

Generalized symmetry:

Towards a theory of everything

Zhengcheng Gu

Chinese University of Hong Kong

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Since 1993, Prof. Yang Chen-Ning took a photo with all students and staffs in our department almost every year.



Prof. Yang Chen-Ning taught a course on university physics in 2004 at Tsinghua University. I was very lucky to be one of his TA and get a chance to talk with him.

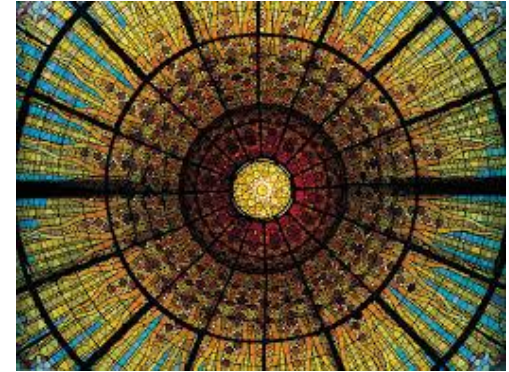


香港中文大學物理系應屆畢業班同學與全體教職員合照
二〇一六年三月廿九日



Colleagues in the department joined a gathering in 2017 celebrating Professor Yang's 95th birthday

Prof. Yang Chen-Ning's philosophy on physics: symmetry and beauty



Noether's theorem: *Symmetry = Conservation Laws*

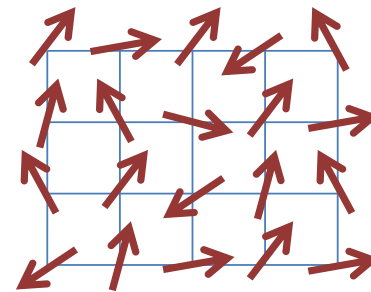
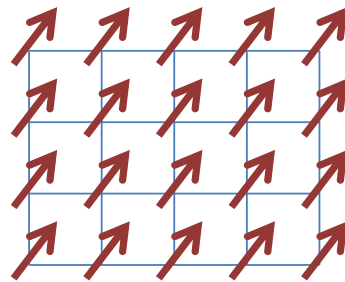
Momentum conservation: Space translational symmetry

Energy conservation: Time translational symmetry

Angular momentum conservation: Rotational symmetry

Traditional theory for phase transition

Landau's paradigm: *Symmetry breaking and group theory!*

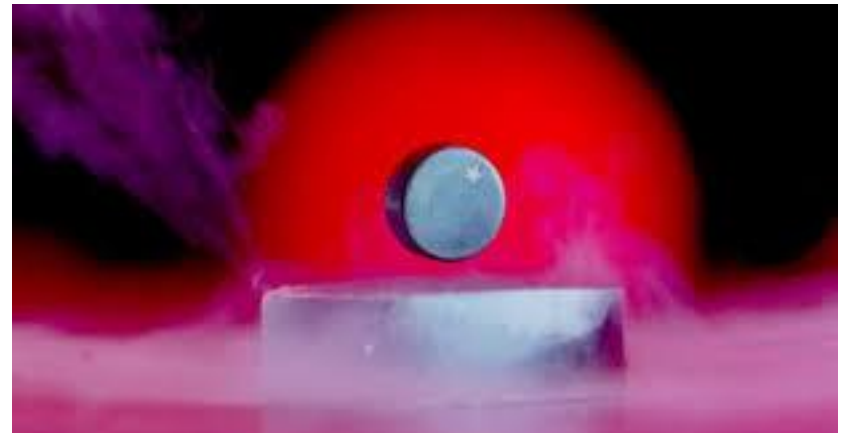


Temperature



Low symmetry

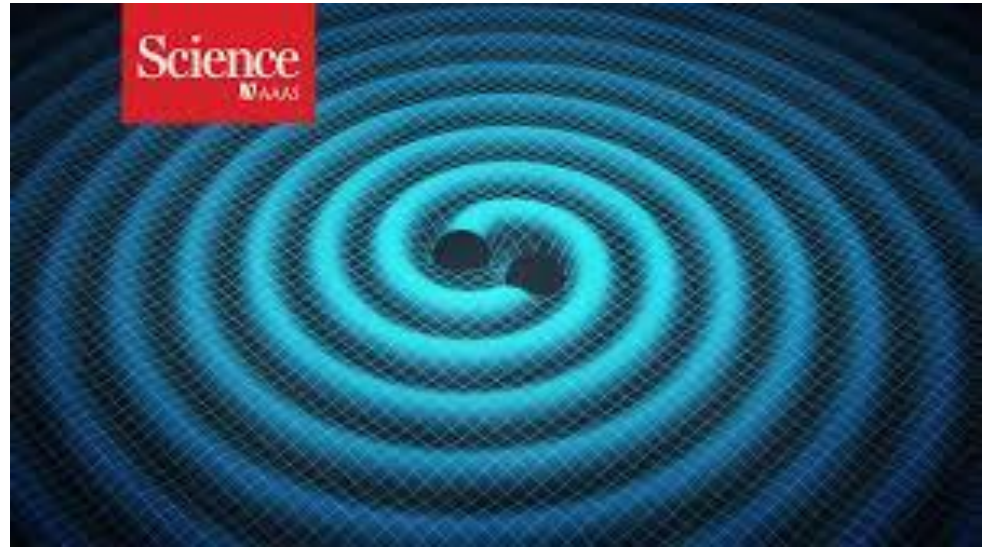
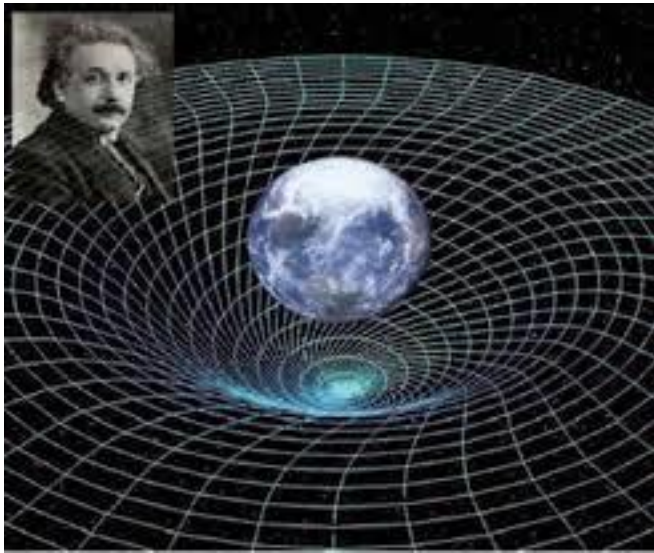
High symmetry



Prof. Yang Chen-Ning's cutting-edge idea on modern physics

Local Conservation Laws = Local Symmetry = Geometry!

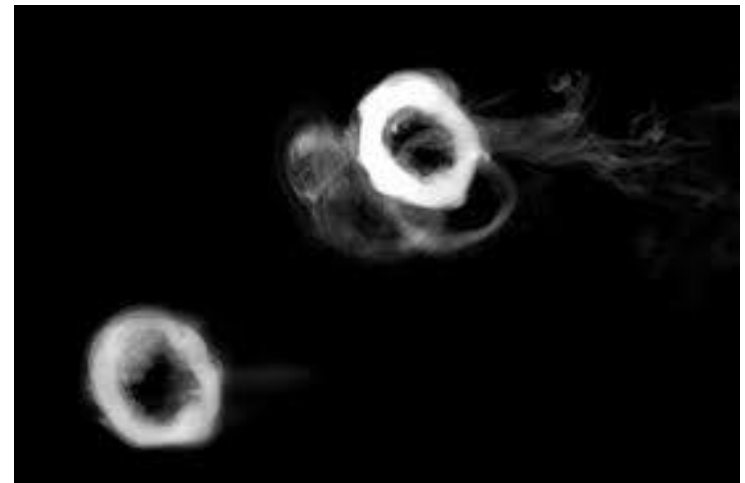
Einstein's geometric approach to gravity:



Yang and Mills generalize such a geometric approach to electric-weak, strong interactions.

A model perspective: the essential property of local symmetry/gauge fields is no longer symmetry, but topology, e.g. Chern class of a fiber-bundle

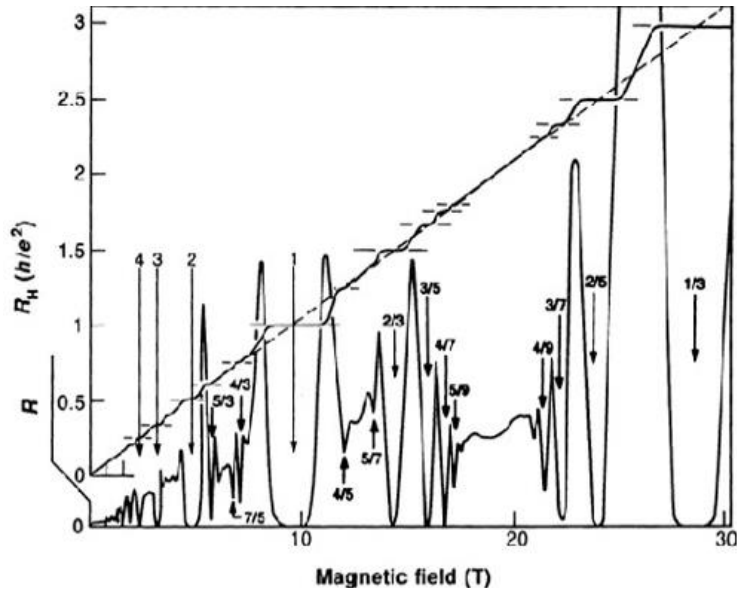
Topological phenomena in classical world



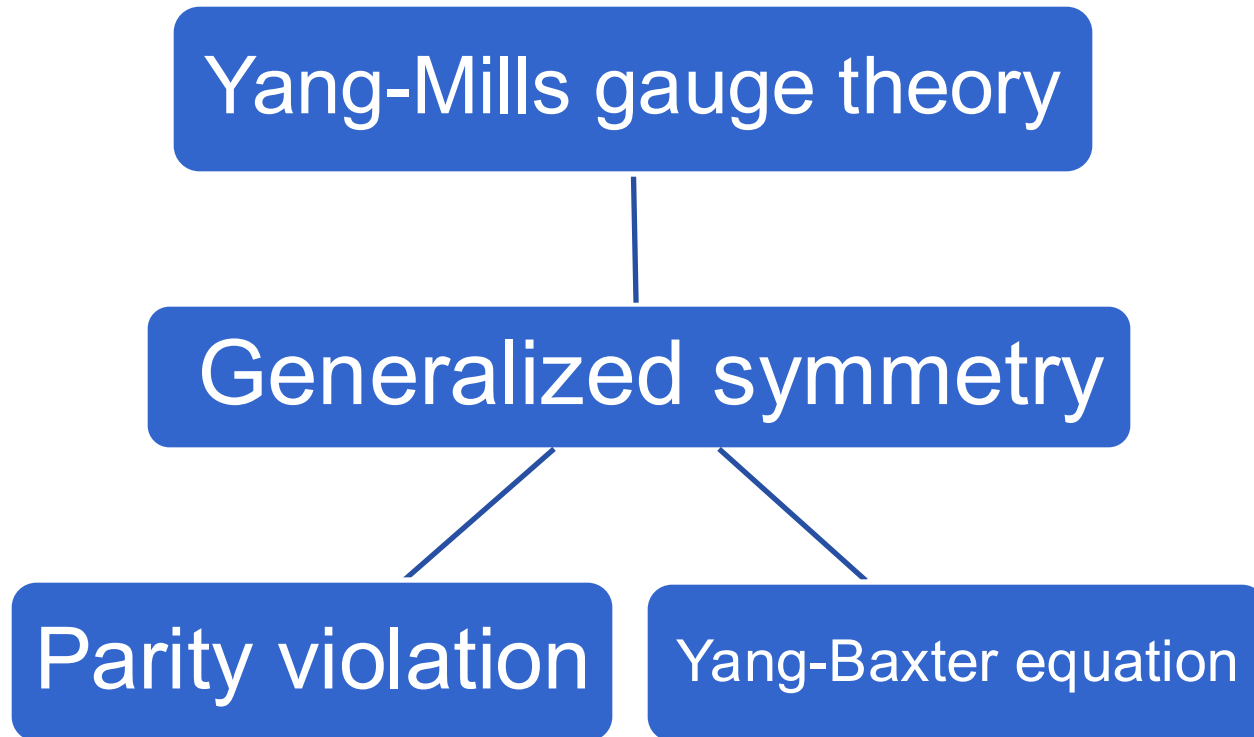
<https://youtu.be/mHyTOcfE99o>

Topological phases and emergent gauge field

Fractional Quantum Hall Effect (FQHE) D C Tsui, *et al* 1982

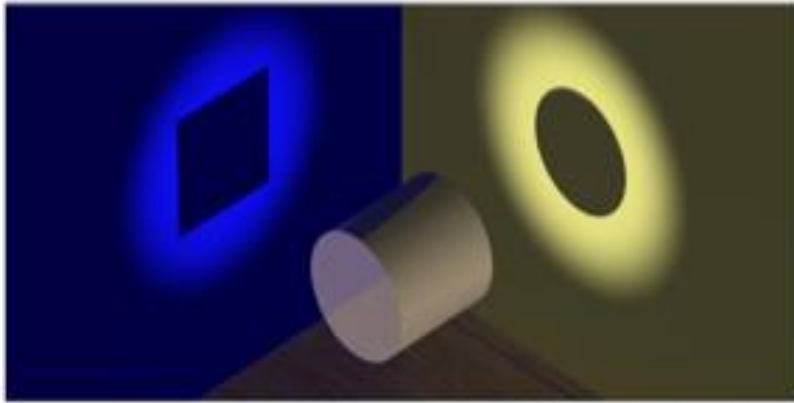


A modern perspective on Prof. Yang Chen-Ning's three most important contributions

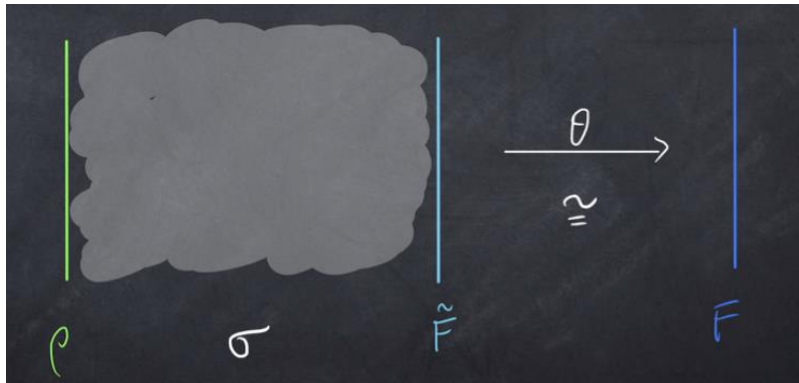


How to understand generic topological and quantum phase transitions?

Beyond Landau's paradigm: *Generalize symmetry and category theory!*



SmyTFT

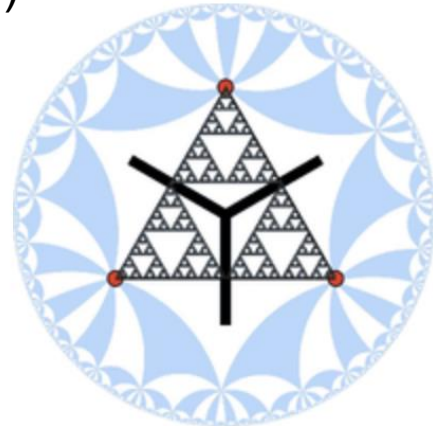


Generalize symmetry as topological order in one dimensional higher

W Ji, XG Wen, PRR 2, 033417 (2020)

Fixed-point tensor network representation for conformal field theory and exact holographic duality

C Gong, C Lin, Z C Gu, L Y Hung PRX 15, 011073 (2025)



Condensed matter physics

Quantum phase transitions

Quantum machine learning

Tensor network (quantum neuron network) with generalized symmetry

Representation of Higher category

String/membrane field theory?

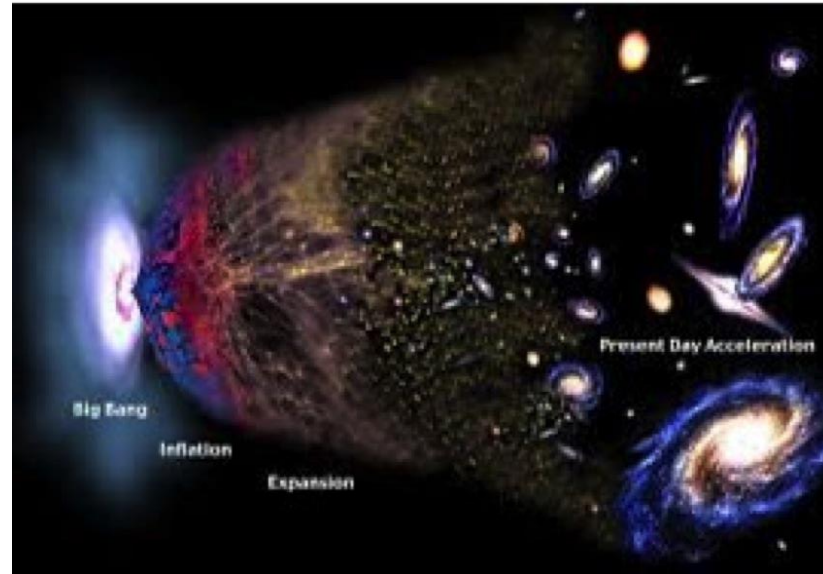
Exact holographic duality and quantum gravity

Mathematical physics

Non-perturbative quantum field theory

High energy physics

Topological physics and Chinese Culture



Chinese culture emphasize on global structure and it provides us a unique vision to understand the ultimate nature of our universe!

A new world is waiting for us



FQHE: $F=*J$



Einstein gravity: $G=T$