Science and Ann Nelson

Part I: Ann Nelson, experimentalist

Undergraduate 1977

Nuclear Physics B
Volume 138, Issue 2, 12 June 1978, Pages 189-217

Anomalous e^+e^- and $\mu^+\mu^-$ events produced in e^+e^- annihilation ☆

F.B. Heile [a, b], M.L. Perl [a, b], G.S. Abrams [a, b], M.S. Alam [a, b], A.M. Boyarski [a, b], M. Breidenbach [a, b], J. Dorfan [a, b], G.J. Feldman [a, b], G. Goldhaber [a, b], G. Hanson [a, b], J.A. Jaros [a, b], J.A. Kadyk [a, b], D. Lüke [a, b, ★★], R.J. Madaras [a, b], A.E. Nelson [a, b], J.M. Paterson [a, b], I. Peruzzi [a, b, ‡], M. Piccolo [a, b, ‡] … G. Grammer Jr.

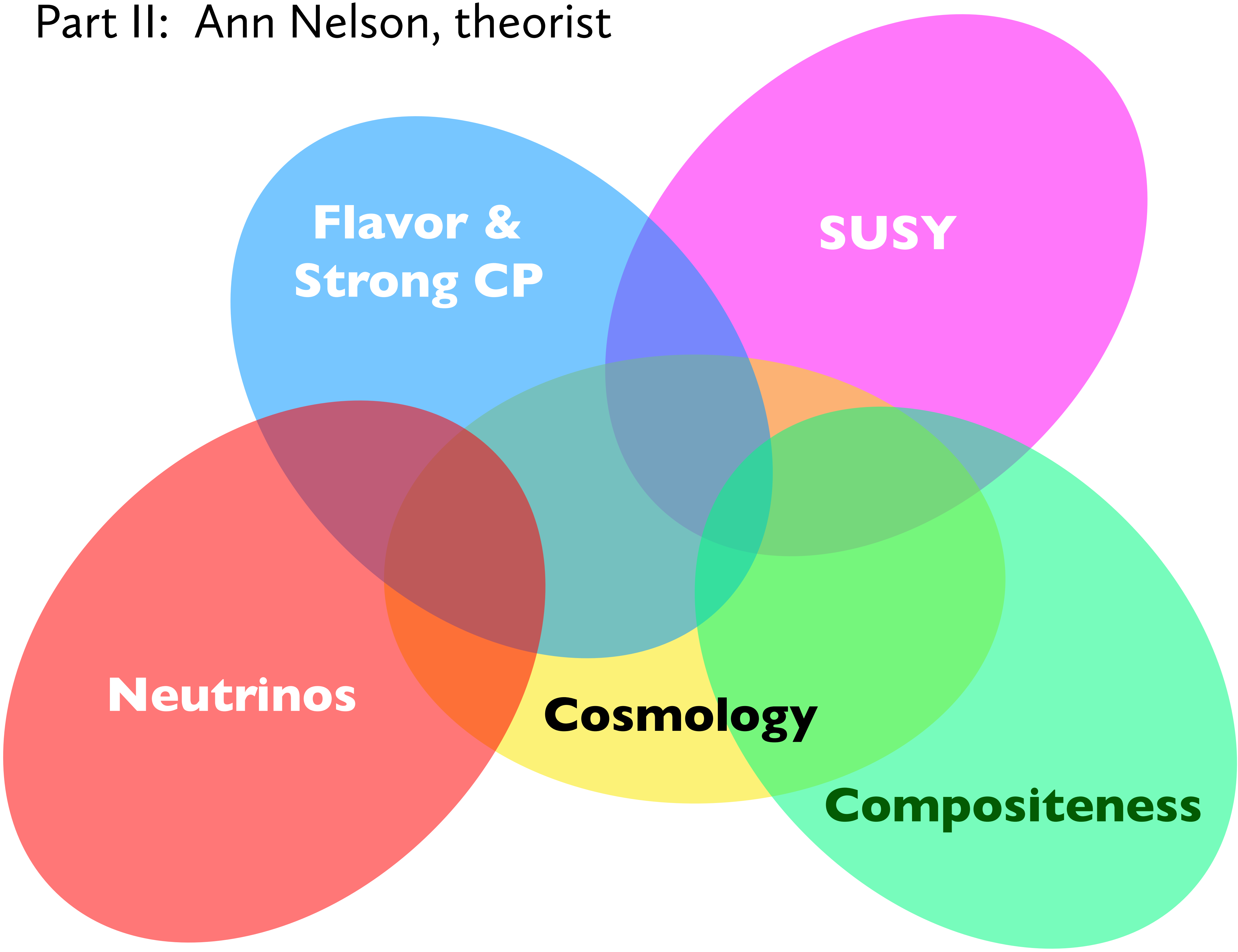
⊞ Show more

https://doi.org/10.1016/0550-3213(78)90243-2

Abstract

We have observed events of the form $e^+ + e^- \to e^+ + e^-$ and $e^+ + e^- \to \mu^+ + \mu^-$ in which there are no other detected particles and there is substantial missing energy; and which cannot be explained by conventional electromagnetic interactions. We show that these events can be explained as the decay products from the pair production, $e^+ + e^- \to \tau^+ + \tau^-$, of a new charged lepton, $\tau^\pm$, of mass ≈1800 MeV/c^2. Some properties of these events are presented. In particular, this production cross section is inconsistent with the τ being an electron-related paralepton.

Part II: Ann Nelson, theorist



Flavor & Strong CP 1983-1991

Graduate student, 1982

- On the proposition that all fermions are created equal
- Spontaneously Broken CP and the Renormalization of Theta-Barr
- Flavor symmetry and proton decay
- Naturally weak CP violation
- CP violation and Fritzsch mass matrices
- Axion-familon model with a harmless 17 keV neutrino
- Constraints on moose-model building
- Chiral composite fermions without U(1)'s
- Strange goings on in dense nucleonic matter
- Strange condensate realignment in relativistic heavy ion collisions
- Kaon condensation in the early universe
- The Peccei-Quinn mechanism without an axion
- Strange baryon matter
- An effective up quark mass from new light particles
- Prediction for top mass and Kobayashi-Maskawa parameters from a solution to the strong CP problem

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Flavor & Strong CP

NATURALLY WEAK *CP* VIOLATION

Ann NELSON
Lyman Laboratory of Physics, Harvard University, Cambridge, MA 02138, USA

Received 14 December 1983

An SU(5) GUT model is proposed in which the observed *CP* violation is due to spontaneous symmetry breakdown. The effective field theory below the GUT scale is simply the standard model. Matching conditions at the GUT scale give a non-zero contribution to $\bar{\theta}$ at the one-loop level. This contribution is proportional to ratios of superheavy fermion masses over the GUT scale, which can be naturally small, in the sense of 't Hooft.

Flavor & Strong CP

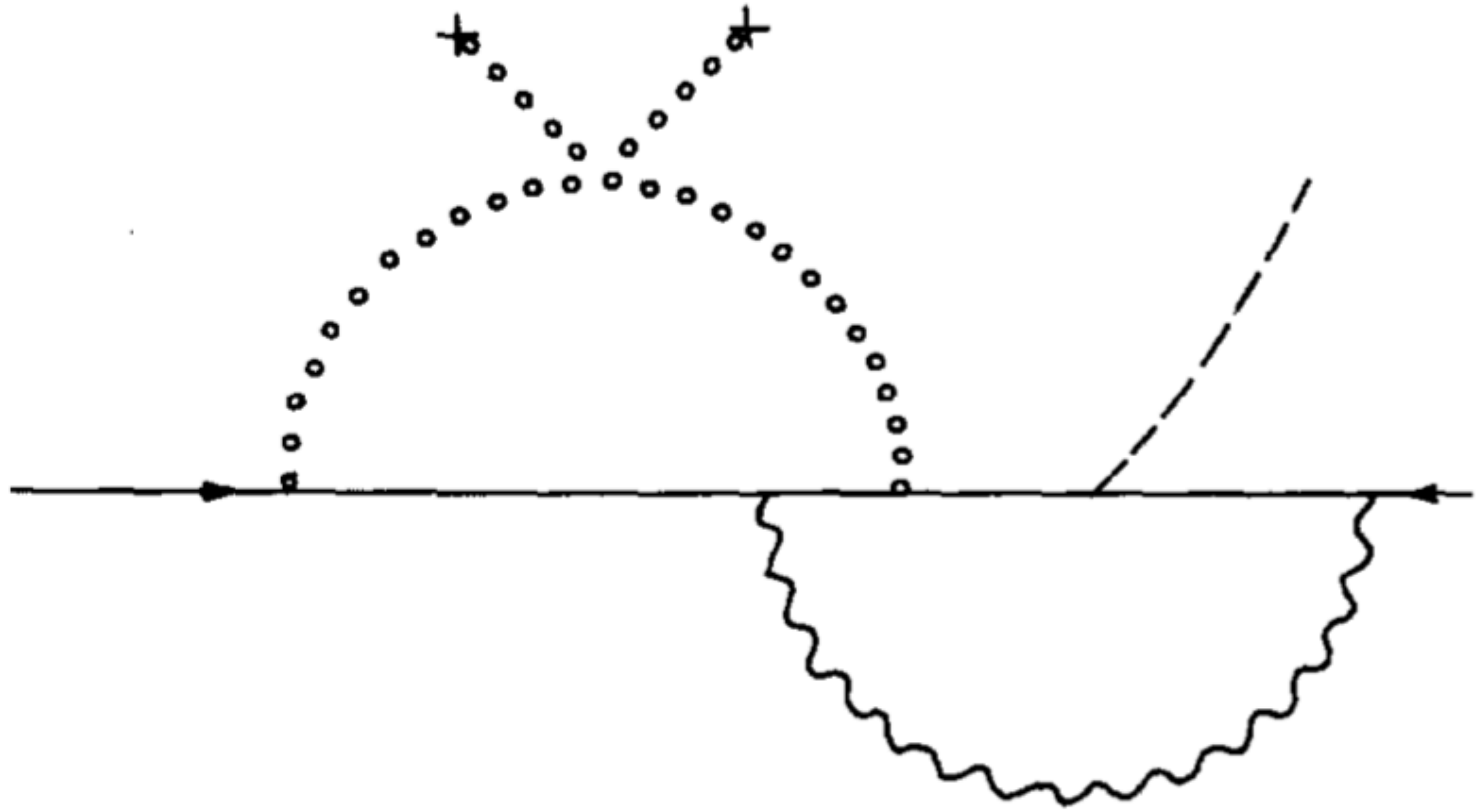


Fig. 3. This is an example of a complex two-loop contribution to λ_{ij} which is suppressed by small Yukawa couplings instead of fermion masses, fondly known as the dead duck graph.

Flavor & Strong CP

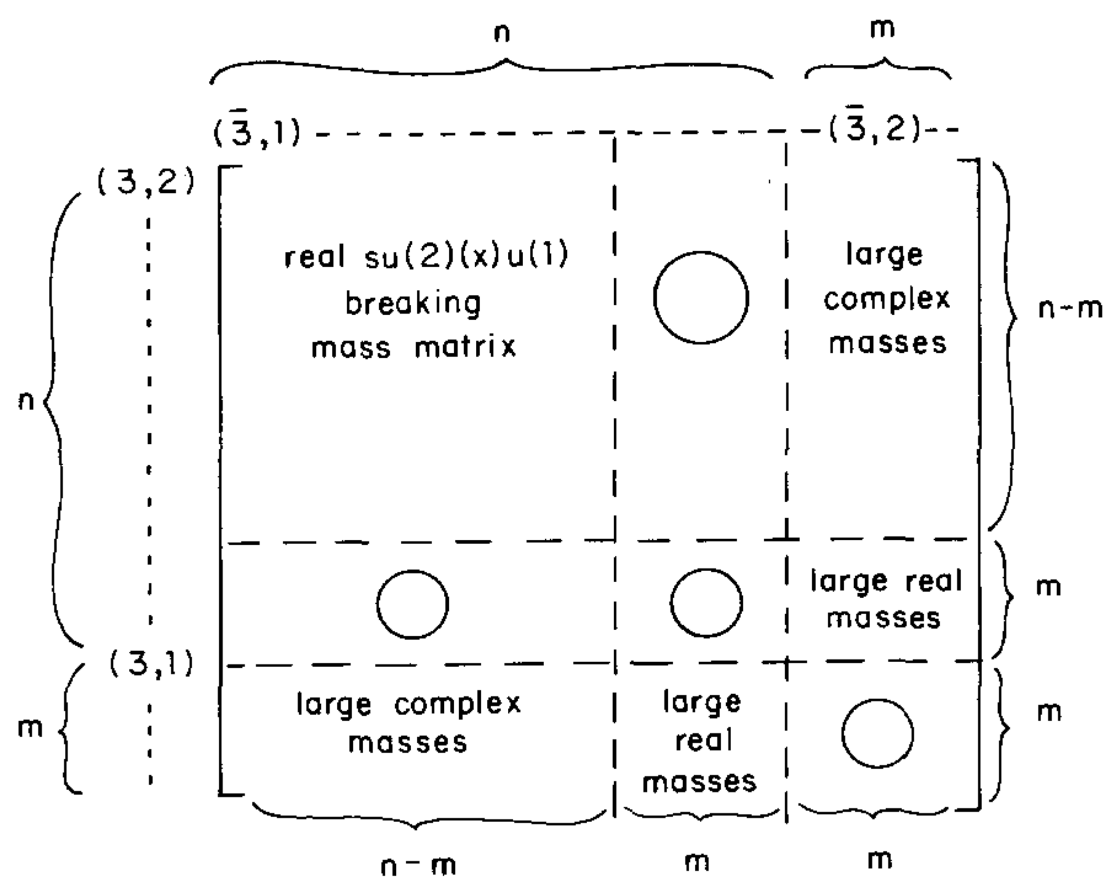
CALCULATION OF θ BARR

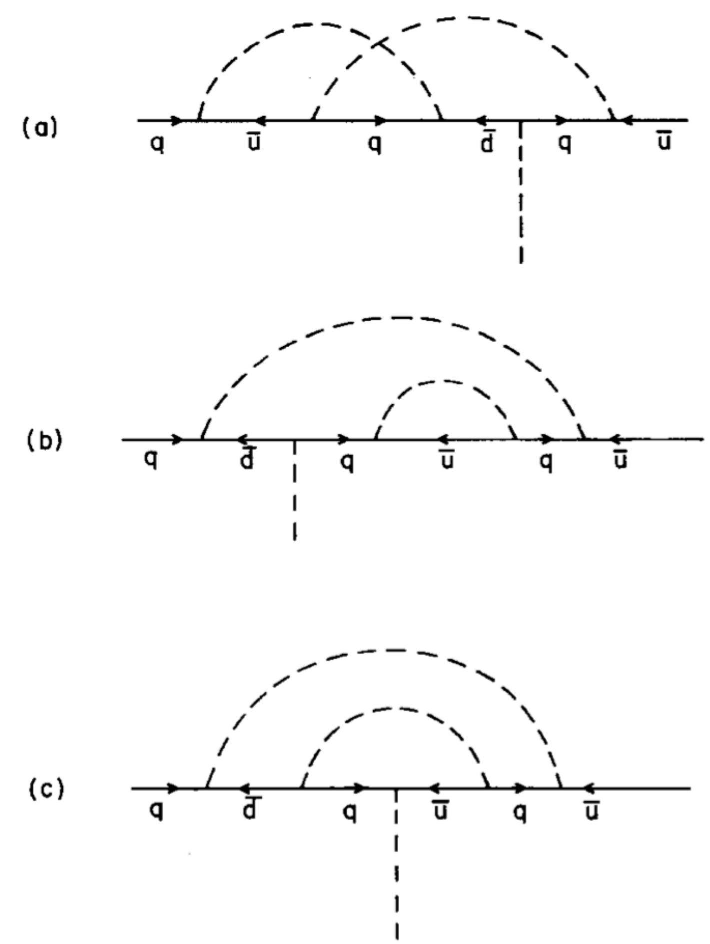
Ann NELSON

Lyman Laboratory of Physics, Harvard University, Cambridge, MA 02138, USA

Received 26 April 1984

We compute $\bar{\theta}$ to the two-loop order in a class of models with spontaneously broken CP. We find $\bar{\theta}$ is naturally small in these models, which are simple to construct. Two loop graphs give contributions to $\bar{\theta}$ in an experimentally interesting range. These models have the standard model as their low energy limit, with *CP* violation in the weak interactions due to the Kobayashi–Maskawa mechanism.





$$\Delta\theta \approx 10^{-11}$$

PhD! 1984

Ann’s PhD thesis consisted primarily of two single-author papers on a new solution to the strong CP problem

Ann’s PhD thesis consisted primarily of two single-author papers on a new solution to the strong CP problem

Howard Georgi:

I had many fabulous students who are better than I am at many things. Ann was the only student I ever had who was better than I am at what I do best, and I learned more from her than she learned from me.

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Graduate student, 1982

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Flavor & Strong CP   1993-2011

Graduate student, 1982

- Is CP a gauge symmetry?
- CP violation and electroweak baryogenesis in extensions of the standard model
- B-factory physics from effective supersymmetry
- CP violation and FCNC in the third family from effective supersymmetry
- Horizontal, anomalous U(1) symmetry for the more minimal supersymmetric standard model
- Realistic supersymmetric model with composite quarks
- New multi-scale supersymmetric models with flavor changing neutral current suppression
- Fermion masses and gauge mediated supersymmetry breaking from a single U(1)
- Testing $m_u = 0$ on the lattice
- New Dimensions and other New Ideas for Flavor
- Suppressing flavor anarchy
- Exact results for supersymmetric renormalization and the supersymmetric flavor problem
- Inflationary axion cosmology beyond our horizon
- CP violating contribution to $\Delta\Gamma$ in the B s system from mixing with a hidden pseudoscalar
- Unified, flavor symmetric explanation for the $t\,\bar{t}$ asymmetry and W j j excess at CDF

JHEP HYPER VERSION
RECEIVED: *August 4, 2000*, ACCEPTED: *September 19, 2000*

Suppressing flavor anarchy

Ann E. Nelson
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E-mail: anelson@fermi.phys.washington.edu

Matthew J. Strassler
School of Natural Sciences, Institute for Advanced Study
Princeton, NJ 08540, USA
E-mail: strasslr@ias.edu

- SM particles coupled to conformal sector
- Flavor structure from RG flow and scaling dimensions
- Conformal sector ▸ power law scaling

	$SU(5)_{GUT}$	$Sp(8)$	$Sp(8)'$	dimension
$T_{1,2,3}$	10	1	1	$42/25, 69/50, 1$
$\bar{F}_{1,2,3}, \bar{H}$	$\bar{5}$	1	1	1
H	5	1	1	1
Q	$\overline{10}$	8	1	$87/100$
A	1	27	1	$3/5$
J, K, L, M	1	8	1	$3/4, 3/4, 3/4, 9/20$
$\bar{Q}'$	10	1	8	(confined)
R, S	1	1	8	(confined)

Table 2: Quantum numbers and scaling dimension of chiral superfields in the 10-centered model.

Chanda Prescod-Weinstein:

Ann told me that to be happy as a model builder in particle physics, I had to be OK with something like mounting a moose head on the wall and putting a purple scarf on it and not worrying about why it was wearing a purple scarf.

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Flavor & Strong CP 2014-2019

Graduate student, 1982

- CP violation in pseudo-Dirac fermion oscillations
- Heavy flavor and dark sector
- CP-violating baryon oscillations
- Baryogenesis from oscillations of charmed or beautiful baryons
- Relaxion: a landscape without anthropics
- Axion cosmology with early matter domination
- Baryogenesis from B meson oscillations
- Dark Matter and Baryogenesis from B mesons.
- A Supersymmetric Theory of Baryogenesis and Sterile Sneutrino Dark Matter from B Mesons

Neutrinos 1985-2011

Post-doc 1985

- New ν constraints on Majorana mass matrices
- Axion-familon model with a harmless 17 keV neutrino
- Upper bound on baryogenesis scale from neutrino masses
- Constraints on neutrino mixing with a 17-keV neutrino
- Solar and atmospheric neutrino oscillations from bilinear R-parity violation
- Neutrino oscillations as a probe of dark energy
- Dark energy from mass varying neutrinos
- Short baseline neutrino oscillations and a new light gauge boson
- Effects of CP violation from neutral heavy fermions on neutrino oscillations, and the LSND/MiniBooNE anomalies

Dark Energy from Mass Varying Neutrinos

Rob Fardon, Ann E. Nelson and Neal Weiner

Department of Physics, Box 1560, University of Washington,
Seattle, WA 98195-1560, USA

2 3 Nov 2003

ABSTRACT: We show that mass varying neutrinos (MaVaNs) can behave as a negative pressure fluid which could be the origin of the cosmic acceleration. We derive a model independent

Coincidences and Damn Coincidences

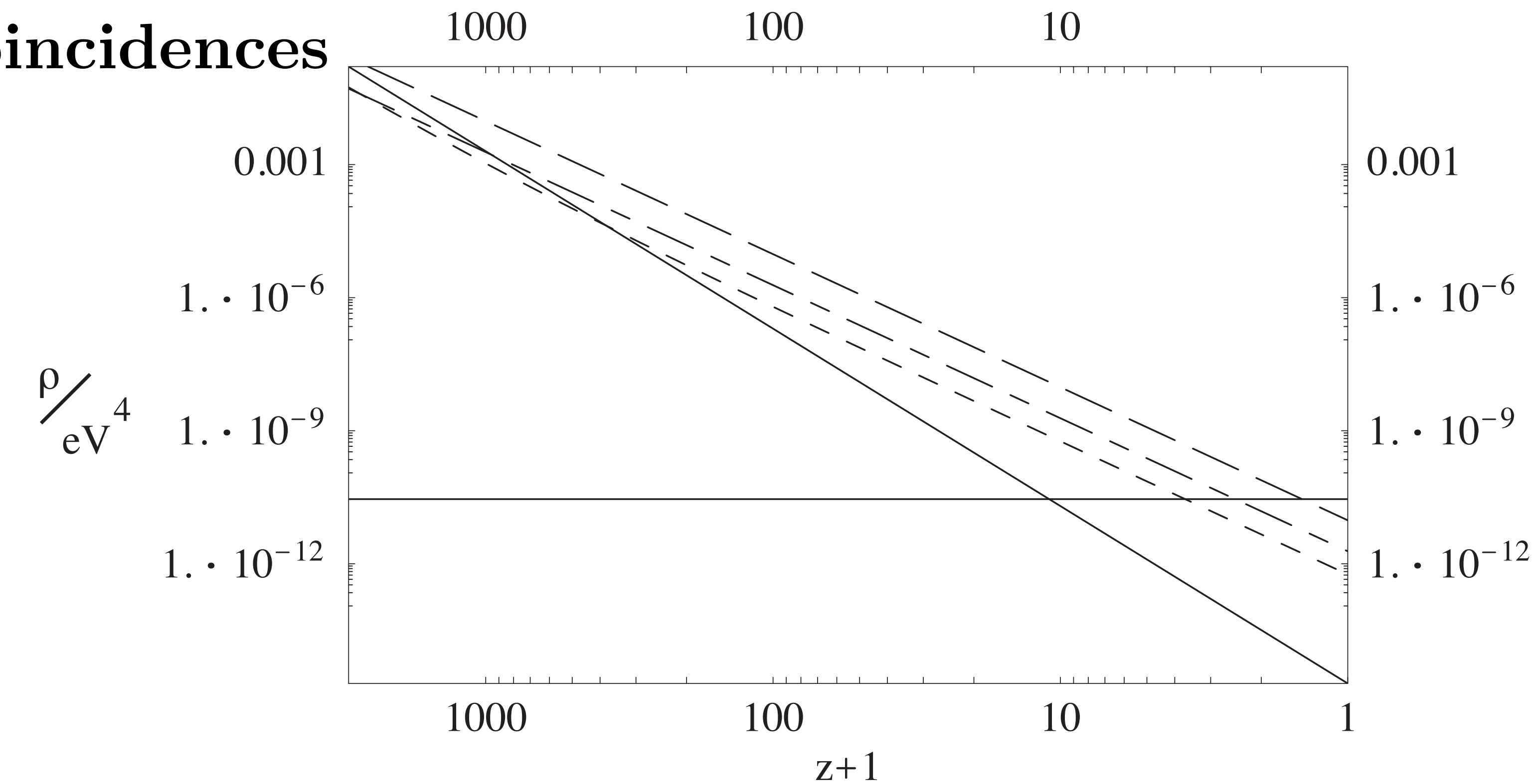

Figure 1: Cosmological energy densities as a function of redshift in the ΛCDM model. The different lines are: long dashed - CDM; long-short dashed - baryons; short-dashed - neutrinos; solid sloped - radiation; solid horizontal - cosmological constant.

Neutrinos

mass varying neutrinos (MaVaNs)

	n_ν eV^3	E_ν	r
BBN	10^{30}	$\sim$ MeV	10^{36}
SN cores	10^{21}	$\sim$ MeV	10^{27}
solar core	$\sim 10^{-7}$	0.1 MeV	1
reactor cores	10^{-11}	0.1 MeV	10^{-4}
beams	$< 3 \times 10^{-7}$	GeV	$< 10^{-2}$

Table 1: r values for various environments. $r \geq 1$ implies that neutrino mass parameters could be modified.

Assist. Professor 1993

Neal Weiner:

Models and ideas would flash through her mind… When you could keep up it was fantastically fun. **Fun.** I think this is perhaps the hardest thing to convey for me just how much she enjoyed physics.

…we came up with names for hypothetical particles, with Ann giggling furiously at some of the absurd suggestions. She was very serious about her work, but that seriousness didn't prevent some silliness and a joyful approach to new ideas.

Neutrinos 2014 - 2017

Post-doc 1985

- Effects of mass varying neutrinos on cosmological parameters as determined from the cosmic microwave background
- CP violation in pseudo-Dirac fermion oscillations
- Constraints and consequences of reducing small scale structure via large dark matter-neutrino interactions
- Probing nonstandard neutrino cosmology with terrestrial neutrino experiments

Supersymmetry 1992 - 1997

Assist. Professor 1991

- Supersymmetric baryogenesis
- Dynamical supersymmetry breaking at low energies
- Naturally large tan β
- Cosmological implications of dynamical supersymmetry breaking
- R-symmetry breaking versus supersymmetry breaking
- Low energy dynamical supersymmetry breaking simplified
- Consequences of low energy dynamical supersymmetry breaking
- A Viable model of dynamical supersymmetry breaking in the hidden sector
- New tools for low energy dynamical supersymmetry breaking
- Electroweak baryogenesis in supersymmetric models
- The more minimal supersymmetric standard model
- B-factory physics from effective supersymmetry
- CP violation and FCNC in the third family from effective supersymmetry
- Dynamical supersymmetry breaking

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Supersymmetry 1992 - 1997

PHYSICAL REVIEW D VOLUME 51, NUMBER 3 1 FEBRUARY 1995

Low energy dynamical supersymmetry breaking simplified

Michael Dine
Santa Cruz Institute for Particle Physics, University of California, Santa Cruz, California 95064

Ann E. Nelson
Department of Physics, FM-15, University of Washington, Seattle, Washington 98195

Yuri Shirman
Santa Cruz Institute for Particle Physics, University of California, Santa Cruz, California 95064
(Received 12 September 1994)

We present a model in which supersymmetry is dynamically broken at comparatively low energies. Previous efforts to construct simple models of this sort have been hampered by the presence of axions. The present model, which exploits an observation of Bagger, Poppitz, and Randall to avoid this problem, is far simpler than previous constructions. Models of this kind do not suffer from the naturalness difficulties of conventional supergravity models, and make quite definite predictions for physics over a range of scales from 100 of GeV to 1000's of TeV. Thus "renormalizable visible sector models" are a viable alternative to more conventional approaches. Our approach also yields a viable example of hidden sector dynamical supersymmetry breaking.

Supersymmetry 1992 - 1997

Old hidden sector SUGRA dogma for SUSY breaking suffered from very light gauginos, assumptions w/o models for flavor, unwieldy gauge groups, etc.

Supersymmetry 1992 - 1997

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Post-1994 virtues of dynamical SUSY breaking: 1997

1. contain gauge singlets, hence are quite workable as hidden sector models with comparable gaugino and scalar masses [4,5].
2. are not chiral under the gauge group [5]. This is possible in theories where adding mass terms to all superfields allows supersymmetric vacua to move in from infinity in field space.
3. have large unbroken global symmetries, enabling direct embedding of the standard model gauge interactions into the DSB sector [6].
4. have classically flat directions lifted by quantum effects [4–7]. As I will discuss later, this is a necessary condition for the quarks and leptons to participate directly in the supersymmetry dynamics.
5. generate multiple scales [4–8]. This has a variety of model building applications.
6. do not have any $U(1)_R$ invariance [9].

Supersymmetry 1992 - 1997

Old hidden sector SUGRA dogma for SUSY breaking suffered from very light gauginos, assumptions w/o models for flavor, unwieldy gauge groups, etc.

Ann et al. papers were the foundation for:

- gauge mediation
- gaugino mediation
- anomaly mediation
- new solutions to the μ problem
- gravitino dark matter

Post-1994 virtues of dynamical SUSY breaking: 1997

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Supersymmetry 1992 - 1997

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- The more minimal supersymmetric standard model
- B-factory physics from effective supersymmetry
- CP violation and FCNC in the third family from effective supersymmetry
- Dynamical supersymmetry breaking

Supersymmetry 1997 - 2002

Assist. Professor 1991

- Horizontal, anomalous U(1) symmetry for the more minimal supersymmetric standard model
- Realistic supersymmetric model with composite quarks
- Counting 4π's in strongly coupled supersymmetry
- New multi-scale supersymmetric models with flavor changing neutral current suppression
- Fermion masses and gauge mediated supersymmetry breaking from a single U(1)
- Solar and atmospheric neutrino oscillations from bilinear R-parity violation
- Gaugino mediated supersymmetry breaking
- Gauge/anomaly syzygy and generalized brane world models of supersymmetry breaking
- Anomaly, gauge and gaugino mediation in brane worlds with messenger matter
- Exact results for supersymmetric renormalization and the supersymmetric flavor problem
- The minimal supersymmetric model without a μ term
- Dirac gaugino masses and supersoft supersymmetry breaking

Supersoft: make gauge sector be N=2 supersymmetric

Patrick J. Fox*, Ann E. Nelson†and Neal Weiner‡ (2006)

- All superpartners obtain masses which are simultaneously consistent with experiment and natural electroweak symmetry breaking. In particular we can predict the sign of scalar masses squared, and only the Higgs mass squared is negative.
- The necessary size of the μ and B_μ parameters can naturally and simply be generated from supersymmetry breaking.
- There are no beyond the standard model flavor changing neutral currents and lepton flavor violation.
- There is no CP violation in conflict with experiment.
- The above features are achieved in a simple, automatic way without any appearance of contrivance.
- The theory is distinctively predictive and testable, and the predictions are insensitive to UV physics.

Supersymmetry 2002 - 2019

- The MSSM without mu term
- Scalar Fields, SUSY, and Dark Matter
- Supersymmetric theories of neutrino dark energy
- New Supersoft Supersymmetry Breaking Operators and a Solution to the mu Problem
- Generalized Supersoft Supersymmetry Breaking and a Solution to the μ Problem
- Extended anomaly mediation and new physics at 10 TeV
- Baryogenesis via mesino oscillations
- A Supersymmetric Theory of Baryogenesis and Sterile Sneutrino Dark Matter from B Mesons

Assist. Professor 1991

Compositeness 1986- 2019

Professor 1999

- Constraints on moose-model building
- Chiral composite fermions without U(1)'s
- Contact terms, compositeness, and atomic parity violation
- Realistic supersymmetric model with composite quarks
- Counting 4π's in strongly coupled supersymmetry
- The littlest higgs
- The minimal moose for a little Higgs
- A composite little Higgs model
- Lattice-friendly gauge completion of a composite Higgs with top partners

Compositeness 1986- 2019

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Accepted: *July 12, 2002*

The littlest Higgs

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Andrew G. Cohen
Physics Department, Boston University
Boston, MA 02215, USA
E-mail: cohen@bu.edu

Emanuel Katz and Ann E. Nelson
Department of Physics, Box 1560, University of Washington
Seattle, WA 98195-1560, USA
E-mail: amikatz@fermi.phys.washington.edu, anelson@phys.washington.edu

Cosmology and gravity 1990 - 1994

Sakurai Prize Talk:
"Baryogenesis" 2018

- Kaon condensation in the early universe
- Weak scale baryogenesis
- Upper bound on baryogenesis scale from neutrino masses
- Baryogenesis at the electroweak phase transition
- Spontaneous baryogenesis at the weak phase transition
- Baryogenesis from anomalous weak interactions at the weak phase transition
- Why there is something rather than nothing: Matter from weak interactions
- Debye screening and baryogenesis during the electroweak phase transition
- Implications of a 17 keV neutrino for baryogenesis
- Supersymmetric baryogenesis
- Progress in electroweak baryogenesis
- Cosmological implications of dynamical supersymmetry breaking
- Diffusion enhances spontaneous electroweak baryogenesis

Cosmology and gravity 1995 - 2007

Sakurai Prize Talk:
"Baryogenesis" 2018

- CP violation and electroweak baryogenesis in extensions of the standard model
- Electroweak baryogenesis in supersymmetric models
- Effective field theory, black holes, and the cosmological constant
- Solution to the hierarchy problem with an infinitely large extra dimension and moduli stabilization
- New angle on intersecting branes in infinite extra dimensions
- Lower bound on the propagation speed of gravity from gravitational Cherenkov radiation
- Scalar Fields, SUSY, and Dark Matter
- Tests of the gravitational inverse-square law
- Neutrino oscillations as a probe of dark energy
- Dark energy from mass varying neutrinos
- Supersymmetric theories of neutrino dark energy
- Inflationary axion cosmology beyond our horizon

Cosmology and gravity 2007 - 2018

Sakurai Prize Talk: "Baryogenesis" 2018

- Slightly non-minimal dark matter in PAMELA and ATIC
- Dark matter annihilation rate with nonstandard thermal history
- Dark light, dark matter, and the misalignment mechanism
- MeV dark matter in the 3+ 1+ 1 model
- Dark matter thermalization in neutron stars
- Effects of mass varying neutrinos on cosmological parameters as determined from the cosmic microwave background
- Renormalizable model for the Galactic Center gamma-ray excess from dark matter annihilation
- Reducing cosmological small scale structure via a large dark matter-neutrino interaction: constraints and consequences
- Baryogenesis via mesino oscillations
- Baryogenesis from oscillations of charmed or beautiful baryons
- Relaxion: a landscape without anthropics
- Hidden-sector spectroscopy with gravitational waves from binary neutron stars
- Neutron stars exclude light dark baryons
- Axion cosmology with early matter domination

Cosmology and gravity 2007 - 2018

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Cosmology and gravity 2018 - 2019

Sakurai Prize Talk:
"Baryogenesis" 2018

- Baryogenesis from B meson oscillations
- Dark Matter and Baryogenesis from B mesons.
- Dark halos around neutron stars and gravitational waves
- A Supersymmetric Theory of Baryogenesis and Sterile Sneutrino Dark Matter from B Mesons

15 Oct 2019

A Supersymmetric Theory of Baryogenesis and Sterile Sneutrino Dark Matter from B Mesons

Gonzalo Alonso-Álvarez,[a] **Gilly Elor,**[b] **Ann E. Nelson***,[b] **and Huangyu Xiao**[b]

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[b] *Department of Physics, Box 1560, University of Washington, Seattle, WA 98195, U.S.A.*

Low-scale baryogenesis and dark matter generation can occur via the production of neutral B mesons at MeV temperatures in the early Universe, which undergo CP-violating oscillations and subsequently decay into a dark sector….The produced matter-antimatter asymmetry is directly related to observables measurable at B factories and hadron colliders… potential LHC signals with a focus on novel long lived particle searches which are directly linked to properties of the dark sector.

1965

John Preskill:

No matter what the topic, we wound up laughing. I suppose that was because the pleasure Ann derived from thinking about and talking about physics was so infectious.