Activities and Collaboration 1.

Division of Particle Physics and Astrophysics

Computational Particle Physics Group

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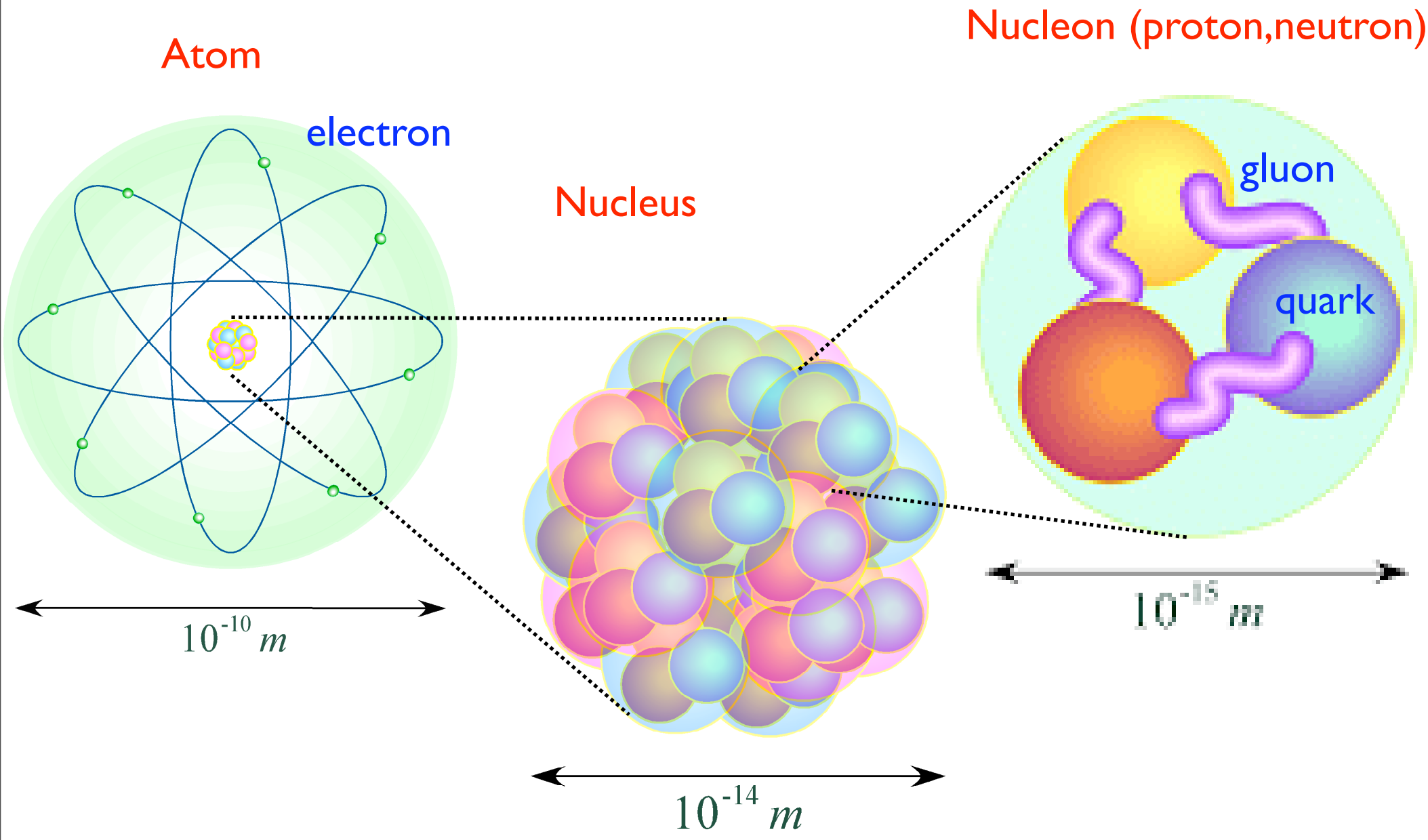
Elementary Particle Physics

- What is the most fundamental constituent in Nature ?



- What is the fundamental law in Nature ?

  - electromagnetic interaction
  - weak interaction (β decay)

  Weinberg-Salam model
  (Electroweak interaction)

  - strong interaction (nuclear force)

  Quantum ChromoDynamics(QCD)

  Grand Unified Theory (GUT) ?

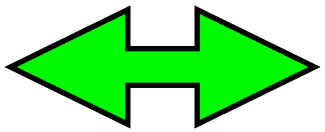
  - Gravity

String theory ?

standard model of elementary particle = Weinberg-Salam model + QCD

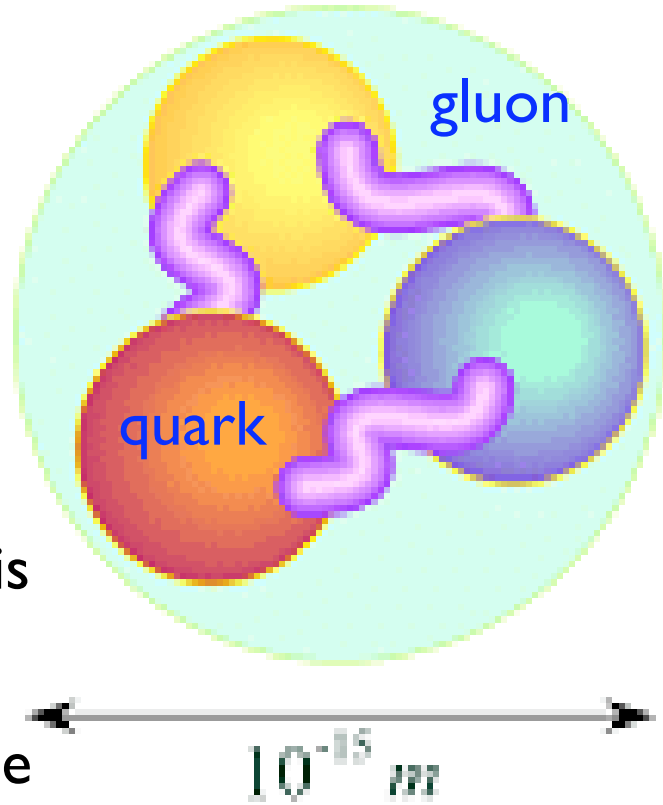
Quantum ChromoDymanics (QCD)

- Dynamics of quarks and gluons
- "hadrons" are bound states of quarks
- interaction is "strong"
  - perturbative expansion in coupling is not reliable.



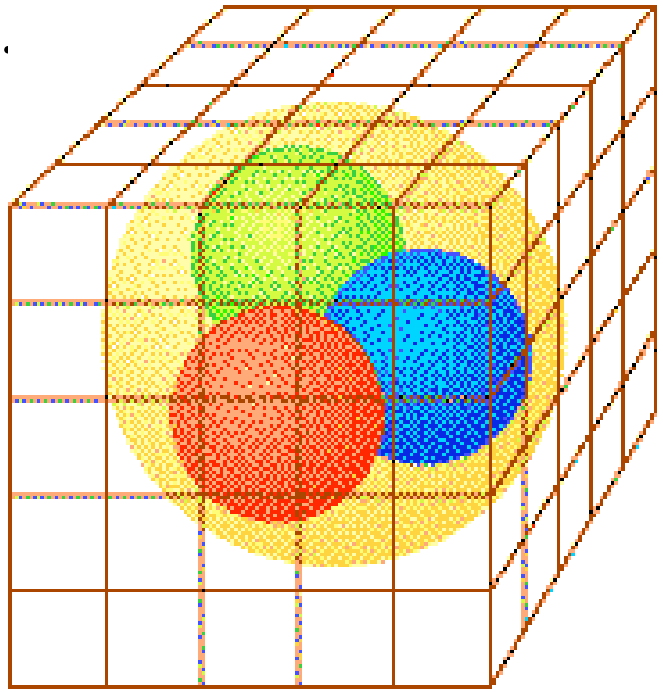
Electroweak interaction

- processes involving hadrons are affected by this interaction.
  - effects of QCD must be included for reliable predictions from the standard model.
  - it is also necessary to investigate possibilities "beyond the standard model".



Lattice QCD

- define QCD on discrete space-time (lattice)
- suitable for strong interaction
- Numerical simulations are possible for lattice QCD
  - generate "gluon fields" by Monte-Carlo method
  - behavior of "quarks" is calculated on "gluon fields"
  - huge computational powers are required.



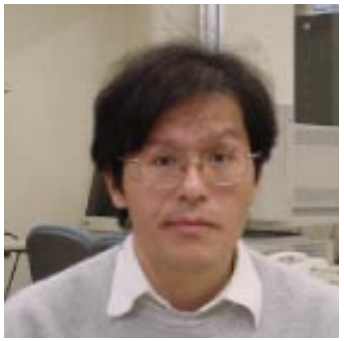
Activities of computational particle physics group

- Researches in lattice QCD using super-computer
  - fundamental properties of hadrons such as masses and decay constants
    - test of QCD/lattice QCD → talk by Kuramashi
  - more complicated quantities
    - U(1) problem → talk by Yoshie
    - ρ meson decay → talk by Ishizuka
    - nuclear force → talk by Ishii
    - QCD effects to electroweak process for Kobayashi-Maskawa matrix
    - hardonic matrix elements of CP violation → talk by Taniguchi
- ILDG/JLDG
  - store "gluon fields" for public uses

Group members

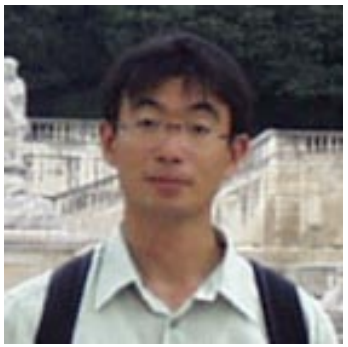
A. Ukawa (Prof.)

T. Yoshie (Assoc. Prof.)



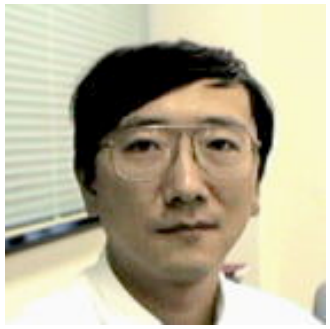
N. Ishizuka (Assoc. Prof.)

Y. Kuramashi (Lecturer)



Y. Taniguchi (Asst. Prof.)

CCS



K. Kanaya (Prof.)

S. Aoki (Prof.)

Graduate School of
Pure and Applied Sciences

+ 6 postdoctoral fellows

+ 6 graduate students

Collaborations in CCS

- Construction of PACS-CS
  - Division of High Performance Computing Systems (Sato, Boku, Tatebe, Takahashi)
    - Total system: regular meeting
    - Network: regular meeting
    - Operation
    - Tuning
- Improvement of algorithms
  - Division of High Performance Computing Systems (Sakurai)
    - Inversion/Eigenvalue problem: regular meeting
- ILDG/JLDG
  - Division of High Performance Computing Systems (Sato, Boku)

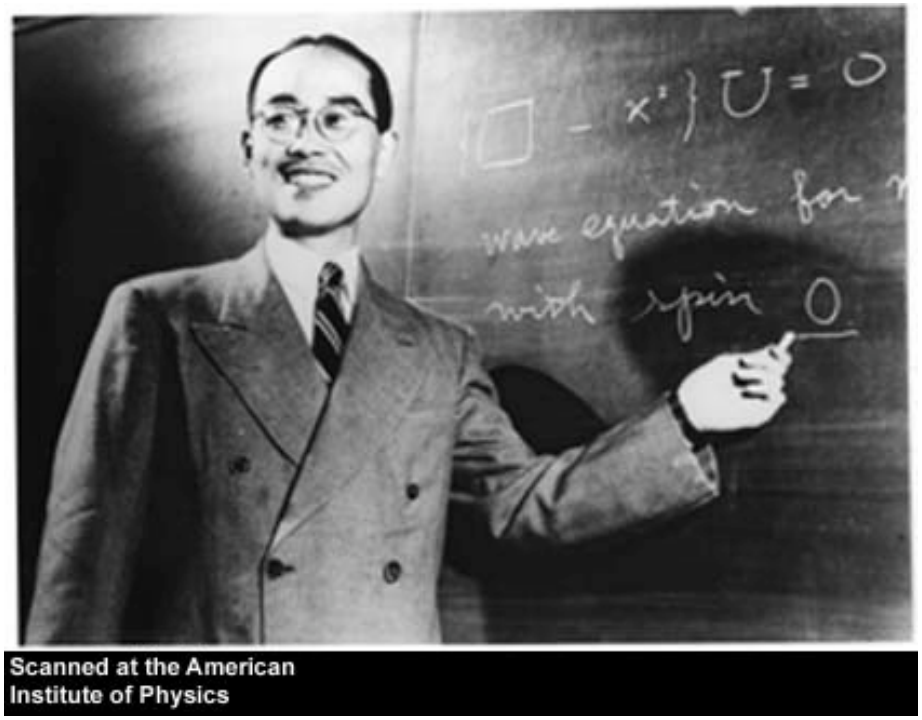
Research results: an example

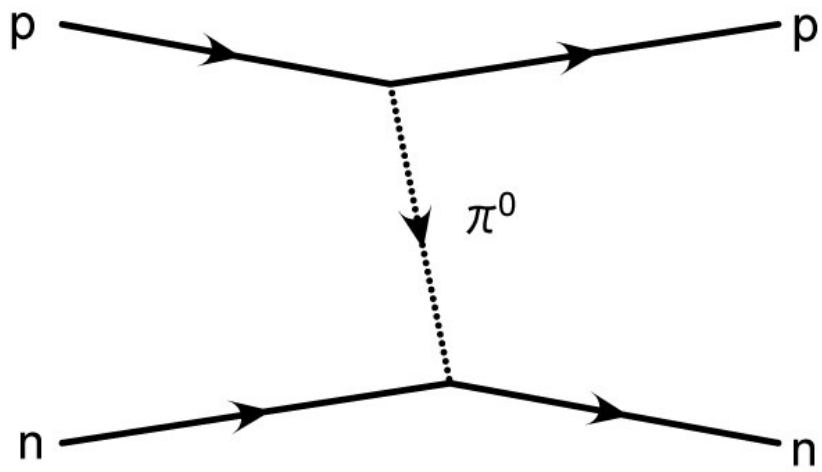
Force between Nucleons(The nuclear force)

1935 H. Yukawa

mesons

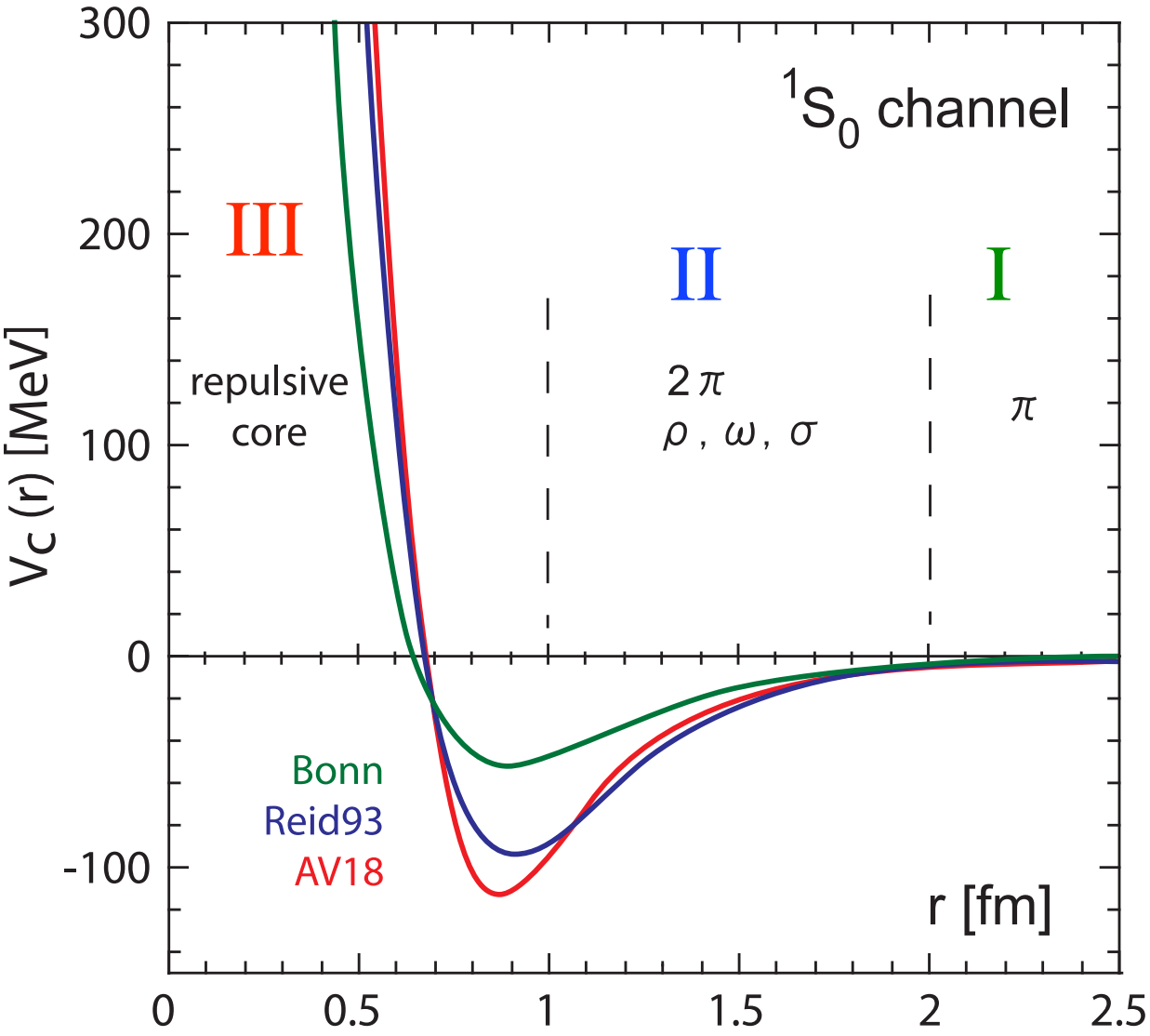
The nuclear force ⇔ exchange of virtual particles between nucleons

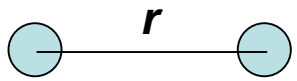




1949 Nobel prize

Modern nucleon-nucleon potential





I Long range part

one pion exchange potential (OPEP)

II Medium range part

σ, ρ, ω exchange

2π exchange

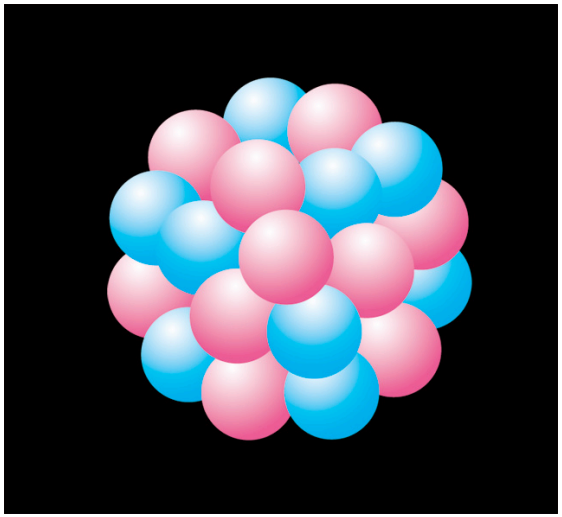
III Short range part

repulsive core (RC)

quark ?

Importance of repulsive core

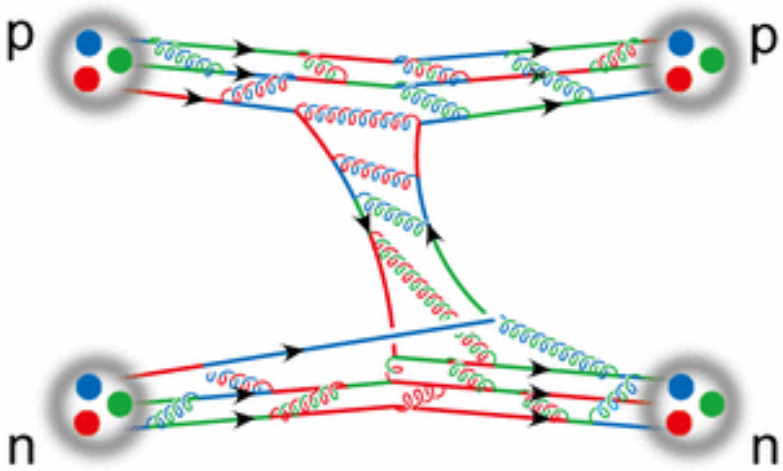
stability of nuclei



neutron star

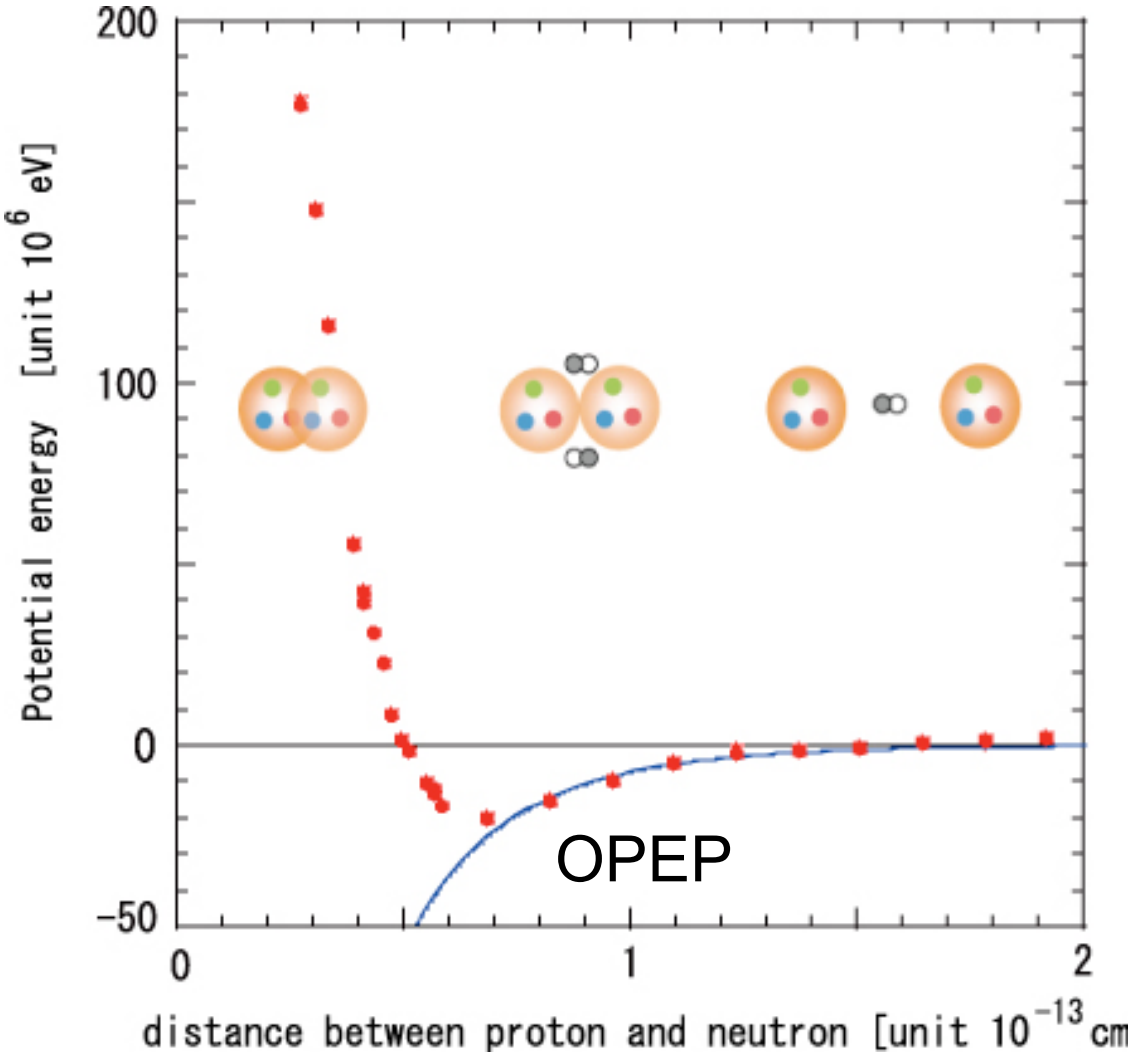
supernova explosion

Origin of RC: “The most fundamental problem in Nuclear physics.”



Our results from lattice QCD

Ishii-Aoki-Hatsuda, 2007



Not only a repulsion at short distance (RC)
but also attractions at long-medium distances
are reproduced !