n - $\bar{n}$ Oscillations

Useful complement to nucleon decay

Potential connections to ν mass

Implications for leptogenesis

Color sextets on TeV scale

Rate suppressed in bound neutrons:
free neutrons cleaner test,
but matrix elements uncertain

Lifetime target: 10^{10} - 10^{11} s

CQ, 22.6.2012

n - $\bar{n}$ Oscillations

Work Ahead

Go beyond a few GUT examples
How widespread is impact?
Network of implications

Rate suppression in bound neutrons
Matrix elements on lattice, chiral limit

What is a worthy demonstrator?
Broader cold-neutron program?

Benchmark goal for ruling out new physics scenarios

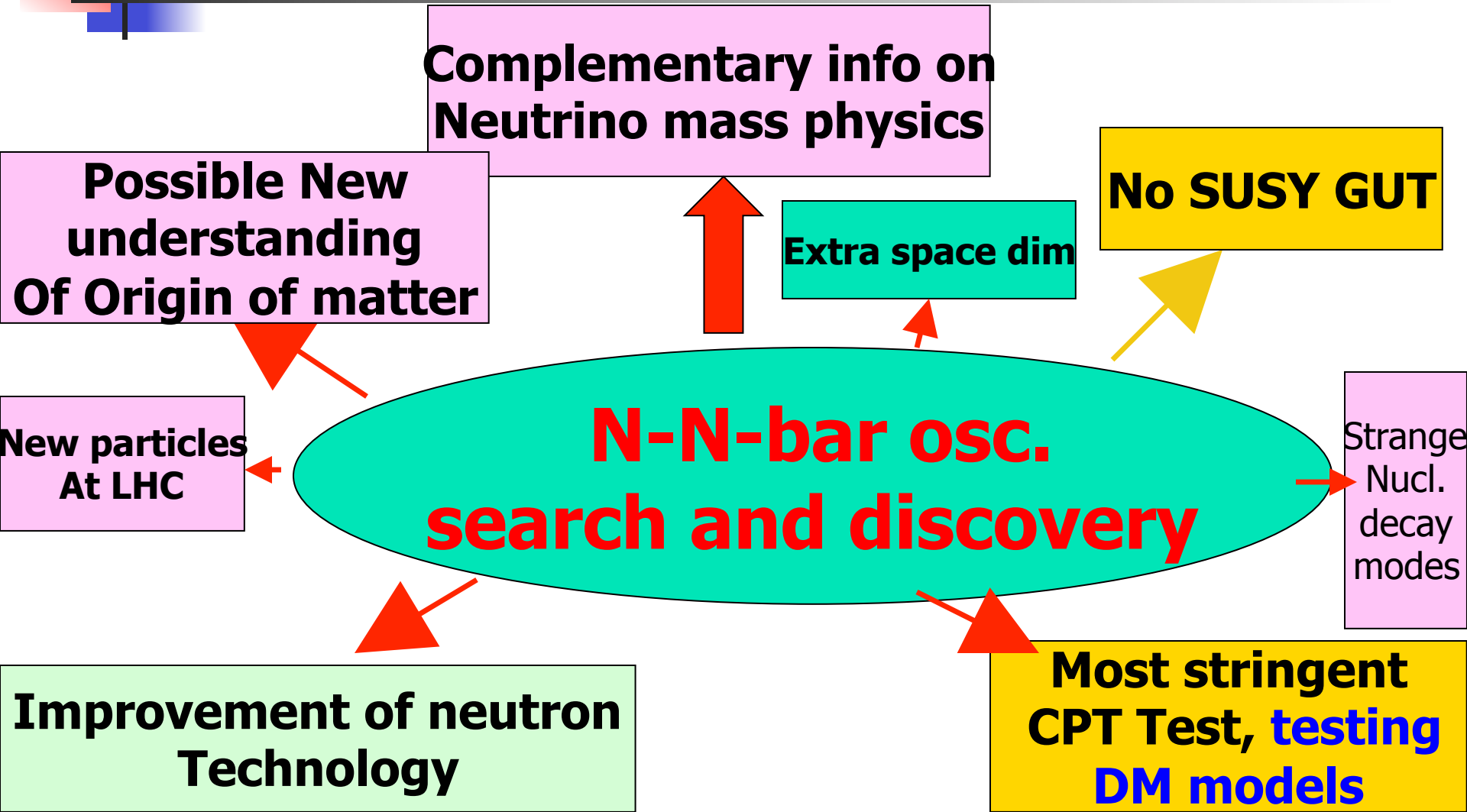
- **No NNbar oscillation till ~10^{10} -10^{11} sec.**

★ Will rule out a class of SU(2)xSU(2)xSU(4)$_C$ models for post sphaleron baryogenesis for v_{BL} < 30-100 TeV.

★ Will rule out a class of SO(10) models for neutrino masses that predicted recently observed large θ_{13} if it is to explain the origin of matter.

THANK YOU !!

NN-bar oscillation- gold mine of new physics info– 10^{11} sec. benchmark goal



Summary and Conclusions

Post–sphaleron baryogenesis predicts observable $n - \overline{n}$ oscillations

Colored scalars at TeV scale should be accessible to LHC

New GUT scale $(B - L)$–genesis proposed which is sphaleron–proof

Both models predict

$$\tau(n - \overline{n}) \sim (10^9 - 10^{11}) \text{ sec}$$

$n - \overline{n}$ oscillation experiments can probe a class of theories which explains the origin of matter in the universe

Summary

- We explore extensions of the MSSM in which TeV scale vector-like multiplets can mediate observable $\mathrm{n} - \overline{\mathrm{n}}$ oscillations.
- In this scenario we can have vector-like diquark with mass around a TeV scale.
- For plausible values of the diquark-quark-quark couplings can be produced at the LHC and detected through its decay into a top quark and a jet.

Conclusions

- origin of matter: one of the great mysteries in particle physics and cosmology
- leptogenesis: an appealing baryogenesis mechanism connected to neutrino physics
- various leptogenesis mechanisms:
  - standard leptogenesis: gravitino problem, incompatible with SUSY
  - resonance leptogenesis
  - Dirac leptogenesis

- While there is no model-independent way to test leptogenesis, searches at neutrino experiments (leptonic CPV, neutrino-less double beta decay) can provide supports for/distinguish among the mechanisms
- neutron-antineutron oscillation: complementarity test
  - if observed ⇒ low scale leptogenesis scenarios preferred

Intro

Rabi Mohapatra presented theoretical motivations for neutron-antineutron oscillations.

$\Delta B = 2$ analog of the search for Majorana neutrino, $\Delta L = 2$.

Experimental limits on stability of nuclei set the range of interest for the free neutron oscillation time $\tau_{n\bar{n}}$.

Super-K (2011) $\tau(^{16}O) > 1.97 \times 10^{32}$ yr (Ed Kearns' talk)

Theory, Friedman, Gal (2008), relates it to $\tau_{n\bar{n}}$,

$\tau_A = R\,\tau_{n\bar{n}}^2$ $R = 5 \times 10^{22}\ s^{-1}$ $\tau_{n\bar{n}} > 3.53 \times 10^8$ s

Free neutron ILL experiment (1994)

$\tau_{n\bar{n}} > 0.86 \times 10^8$ s

Where Lattice Can Help

- Is BSM running non-perturbative?

  - Model-dependent (assume pert. models for now)

- Is QCD running non-perturbative?

  - Should be checked (pert. running reasonable)

- What is neutron-antineutron matrix element?

  - Inherently non-perturbative question

- What is effect in nuclei?

  - Very interesting, VERY hard question

PROTON DECAY

- Proton is a topological non-trivial configuration of the pion field (Skyrmion)
- Decay of the proton is protected by topology
- Hybrid Skyrmion/bag model decay possible but exponentially suppressed due to tunneling (instanton)