Supersymmetry Theory Review

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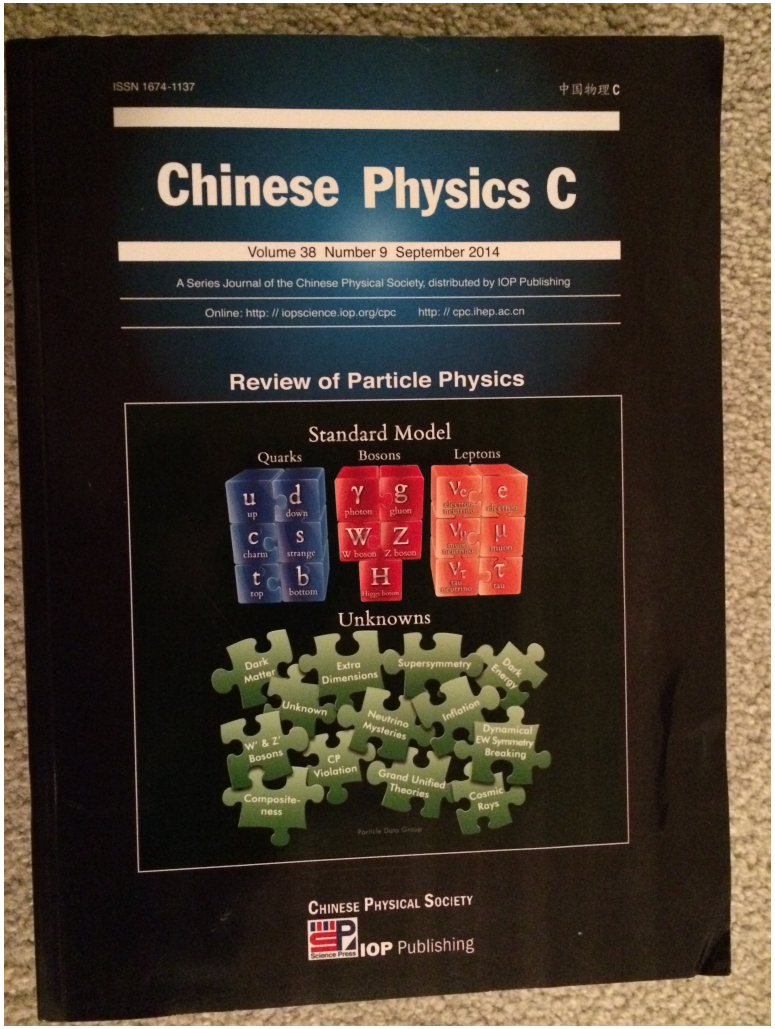

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Philosophy of the Supersymmetry Theory Review

- Provides motivation for supersymmetry (SUSY) searches
  - Theoretical arguments for TeV-scale supersymmetry ("naturalness")
  - Acknowledgment of the tension between the need for new TeV-scale physics and the absence of SUSY signals at the LHC
- Establishes the theoretical framework for SUSY searches
  - Parameters of the minimal supersymmetric model (MSSM)
  - Models of SUSY-breaking to reduce the MSSM parameter space
  - Brief mention of non-minimal extensions (NMSSM, ...)
- Provides the context for experimental SUSY searches
  - relevant for the SUSY Experimental review
  - relevant for the SUSY search listings of the PDG
- Provides a review and references for graduate students and researchers

Table of Contents for the Supersymmetry Theory Review

I.1. Introduction

I.2. Structure of the MSSM

- I.2.1. R-parity and the lightest supersymmetric particle
- I.2.2. The goldstino and gravitino
- I.2.3. Hidden sectors and the structure of supersymmetry-breaking
- I.2.4. Supersymmetry and extra dimensions
- I.2.5. Split-supersymmetry

I.3. Parameters of the MSSM

- I.3.1. The supersymmetry-conserving parameters
- I.3.2. The supersymmetry-breaking parameters
- I.3.3. MSSM-124

I.4. The supersymmetric-particle spectrum

- I.4.1. The charginos and neutralinos
- I.4.2. The squarks, sleptons and sneutrinos

I.5. The supersymmetric Higgs sector
    I.5.1. The tree-level Higgs sector
    I.5.2. The radiatively-corrected Higgs sector
I.6. Restricting the MSSM parameter freedom
    I.6.1. Gaugino mass unification
    I.6.2. The constrained MSSM: mSUGRA, CMSSM, ...
    I.6.3. Gauge-mediated supersymmetry-breaking
    I.6.4. The phenomenological MSSM
I.7. Experimental data confronts the MSSM
    I.7.1. Naturalness constraints and the little hierarchy
    I.7.2. Constraints from virtual exchange of supersymmetric particles
I.8. Massive neutrinos in low-energy supersymmetry
    I.8.1. The supersymmetric seesaw
    I.8.2. R-parity-violating supersymmetry
I.9. Extensions beyond the MSSM

Key ingredients of the Supersymmetry Theory Review

- Defining and identifying the SUSY parameters and particles of the MSSM
  - Superpartners: the targets of the SUSY searches
  - SUSY parameters: they control the basic properties of the SUSY particles and interactions
  - The (N)LSP and the relevance of missing energy
- Framework for the SUSY interpretation
  - R-parity conservation vs. R-parity violation
  - Approaches to SUSY-breaking and their implications
  - Accommodating massive neutrinos
  - Beyond the minimal structures and assumptions
- Connections to the Higgs sector and dark matter
  - Implications of the observed Higgs boson ($m_H = 125$ GeV)
- Naturalness issues and the energy scale of SUSY parameters

What is omitted from the Supersymmetry Theory Review

- Comprehensive treatment of SUSY phenomenology and search techniques
  - e.g., a more detailed treatment of the "simplified model" strategy
  - better suited to the SUSY Experimental review?
- More complete accounts of dark matter and the Higgs sector in SUSY theories
  - Higgs and dark matter reviews provide places for these treatments
- Implications of SUSY for cosmology and the early universe

Should the SUSY Theory and Experimental reviews be combined into one review?

- This possibility had been considered in the past.
- Separated reviews produce cleaner results. Each review has its own constituency. (The Higgs review would benefit from such a separation.)

Major issues for the upcoming Supersymmetry Theory Review

- Implications of the negative results of SUSY searches
  - Expanding the discussion of the tension between naturalness and the absence (so far) of any observed SUSY signals
  - Theoretical approaches to addressing the little hierarchy problem
  - Possible holes in the standard SUSY searches
  - Relaxing naturalness constraints (mini-split, landscape, etc.)

- Does the SUSY Experimental review require modification of the SUSY Theory review (e.g. additional theoretical topics not presently covered or an enhancement of topics currently treated)?

- Do the SUSY Search Listings include searches that require further introductory material not currently present in the SUSY Theory review?

- Is there too much information in the SUSY Theory review?
  - Can the SUSY Theory review be (significantly) shortened?