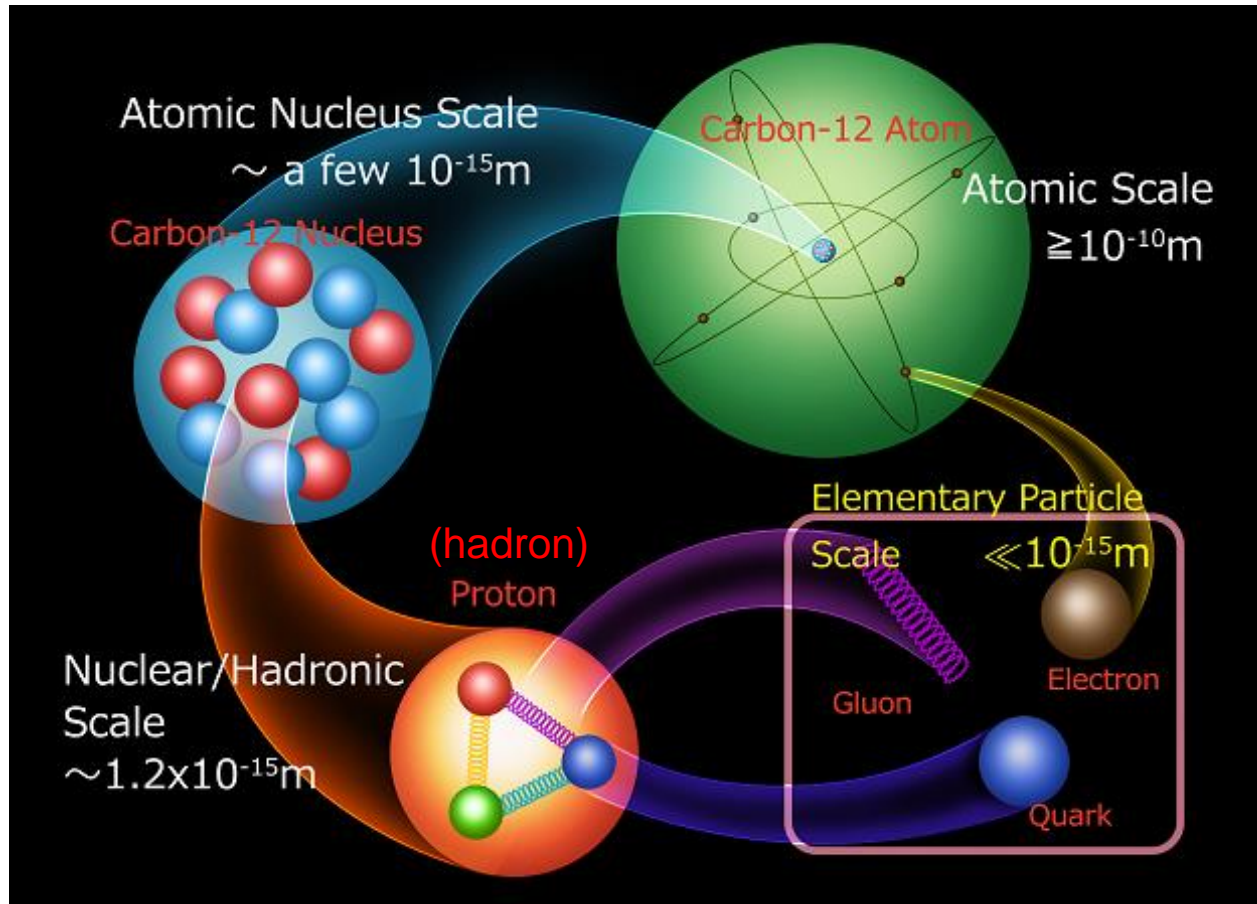




- 中央研究院 物理研究所
- 中高能理論組研究簡介
- Di-Lun Yang (楊迪倫), on behalf of the high energy theory group
- July 05, 2023

Elementary particles

- The smallest building blocks of the nature



- Fundamental Interaction :

- electromagnetism :
e.g. electrons;
exchange photons

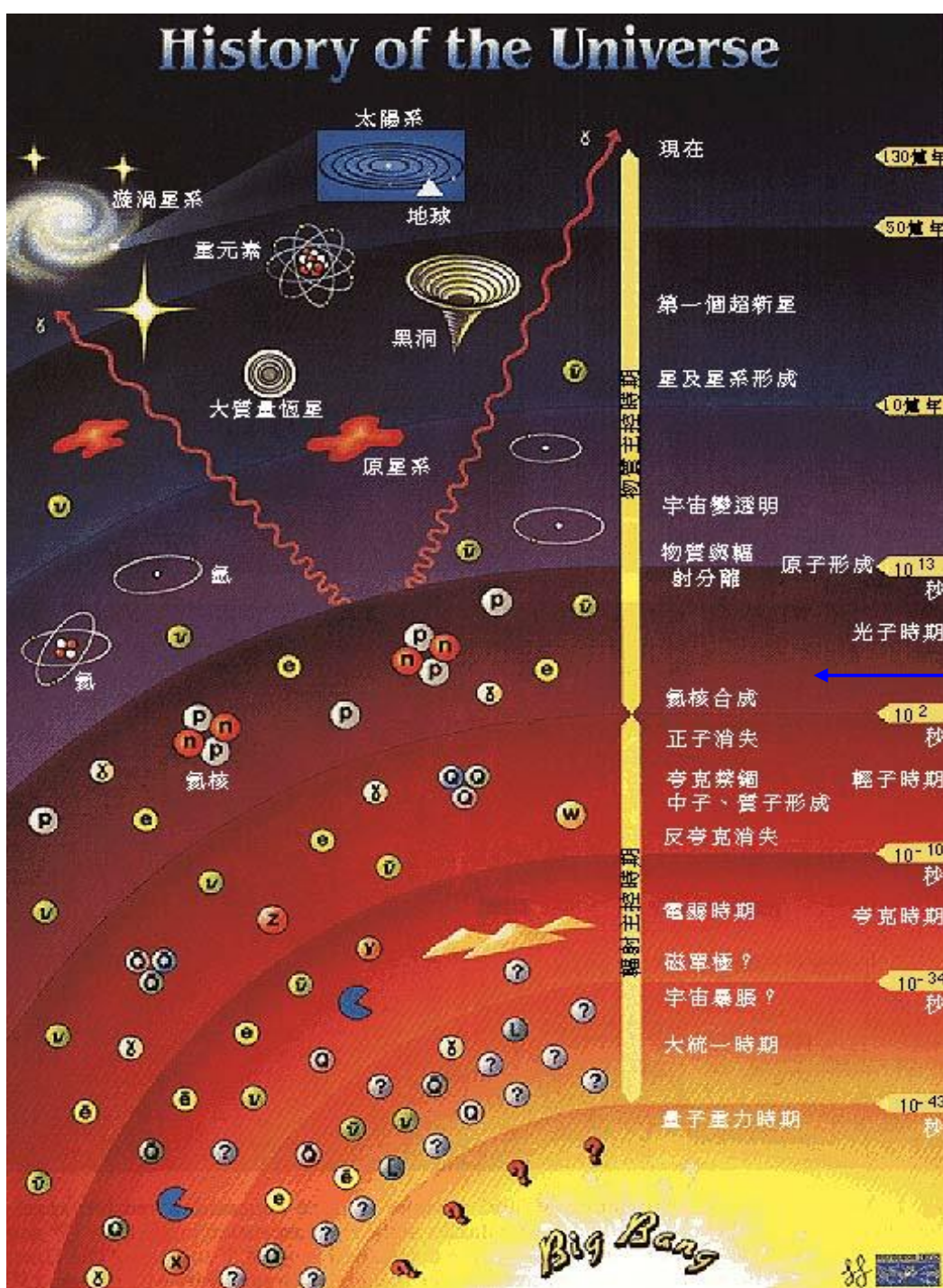
- weak int. :
e.g. electrons, neutrinos;
exchange massive
gauge bosons

- strong int. :
quarks, gluons;
exchange gluons

- gravity :
exchange gravitons

<http://core-u.hiroshima-u.ac.jp/en/research-groups-en/theoretical-particle-physics-en.html>

History of the Universe

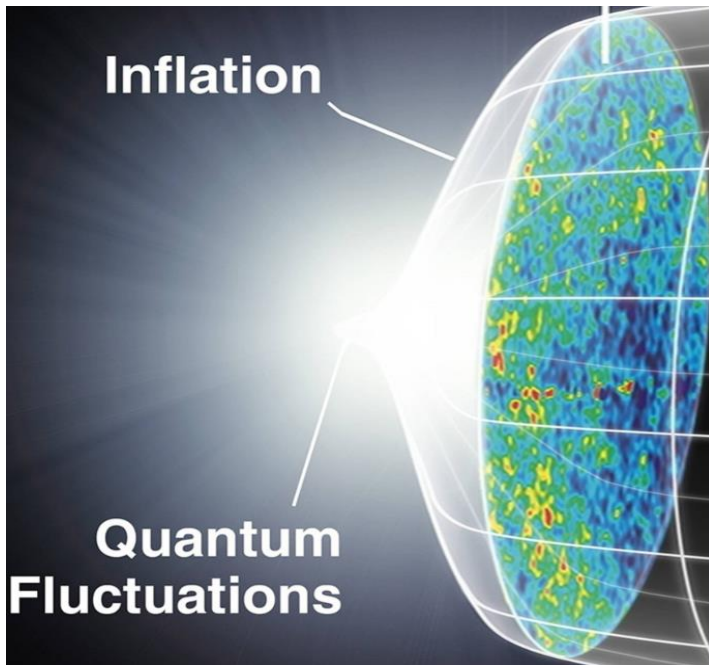


- The evolution of the Universe is governed by the microscopic nature of fundamental physics

Standard Model of Elementary Particles

	three generations of matter (fermions)			interactions / force carriers (bosons)	
	I	II	III		
QUARKS	mass $\approx 2.2 \text{ MeV}/c^2$ charge $\frac{2}{3}$ spin $\frac{1}{2}$ u up	mass $\approx 1.28 \text{ GeV}/c^2$ charge $\frac{2}{3}$ spin $\frac{1}{2}$ c charm	mass $\approx 173.1 \text{ GeV}/c^2$ charge $\frac{2}{3}$ spin $\frac{1}{2}$ t top	mass 0 charge 0 spin 1 g gluon	mass $\approx 124.97 \text{ GeV}/c^2$ charge 0 spin 0 H higgs
	mass $\approx 4.7 \text{ MeV}/c^2$ charge $-\frac{1}{3}$ spin $\frac{1}{2}$ d down	mass $\approx 96 \text{ MeV}/c^2$ charge $-\frac{1}{3}$ spin $\frac{1}{2}$ s strange	mass $\approx 4.18 \text{ GeV}/c^2$ charge $-\frac{1}{3}$ spin $\frac{1}{2}$ b bottom	mass 0 charge 0 spin 1 γ photon	
	mass $\approx 0.511 \text{ MeV}/c^2$ charge -1 spin $\frac{1}{2}$ e electron	mass $\approx 105.66 \text{ MeV}/c^2$ charge -1 spin $\frac{1}{2}$ μ muon	mass $\approx 1.7768 \text{ GeV}/c^2$ charge -1 spin $\frac{1}{2}$ τ tau	mass $\approx 91.19 \text{ GeV}/c^2$ charge 0 spin 1 Z Z boson	
LEPTONS	mass $< 2.2 \text{ eV}/c^2$ charge 0 spin $\frac{1}{2}$ ν_e electron neutrino	mass $< 0.17 \text{ MeV}/c^2$ charge 0 spin $\frac{1}{2}$ ν_μ muon neutrino	mass $< 18.2 \text{ MeV}/c^2$ charge 0 spin $\frac{1}{2}$ ν_τ tau neutrino	mass $\approx 80.39 \text{ GeV}/c^2$ charge ± 1 spin 1 W W boson	GAUGE BOSONS VECTOR BOSONS

• Unsolved Mysteries in Fundamental Physics?

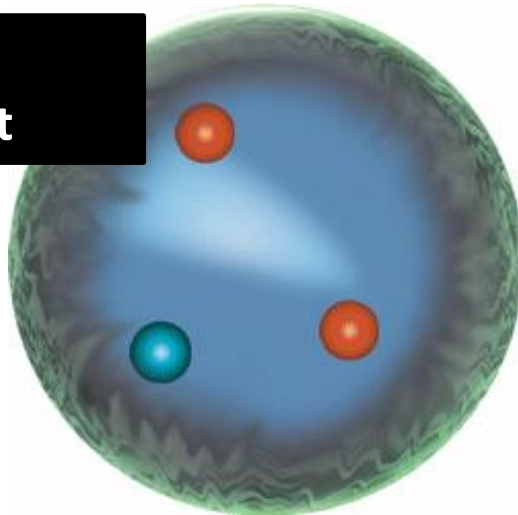


Why No Antimatter?

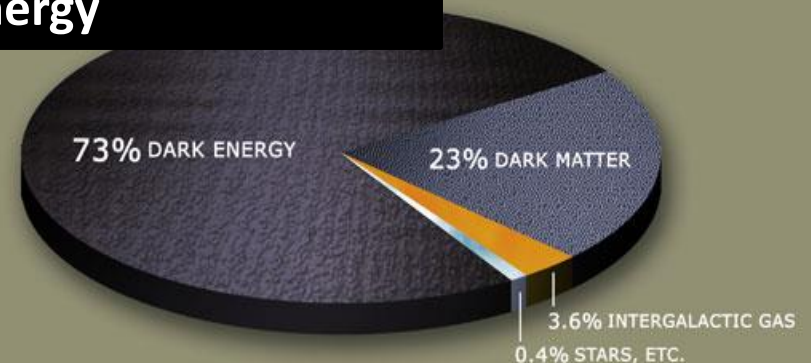
Matter and antimatter were created in the Big Bang. Why do we now see only matter except for the tiny amounts of antimatter that we make in the lab and observe in cosmic rays?

The illustration shows two human figures, one blue and one orange, standing on either side of a central point of annihilation. The blue figure has three yellow spheres on its chest, and the orange figure has three green spheres. A bright, glowing point of light is between them, with rays emanating from it, representing the annihilation of matter and antimatter.

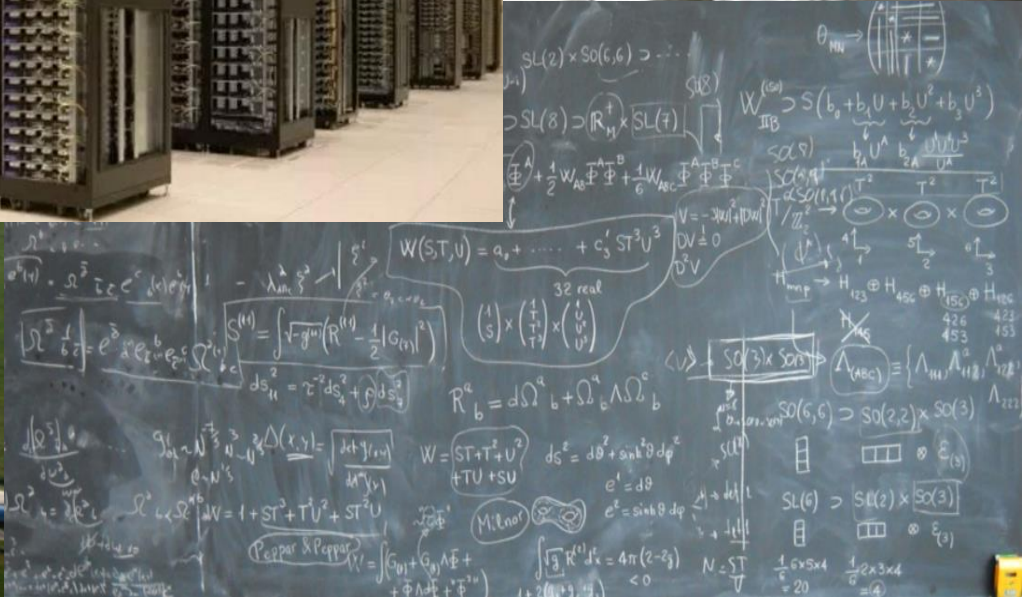
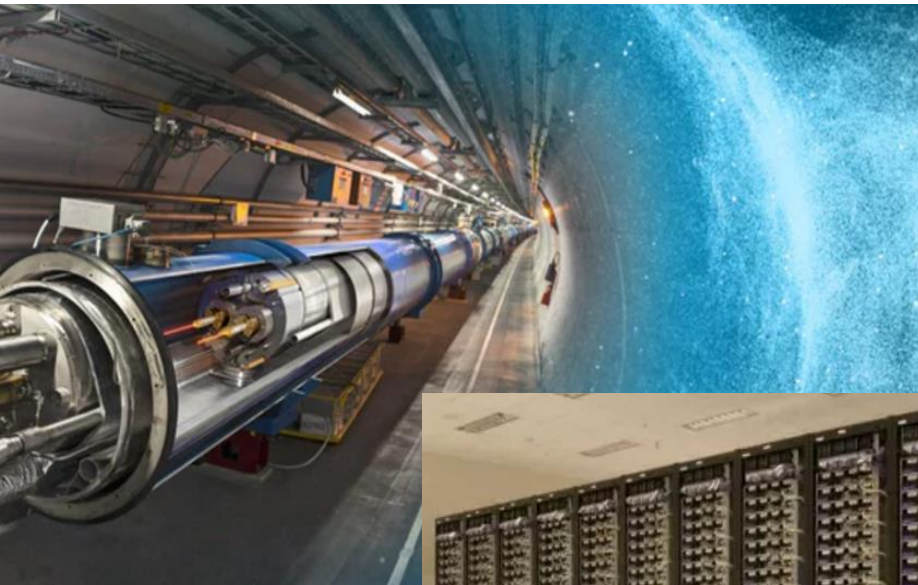
• Quark Confinement



• Dark Matter & Dark Energy



• Tools to explore these questions



Institute of Physics, Academia Sinica

MHEP(Theory) – 7 Faculty Members

- The Early Universe
- Inflation, primordial black holes and CMB



• *K.-W. Ng*

- Hadron Physics
- QCD, meson decays, and CP violation, heavy ion collisions



• *H.-N. Li*



• *D.-L. Yang*

- Collider Phenomology
- Signature of New Physics in Collider



• *H.-N. Li*



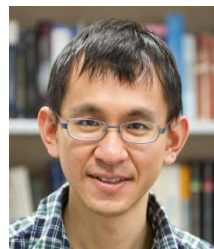
• *T.-C. Yuen*

- Dark Matter & Cosmic Structure
- Imprint of Dark Matter on the cosmic structure



• *K.-W. Ng*

- Astrophysics
- Exploring particle & nuclear physics nature in astrophysics



• *M.-R. Wu*



• *K.-W. Ng*



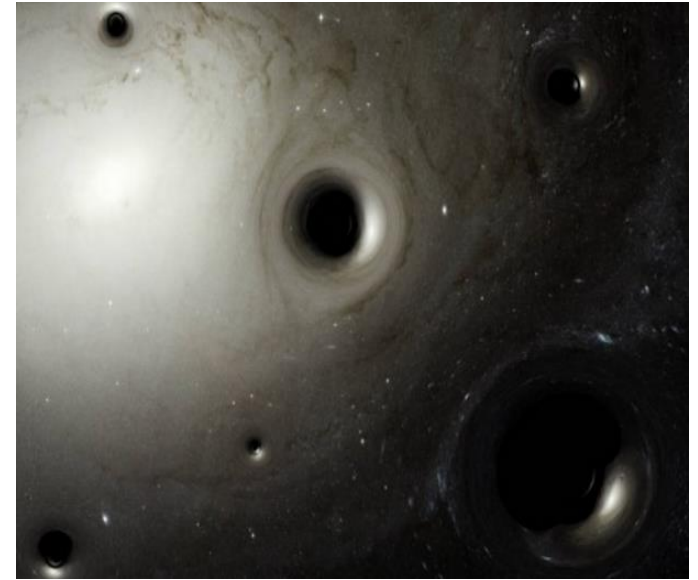
• *A. Fedynitch*



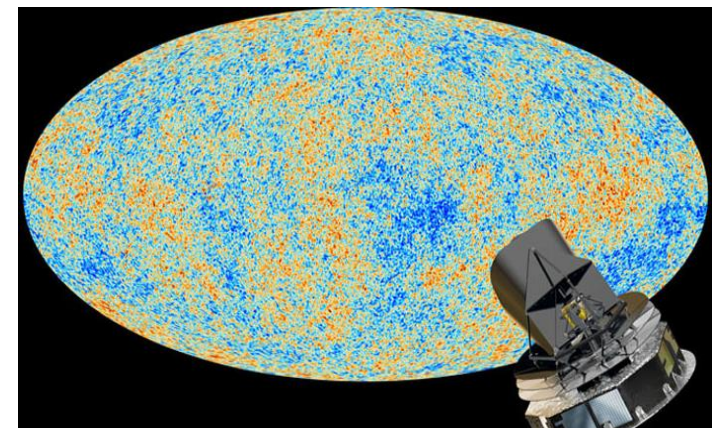
• *D.-L. Yang*

•The Early Universe

- Cosmic Inflation Models and imprints on the cosmic microwave background (CMB)
- Formation of the primordial black holes
- Gravitational waves from the early Universe



• 吳建宏



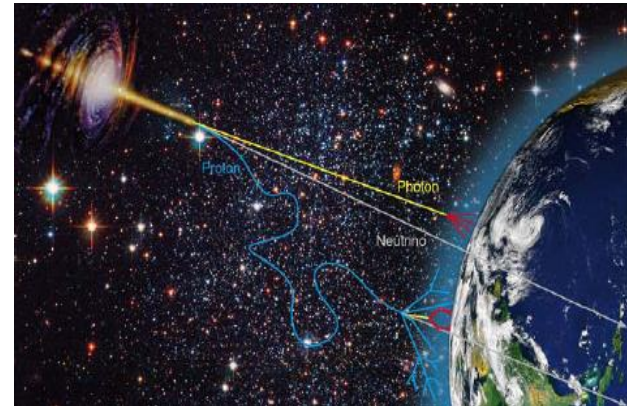
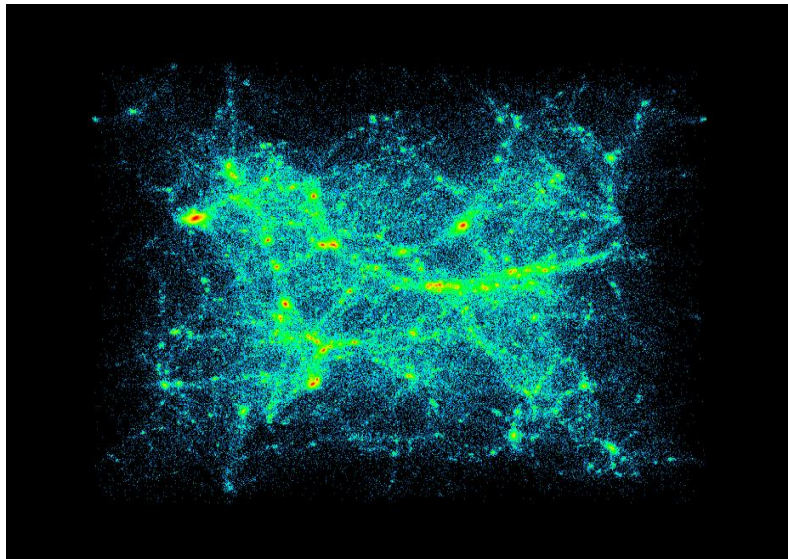
• CMB

• Dark Matter & Cosmic Structure

- Formation of the large scale cosmic structure
- 21 cm line
- Cosmic Rays & Dark Matter
- Dark Sector Physics

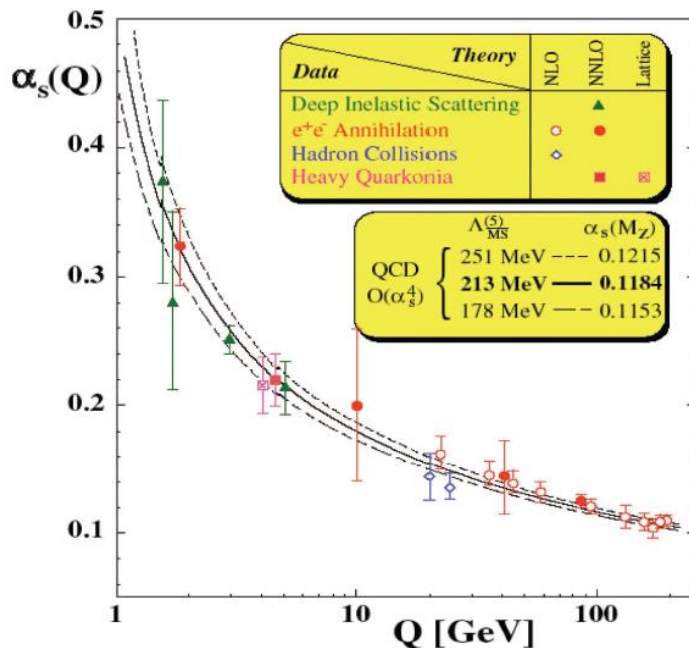


• 吳建宏

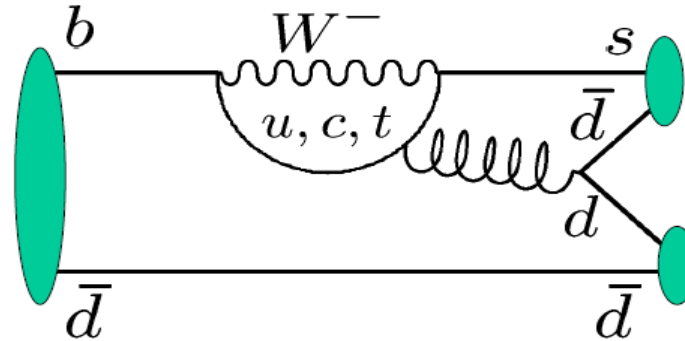


• Hadron Physics

- CP Violation \leftrightarrow The baryon asymmetry
- CP violation in B & D meson decay
- Developing theory for heavy quark physics
- Perturbative quantum chromodynamics (pQCD)



S. Bethke, hep-ex/0211012

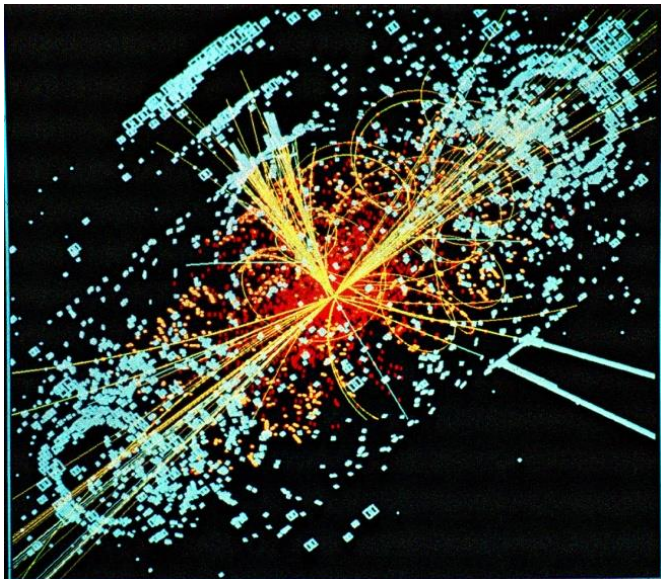


• 李湘楠

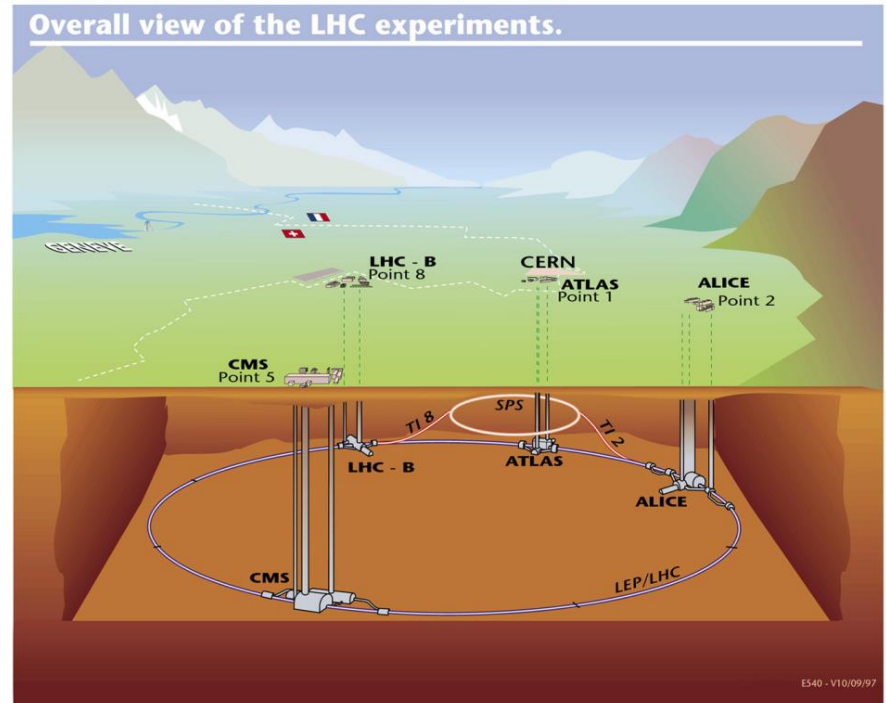
Asymptotic freedom (2004 Nobel Prize in Physics):
H. D. Politzer, D. J. Gross, F. Wilczek, 1979

• Collider Phenomenology

- Top quark, Higgs physics
- Electro-weak symmetry breaking
- Jet physics
- New Physics



• $H \rightarrow b \bar{b}$ 事例



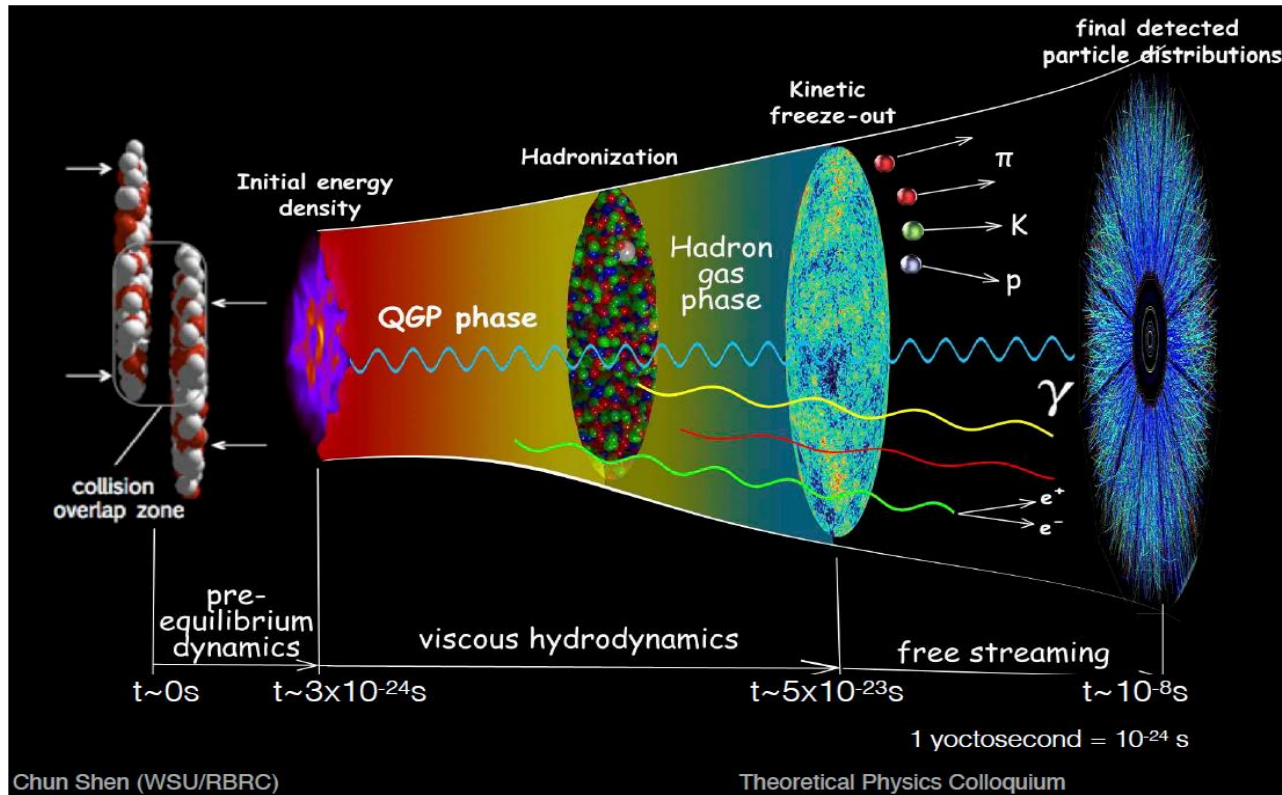
• 李湘楠



• 阮自強

• Heavy Ion Collisions

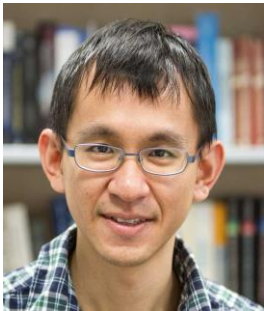
- Little bang from relativistic heavy ion collisions :
quark gluon plasma phase
- Relativistic kinetic theory & relativistic hydrodynamics
- Quantum field theories with strong fields



• 楊迪倫

• Particle and Nuclear Astrophysics

- Neutrino physics in stars and stellar explosions
- Binary neutron star mergers and their multimessenger signals
- Neutron star structure and composition
- New Physics imprints in astrophysics
- Ultra-high energy cosmic rays and hadronic interactions



• 吳孟儒



• 吳建宏



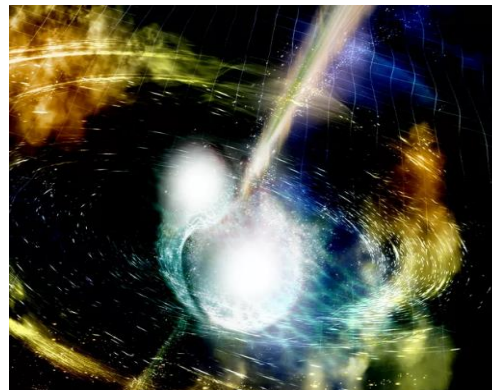
• 安納托里



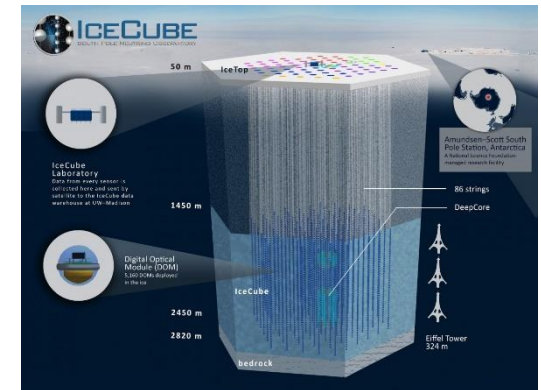
• 楊迪倫



• Supernova explosion



• Neutron star merger



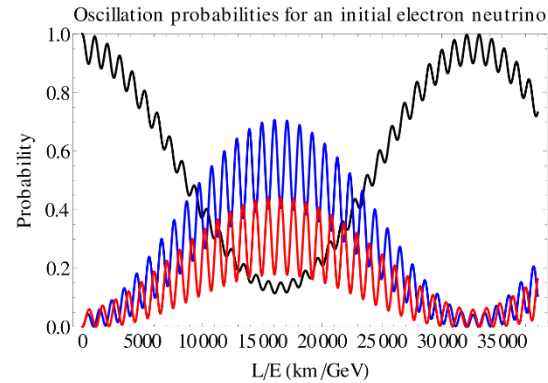
• High-energy neutrinos

• Neutrino physics

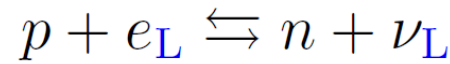
- Collective flavor oscillation



• 吳孟儒



- Chiral effects in compact stars



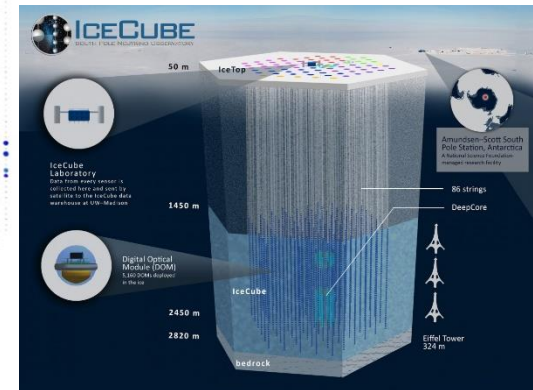
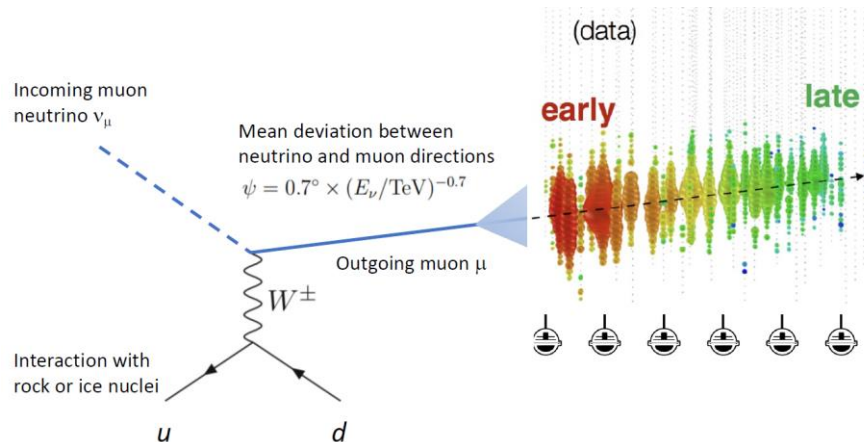
• 楊迪倫



- High energy neutrinos & IceCube experiment



• 安納托里



• You are welcome to join the quest to
“BOLDLY GO WHERE NO MAN HAS GONE BEFORE”

