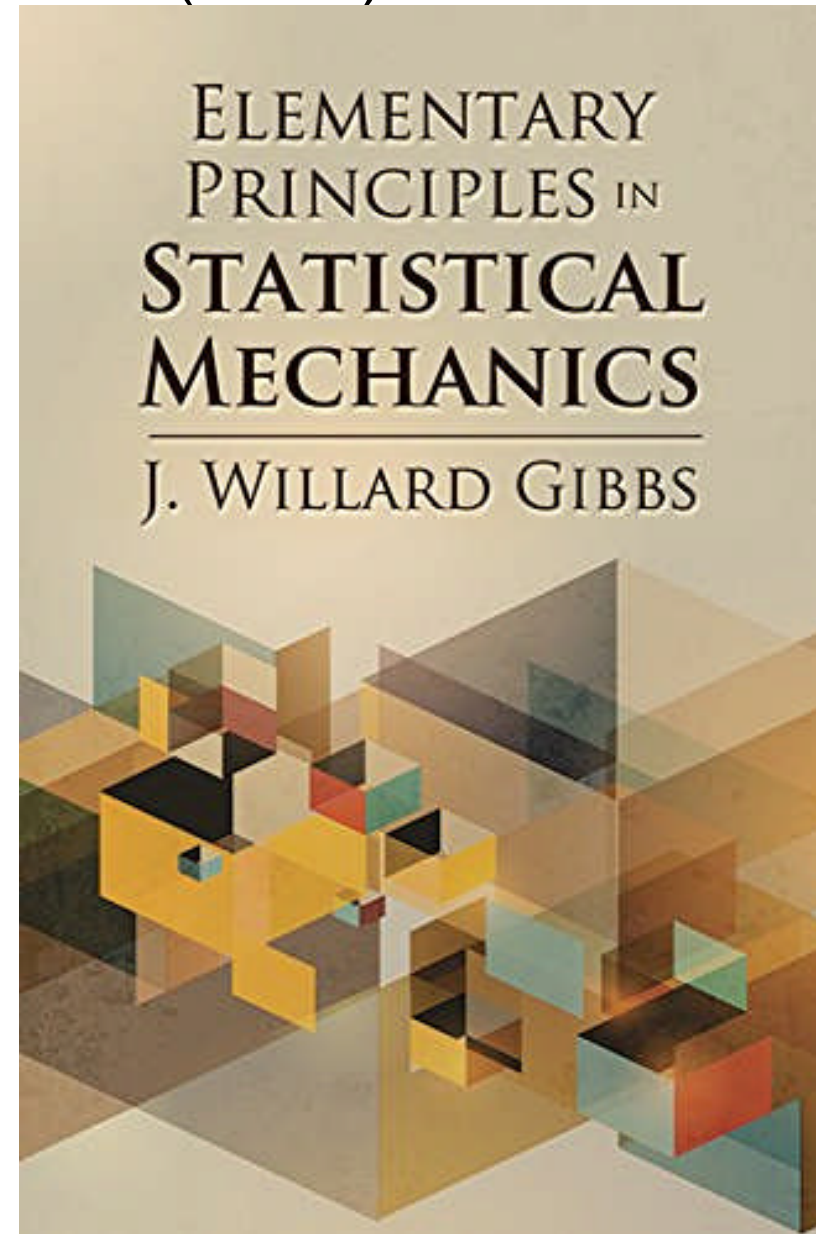


DOMINUS ILLUMINATIO MEA: Psalm 26



Elementary Principles of Statistical Mechanicsby Josiah Willard Gibbs (1902)

Written by J. Willard Gibbs, the most distinguished American mathematical physicist of the nineteenth century, this book was the first to bring together and arrange in logical order the works of Clausius, Maxwell, Boltzmann, and Gibbs himself. The lucid, advanced-level text remains a valuable collection of fundamental equations and principles.





F. Wilczek, 2005

The primary goal of fundamental physics is to discover profound concepts that illuminate our understanding of nature.

Symmetry and Physics

It is well known that symmetry principles play a crucial role in physics. The theory of symmetry is a basic tool for understanding and formulating the fundamental notions of physics.

R. L. Mills noticed that "symmetry is a driving force in the shaping of physical theory".

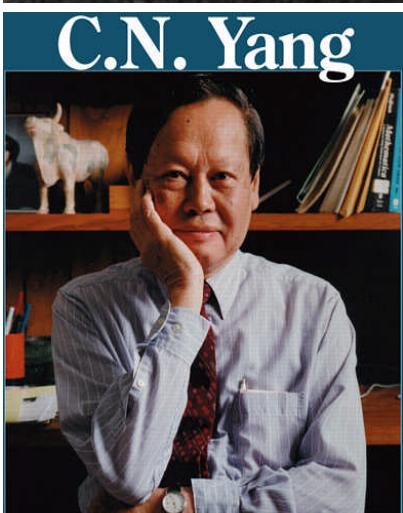
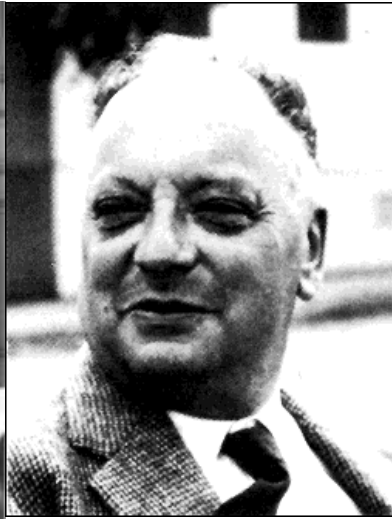
According to **D. Gross**, "the primary lesson of physics of this century is that the secret of nature is symmetry".

Many fundamental laws of physics in addition to their detailed features possess various symmetry properties. These symmetry properties lead to certain constraints and regularities on the possible properties of matter.

Thus the principles of symmetries belong to the **underlying principles** of physics.

Moreover, the idea of symmetry is a useful and workable tool for many areas of the quantum field theory, statistical physics and condensed matter physics

Classics of Symmetry:

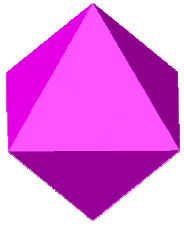


R. P. Feynman on Symmetry:

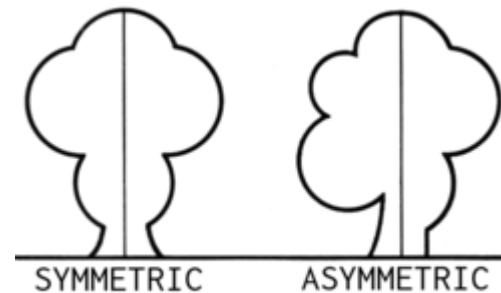
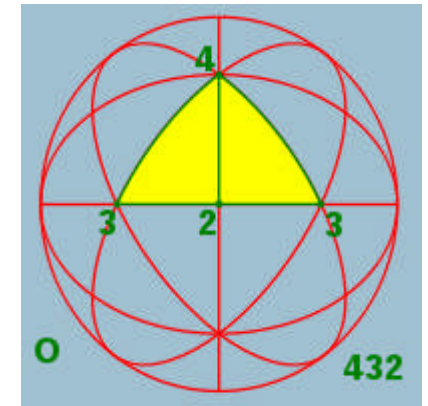
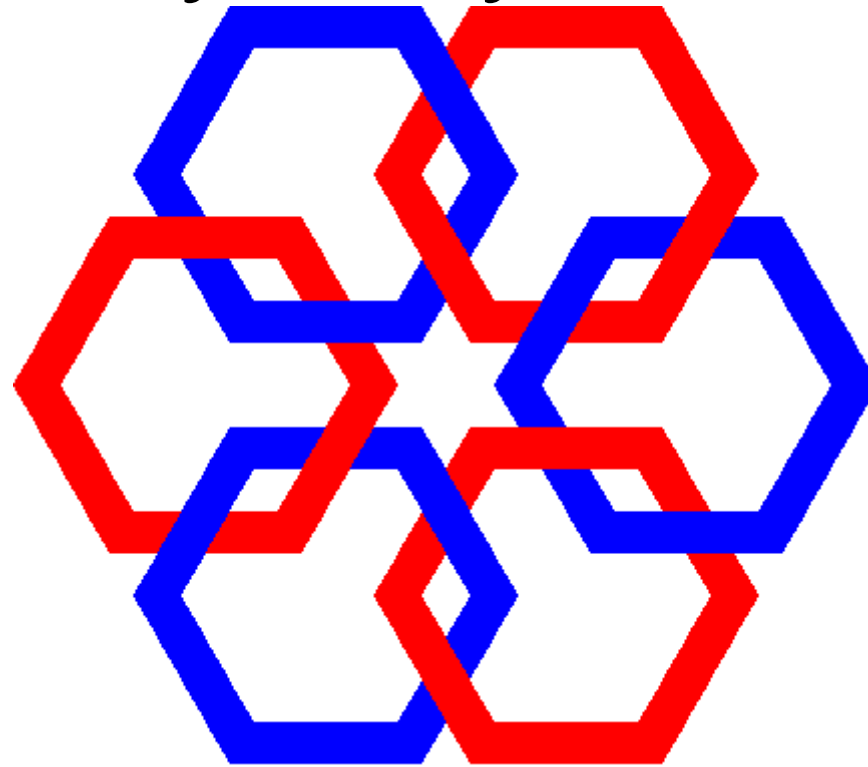
Feynman quotes Hermann Weyl in Feynman, Leighton, and Sands, *The Feynman Lectures on Physics* Definitive Edition, Pearson Addison Wesley, 2006, Vol. I, p. 11-1.

"When a thing is symmetrical, how can we define it? ... 'a thing is symmetrical if one can subject it to a certain operation and it appears exactly the same after the operation.'" —R.P. Feynman





Beauty of Symmetry





F. Wilczek, 2005

The underlying theme of broken symmetry is quite old. It goes back to... Newton, who postulated that the basic laws of mechanics exhibit full symmetry in 3D of space – despite the fact of the experience which clearly distinguishes notions ‘up and down’ and ‘sideway’ directions in our local environment.

Quantum Theory and Interpretations

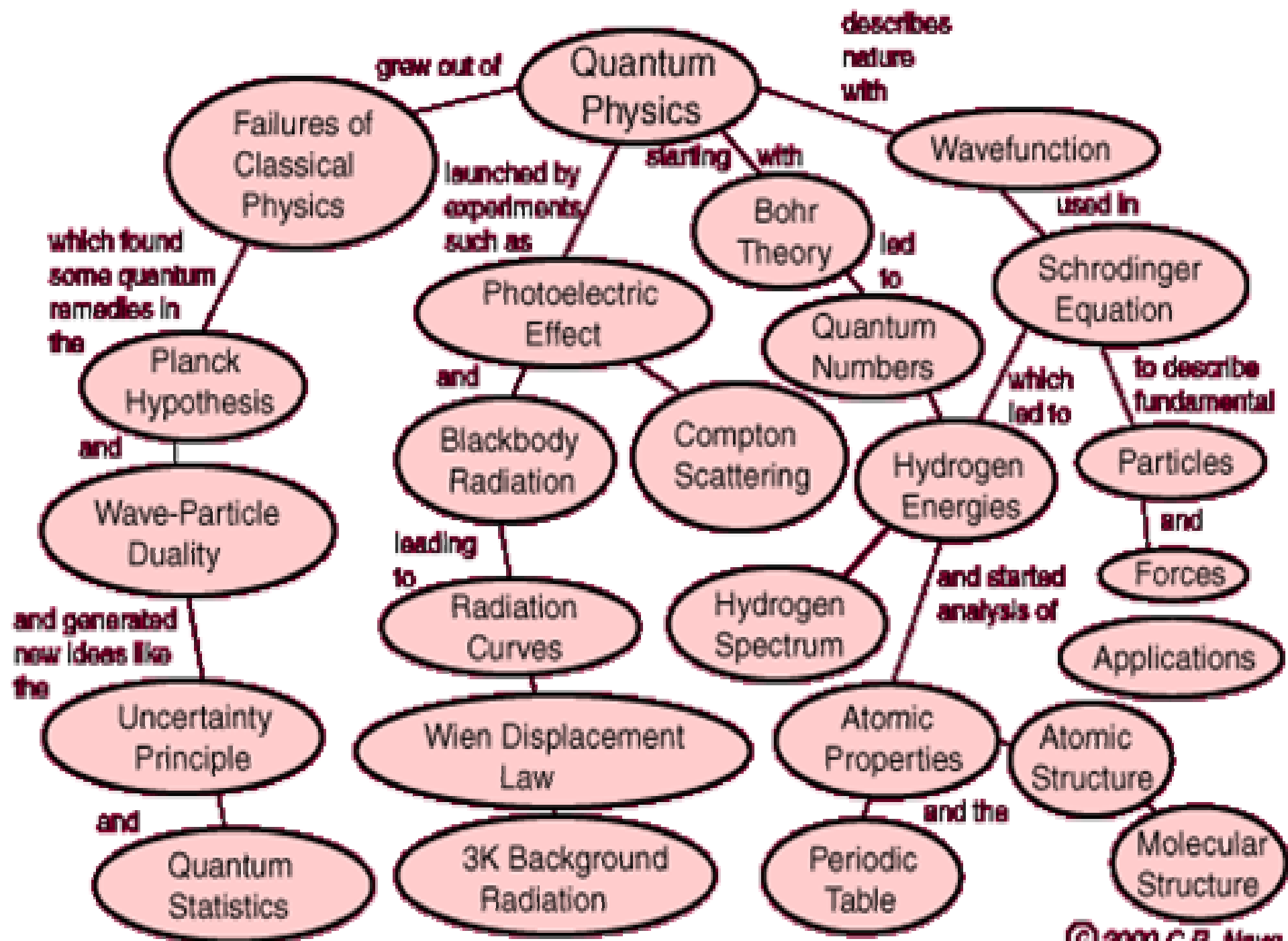
Quantum mechanics is a **theory**. It is our current “standard model” for describing the behavior of matter and energy at the smallest scales (photons, atoms, nuclei, quarks, gluons, leptons, ...).

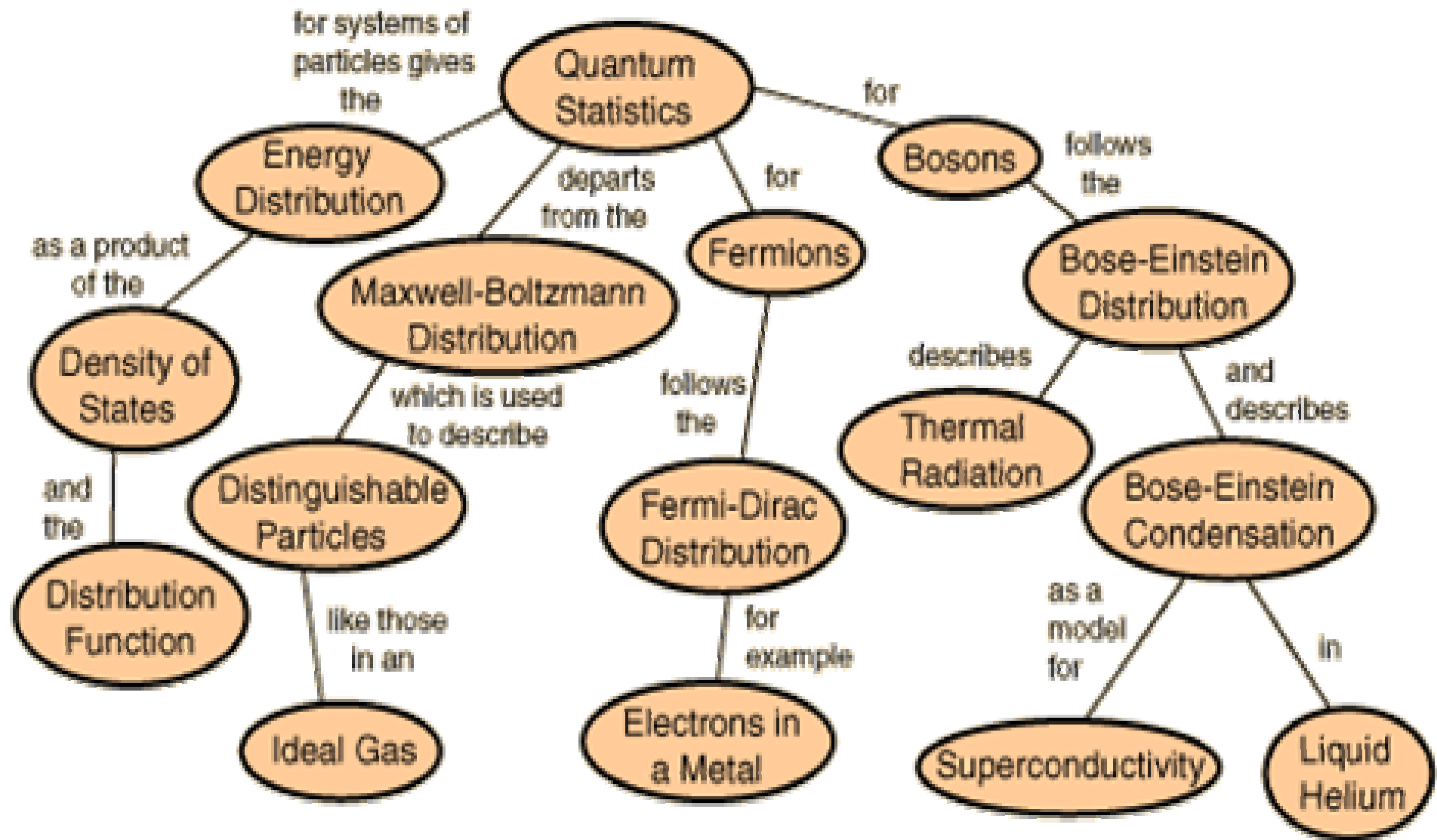
Like all theories, it consists of a mathematical **formalism**, plus an **interpretation** of that formalism.

However, quantum mechanics differs from other physical theories because, while its **formalism** has been accepted and used for 80 years, its **interpretation** remains a matter of controversy and debate. Like the opinions of the 6 blind men, there are many rival QM interpretations on the market.

Physics and Mathematics

- **Mathematical beauty is expected to be a prerequisite for physical truth. This could be a dangerous assumption. It is important not to lose sight of the physical world, and whatever theory finally emerge from today's deliberations cannot be exempt from comparison with experiments and observation, however strong its mathematical pedigree.**
- **Ian Stewart, Why Beauty is Truth**





Basic Question of Quantum Mechanics:

- Does Ψ refer to a single system or to an ensemble?
- Standard Answer: Ψ is a mathematical object pertaining to a single system; its square $|\Psi|^2$ may be called a single system **probability**. However, in order to confront this quantity with reality one must perform observation on a **LARGE NUMBER** of similar systems, in such a way that the probability density **materializes** as an actual probability.

The Role of an Interpretation

An **interpretation of a formalism** should:

- Provide links between the mathematical symbols of the formalism and elements of the physical world;
- Neutralize the paradoxes; all of them; addressing only **a few** of the formalism's interpretational problems is undesirable;
- Provide tools for visualization, for speculation, and for extension.
- An interpretation should **not** have its own sub-formalism!
- It should **not** make its own testable predictions, (but it *may* be falsifiable, if it is found to be inconsistent with the formalism and/or with experiment)!



*The Blokhintsev's
Interpretation of Quantum
Mechanics
(Quantum Ensembles).*

Predecessors:

*John von Neumann,
L.I. Mandelstam,
K. V. Nikolsky*

R.P.Feynman, The Character of Physical Law, 1967

There was a time when the newspapers said that only 12 men understood the theory of relativity... On the other hand, I think it is safe to say that no one understands quantum mechanics...

HENCE:

SHUT UP AND CALCULATE!



Max Born(1882 – 1970)

Born formulated in his lecture “Experiment and Theory in Physics” delivered in 1943:

“Those who want to master the art of scientific prediction should, instead of relying on abstract deduction, try to comprehend the secret language of Nature, which is represented by experimental data.”

DIMA BARDIN DID IT !.

Rudolf Peierls (1907 – 1995)

**Never Invent a Theory
before it is Certain That
the Experiment Was
Correct.**

Trieste, 1989

Homage to Dima BARDIN



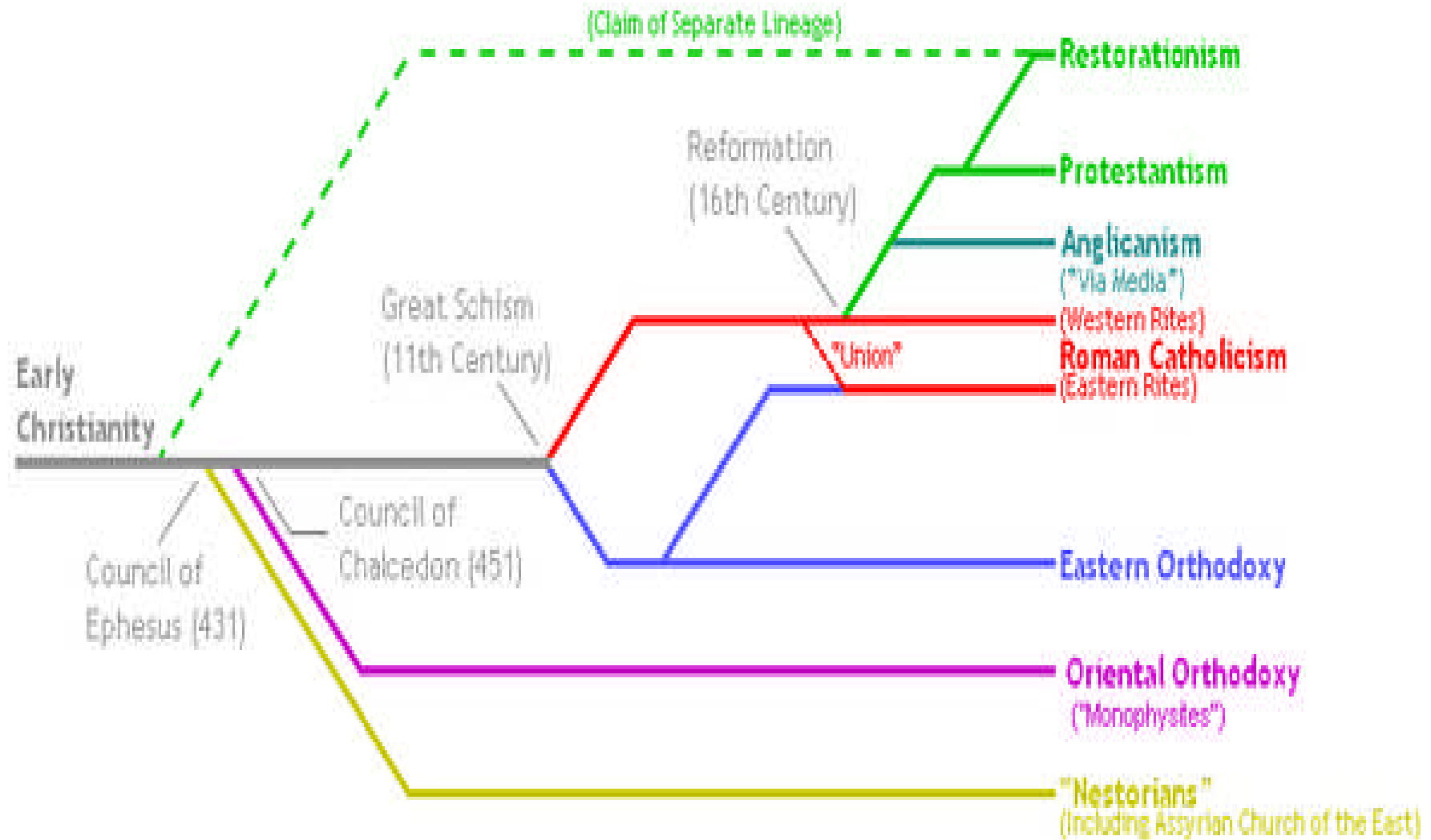




Father Alexander MEN (1935-1990)

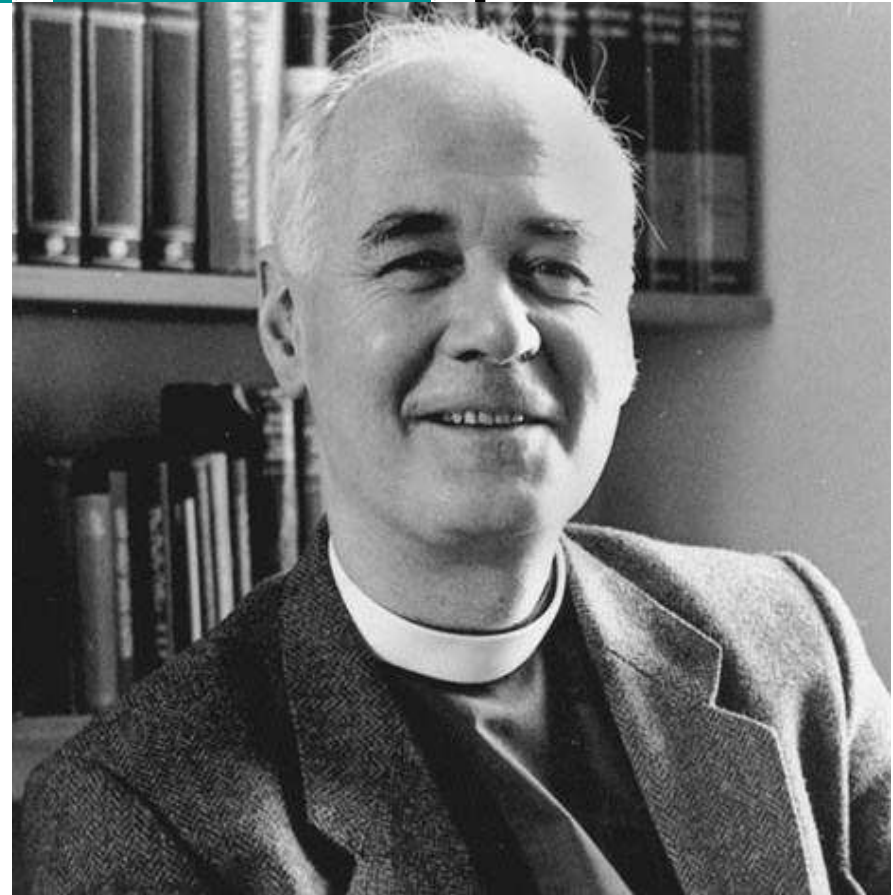
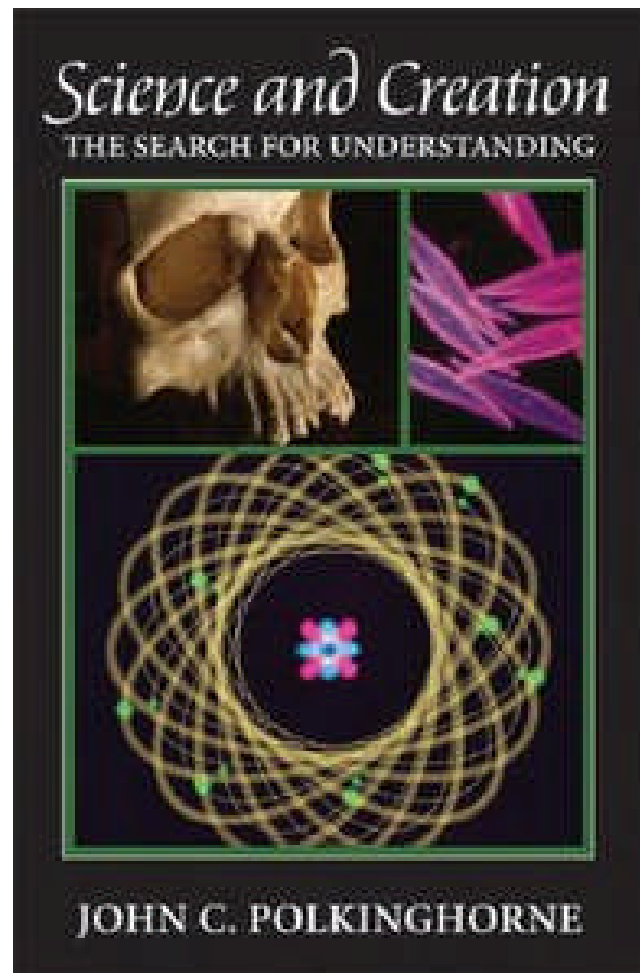


Christian Lineage



John Polkinghorne (born Oct. 1930)

theoretical physicist, theologian, priest



Леонардо да Винчи:

**«Речная вода, которой ты касаешься
рукой, только что пришла и уже утекает;
то же происходит и с мгновениями
времени. Достоинно прожитая жизнь –
длинна».**



T.CARLYLE(1795 –1881)

- “The tragedy of life is not so much what men suffer, but rather what they miss...”
- I miss Dima Bardin very much!

