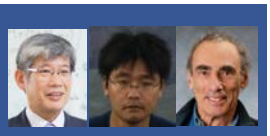
iTHEMS
RIKEN Interdisciplinary Theoretical and Mathematical Sciences Program

From Quarks to Neutron Stars



Tetsuo Hatsuda (RIKEN iTHEMS)

Toru Kojo (Tohoku Univ.) and Gordon Baym (Univ. Illinois at Urbana-Champaign)

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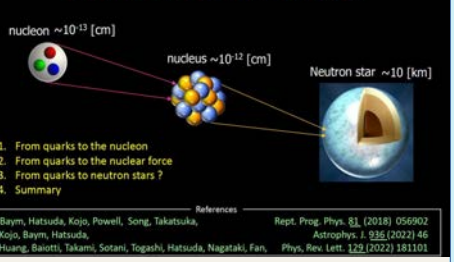
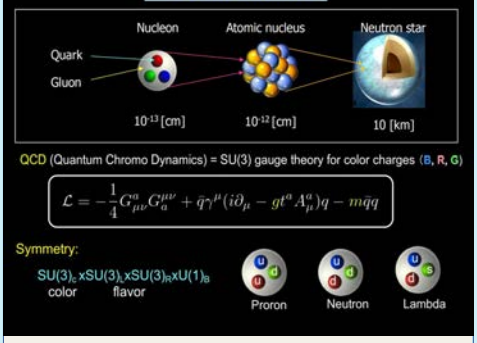
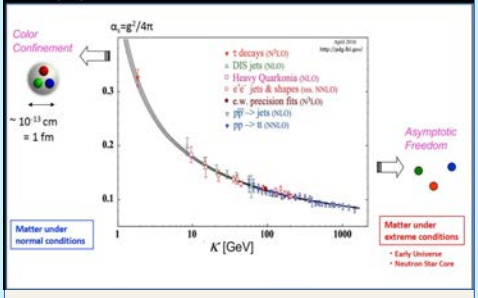


Visible Matter

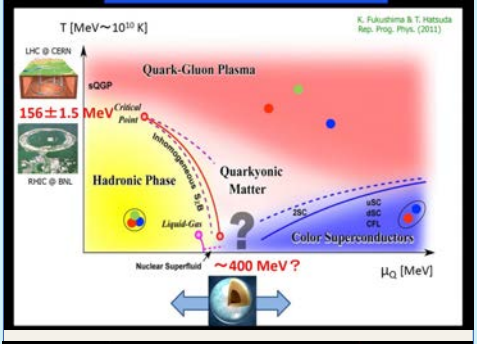


Asymptotic Freedom and Color Confinement

-- two sides of a same coin --



QCD phase diagram (realistic (2+1)-flavor)



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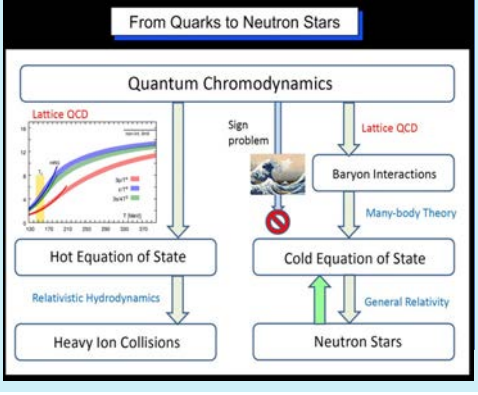
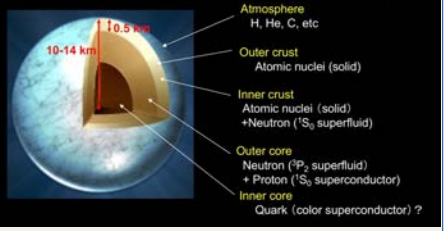
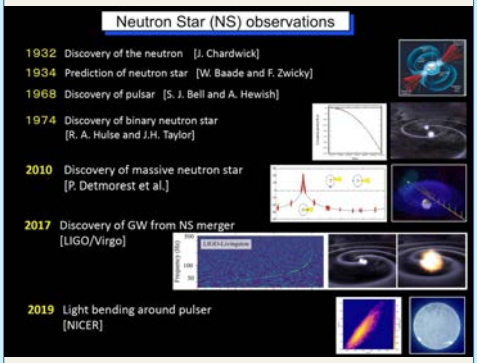


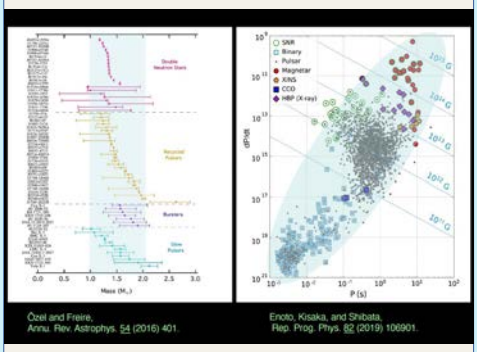
Structure of Neutron Star (NS)

Mass M~(1-2) $M_\odot$
Radius R~10km
Mass density ~10^{12}kg/cm^3 ~ several times atomic nuclei



Neutron Star (NS) observations

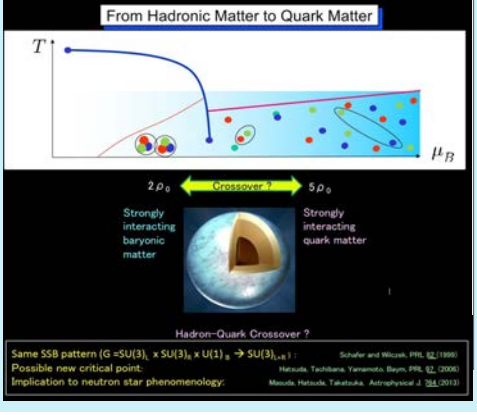




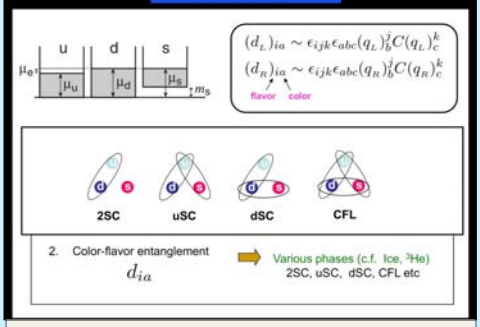
Structure of Neutron Stars

Observables		Matter under extreme condition
• M~(1-2)$M_\odot$ • R ~10 km • T ~10^6-10^9 K • B ~10^6-10^{15} G • P ~1 ms-10 s •	Astrophysics Nuclear physics Particle physics Cond. Matt. physics	• Nuclear pasta • Nuclear superfluid • Meson condensate • Hyperon liquid • Quark liquid & CSC •

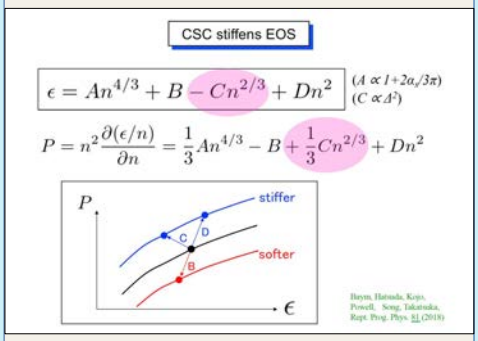
From Hadronic Matter to Quark Matter



Color superconductivity

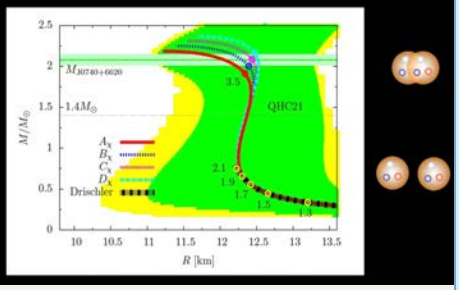


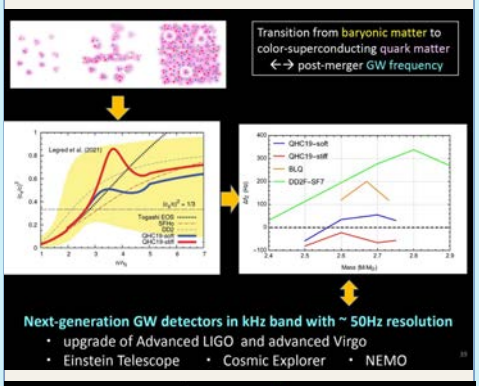
CSC stiffens EOS



QHC21 EOS (Chiral EFT+ NJL) vs. Observation (SD+GW+NICER)

Kojo, Baym, Hatsuda, Astrophys. J. 936 (2022) 46





Summary