Big Present from Hitoshi

----Beyond the Seesaw----

IPMU 2024/12 *Tsutomu Yanagida*

Anomaly Mediation

Hitoshi et al.（*2000*）

Supersymmetry

- Discovery of the supersymmetry --- *1971-1974* ---

I studied it from the papers by Abdus Salam
(I was a graduate student)

I was shocked by unification of fermion and boson!!!

$$\{Q_\alpha, \bar{Q}_{\dot{\beta}}\} = 2(\sigma^\mu)_{\alpha\dot{\beta}} P_\mu$$

- **Discovery of supergravity --- *1976* ---**

Further shock attacked me,
since they extended the space time by adding new fermionic coordinates:

(x,y,z,t) → (x,y,z,t, θ)

Conceptional Big Change !!!

But I ignored such a theoretical discovery

1973; Neutral currents were discovered at CERN
1973; Asymptotic freedom was discovered
1974; Charm quark was discovered
1974; SU(5) GUT was proposed
1974; Lattice QCD was proposed
1975; Instanton solution in QCD was discovered
1975-1977; All anomalies in neutral currents were excluded
---- the SM established<---- 1978; Sakurai's talk
1977; Peccei-Quinn mechanism and Axion
1979; Glashow, Salam and Weinberg were awarded the Nobel prize
1979; Seesaw mechanism was discovered
1981; Inflation universe was proposed
1980-1981; Supersymmetric SM

- However, it brought about a big change in our physics

~1980

The quadratic divergence in the Higgs boson mass
is cancelled out between boson and fermion loops

The light Higgs boson of ~100 GeV
is technically natural !!!

- SUSY standard model became very popular after ~1980

The paradigm shifted to SUSY !!!

and

The SUSY paradigm lasts at present

- However, a lot of problems have been found

1. Gravitino problem; The decay of gravitino destroys the BBN Weinberg (1982)

➔ m(3/2)>30-100 TeV

2. FCNC problem; We have too large FCNC decay of mesons and muon

→ m(squarks, sleptons)>100 TeV

3. Polonyi Problem; The decay of the SUSY breaking field Z destroys the BBN

→m(Z)~m(3/2)>100 TeV

All above problems suggested the large SUSY breaking scale > O(100) TeV…… *~1980-1990*

But all DM candidates need to be lighter than O(1) TeV

Dynamical SUSY Breaking

No Polonyi field and hence no Polonyi problem !!!

BUT

It predicts very light gauginos

$$m(\text{gauginos}) < O(1)\ \text{GeV}$$

No hope for the Dark Matter !!!

BUT

Hitoshi gave us a Big Present

at 2000

Anomaly Mediation

Quantum gravity effects generate the gaugino masses !!!

$$m(\text{gauginos}) = O(1)\ \text{TeV}$$

A gaugino can be a Dark Matter !!!

The anomaly mediation;

$$\mathrm{m(gaugino)}{=}\alpha\ \frac{\Lambda^2}{M_{PL}}$$

The seesaw:

$$\mathrm{m(neutrino)}{=}\ f^2\ \frac{<H>^2}{M_R}$$

“Pure gravity mediation” was proposed

Ibe, Moroi, ty (2005)

m(3/2)=30-100TeV

m_H=120-130 GeV

m(wino DM)=1-2 TeV

Anomaly Mediation Saved Us

The wino DM will be discovered in direct and indirect detection experiments

The Hubble constant Hi must be > 10^13 GeV
The tensor/scalar ratio r >0.001

Harigaya,Ibe … (2015)

Dear all participants

Let us thank Hitoshi for his big present

The bright our future's coming soon!!!