La ri-nascita (?) della "fenomenologia"

gli anni 70-inizi90

Riccardo Barbieri

Fisica e Fisici a Pisa nel 900

Pisa, 7-9 Novembre 2017

QED at higher loops

Fourth-Order Radiative Corrections to Electron-Photon Vertex and the Lamb-Shift Value.

R. BARBIERI

Scuola Normale Superiore - Pisa

J. A. MIGNACO

Departamento de Física
Facultad de Ciencias, Ingenieria y Arquitectura, Universitad - Rosario

E. REMIDDI

Istituto di Fisica dell'Università - Bologna
Istituto Nazionale di Fisica Nucleare - Sezione di Bologna

(ricevuto il 26 Maggio 1971)

Summary. — The slope of the charge form factor of the electron is analytically evaluated in fourth-order perturbation theory of QED and found to be $m^2F_1'(0)=(\alpha/\pi)^2[-4819/5184-(49/72)\zeta(2)+3\zeta(2)\log 2-(3/4)\zeta(3)]=$ $=(\alpha/\pi)^2\cdot 0.470$. Correspondingly the theoretical Lamb-shift value for the hydrogen atom is $\Delta\nu(2S_{\frac{1}{2}}-2P_{\frac{1}{2}})=(1057.90+0.09)$ MHz, in agreement with experiments.

Appelquist-Brodsky

December 1970

$$m^2F_1'(0)=(\frac{\alpha}{\pi})^2(0.48\pm 0.07)$$

$$\Delta E=\mathcal{O}(\alpha^2(Z\alpha)^4m_ec^2)$$

Electron Form Factors up to Fourth Order. - I

R. BARBIERI

Scuola Normale Superiore - Pisa

J. A. MIGNACO (*)

Departamento de Física, Facultad de Ciencias Exactas y Ingenieria
Universitad Nacional de Rosario - Rosario

E. REMIDDI

Istituto di Fisica dell'Università - Bologna
Istituto Nazionale di Fisica Nucleare - Sezione di Bologna

(ricevuto il 17 Gennaio 1972)

Summary. — The explicit results of the analytic evaluation of the discontinuities of the electron form factors and of their zero–momentum-transfer values, up to the fourth order of the perturbative expansion of QED in the electric charge, are presented. Asymptotic and threshold behaviours are discussed. The related form of the dispersion relations for the real parts is given.

(Remiddi and other have kept going)
(connection to Veltman - Schoonschip)

By 1973 the full SM was completely formulated

$$\mathcal{L}_{\sim SM} = -\frac{1}{4}F^a_{\mu\nu}F^{a\,\mu\nu} + i\bar{\psi}\,\not{D}\psi \qquad (\sim 1975\text{-}2000)$$

$$+|D_\mu h|^2 - V(h) \qquad (\sim 1990\ \text{-}2012\text{-}\ \text{now})$$

$$+\psi_i \lambda_{ij} \psi_j h + h.c. \qquad (\sim 2000\ \text{-}\ \text{now})$$

passing over our heads (my head)

Contributing to phenomenological QCD

1. The narrowness of charmonia

Discovery: Nov 1974

Appelquist, Politzer (1975) and De Rujula, Glashow (1975) interpret the narrowness of $J/\Psi(1^{--})$ as a consequence of its 3 gluon decay

$$\frac{\Gamma(\psi \to \text{hadrons})}{\Gamma(\psi \to e^+e^-)} \approx \frac{5(\pi^2-9)}{18\pi}\frac{\alpha_s^3}{\alpha^2}$$

CALCULATION OF THE ANNIHILATION RATE OF P WAVE QUARK-ANTIQUARK BOUND STATES

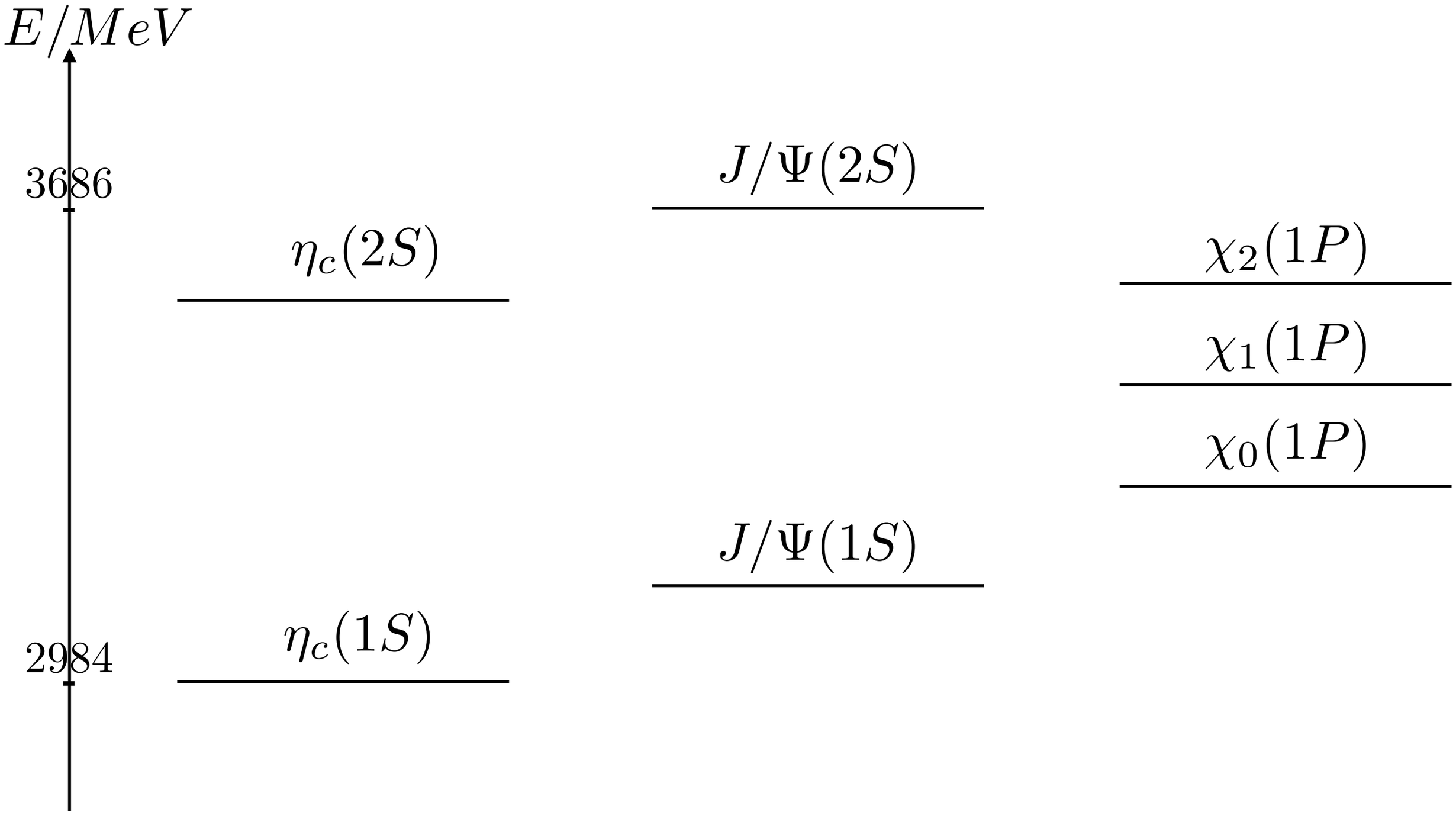
R. BARBIERI, R. GATTO* and R. KÖGERLER

CERN, Geneva, Switzerland

Received 27 October 1975

In the framework of the gauge theory of strong interactions (in particular for the charm scheme) we calculate the annihilation rates of P wave quark-antiquark bound states of $J^{PC} = 0^{++}, 2^{++}$. Applications can be made to the decays of the $C = +1$ states lying between ψ and ψ', to their gluonic production, and to f' decay. Annihilations into 2γ and the Primakoff productions are also discussed.

Charmonium spectroscopy



Γ's between 100 kEV and 30 MeV

SINGULAR BINDING DEPENDENCE IN THE HADRONIC WIDTHS OF 1^{++} AND 1^{+-} HEAVY QUARK ANTIQUARK BOUND STATES

R. BARBIERI and R. GATTO*
CERN, Geneva, Switzerland

and

E. REMIDDI
Istituto di Fisica dell'Università, Bologna,
Istituto Nazionale di Fisica Nucleare, Sezione di Bologna, Italy

Received 10 February 1976

The annihilation rates into hadrons of P-wave heavy quark-antiquark bound states are calculated within SU(3) colour gauge theory (in particular for the charm scheme). An interesting feature we find is a logarithmic divergence for small binding for the states 1^{++} and 1^{+-}. Implications for the asymptotic freedom approach to the decay rates of the new particles are discussed. An attempt to use quantitatively the obtained results for all the C-even P-waves gives $\Gamma_{ann}(0^{++}) : \Gamma_{ann}(2^{++}) : \Gamma_{ann}(1^{++}) \approx 15 : 4 : 1$.

(+ higher orders in α_S and binding corrections)

First measured in 1986 at Crystal Ball (SLAC)

Now:

$$\Gamma(\chi_{c0}) = 10.5 \pm 0.6 \quad \Gamma(\chi_{c2}) = 1.93 \pm 0.11 \quad \Gamma(\chi_{c1}) = 0.84 \pm 0.04 \quad MeV$$

$$\Gamma(0^{++}) : \Gamma(2^{++}) : \Gamma(1^{++}) = 12 : 2.4 : 1$$

STRONG RADIATIVE CORRECTIONS TO ANNIHILATIONS OF QUARKONIA IN QCD

R. BARBIERI
Scuola Normale Superiore, Pisa, Italy

and

Department of Physics, University of Geneva, Switzerland

G. CURCI
CERN, Geneva, Switzerland

E. d' EMILIO
Scuola Normale Superiore, Pisa and
INFN, Sezione di Pisa, Italy

E. REMIDDI
Istituto di Fisica, Università di Bologna and
INFN, Sezione di Bologna, Italy

Received 19 February 1979

The significance of the lowest-order QCD prediction for the annihilations of heavy quark-antiquark bound states is analyzed. The calculation of the leading strong radiative corrections to the hadronic *versus* electromagnetic annihilation rate ratio R of pseudoscalar quarkonium is presented. In terms of the coupling constant α_s, as defined in the minimal subtraction scheme, we find

$$R = R^{(0)}(1 + 22.14\alpha_s/\pi) .$$

The physical significance of this result is discussed by comparing it with the calculation of the non-leading effects in α_s on the scaling violations in deep inelastic scattering. A bad convergence of the relative perturbative expansion is found, demanding for its safe application a value of the relevant momentum definitely higher than that of charmonium physics.

Contributing to phenomenological QCD

2. Beyond the parton picture "Factorisation"

A SIMPLE ALGORITHM FOR QCD JETS

K. KONISHI [1], A. UKAWA and G. VENEZIANO [2]
CERN, Geneva, Switzerland

Received 16 June 1978

A proposal is made, giving multiparticle (parton) spectra inside quark and gluon jets in terms of the tree diagrams of an effective field theory. The resulting "jet calculus" satisfies many consistency checks. A first sample of applications is given.

COLOR SINGLET DISTRIBUTIONS AND MASS DAMPING IN PERTURBATIVE QCD

A. BASSETTO
Dipartimento di Fisica, Libera Università di Trento, and INFN, Sezione di Padova, Italy

M. CIAFALONI
Scuola Normale Superiore, Pisa, and INFN, Sezione di Pisa, Italy

and

G. MARCHESINI
Istituto di Fisica dell'Università di Parma, and INFN, Sezione di Milano, Italy

Received 22 February 1979

A TREATMENT OF HARD PROCESSES SENSITIVE TO THE INFRARED STRUCTURE OF QCD

D. AMATI

CERN, Geneva, Switzerland

A. BASSETTO[1]

Laboratoire de Physique Théorique et Hautes Energies, Université de Paris-Sud, 91405 Orsay, France*

M. CIAFALONI

Scuola Normale Superiore, Pisa and INFN, Sezione di Pisa, Italy

G. MARCHESINI

Istituto di Fisica dell'Università, Parma and INFN, Sezione di Milano, Italy

G. VENEZIANO

CERN, Geneva, Switzerland

Received 30 April 1980

We propose a modified jet evolution equation which resums large corrections to the usual leading logarithmic approximation when phase-space constraints expose the singular infrared structure of QCD. The modification, which consists simply of a rescaling of the argument of the running coupling constant, is based on perturbative arguments verified at the fourth-order level. Processes analyzed by this method include the quark (Sudakov) form factor, the large moments of structure and fragmentation functions, the asymptotic behaviour of multiplicities and the clustering of final quanta in colourless systems which occupy finite regions of (momentum and position) phase space.

(Ciafaloni school in Florence)

EVOLUTION OF PARTON DENSITIES BEYOND LEADING ORDER
The non-singlet case

G. CURCI

CERN, Geneva, Switzerland

W. FURMANSKI

Jagellonian University, Krakow, Poland

R. PETRONZIO

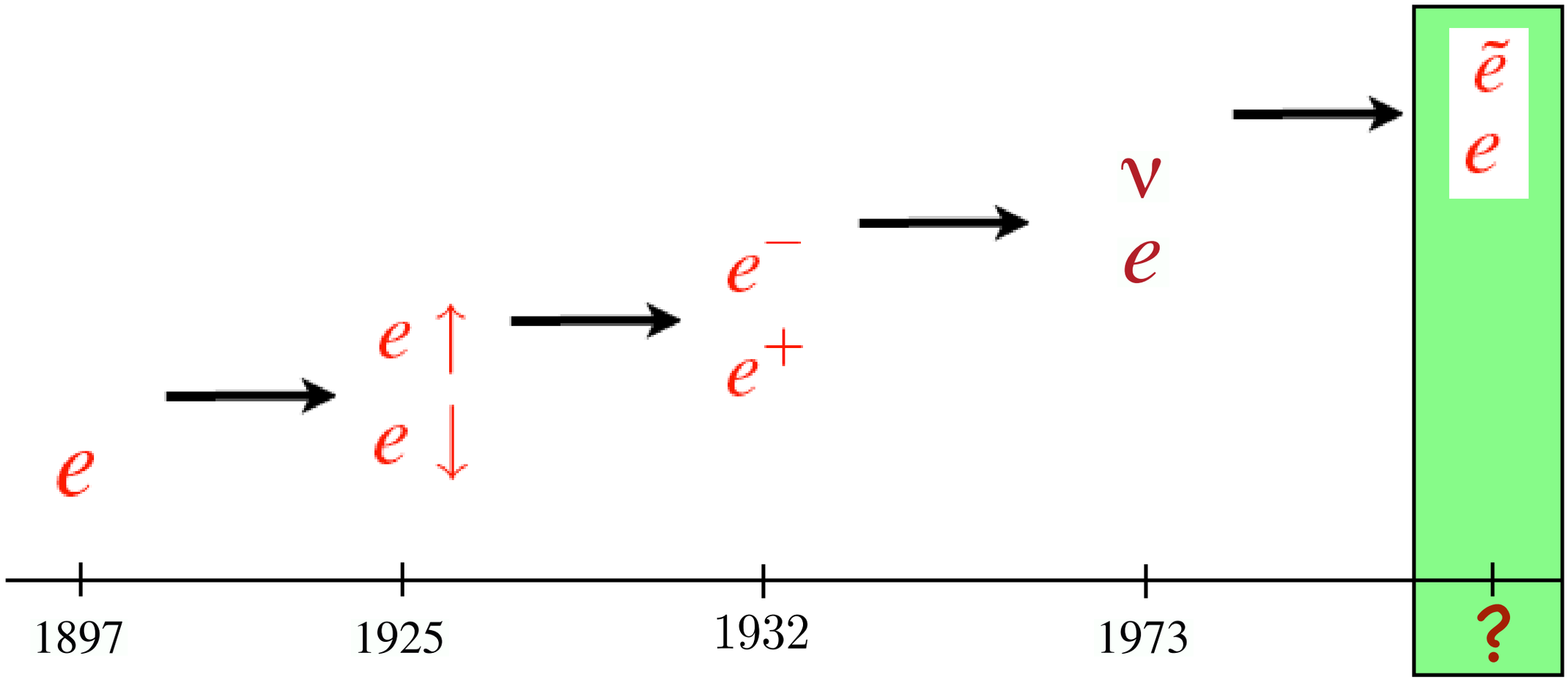
CERN, Geneva, Switzerland

Received 31 March 1980

We develop a technique, based explicitly on the factorization properties of mass singularities, which allows one to calculate the evolution of parton densities beyond leading order. We present the results for the evolution of hadronic structure functions as well as for parton fragmentation functions into hadrons. Within our scheme the predictions for a particular process are obtained by convoluting a universal parton density with a "short-distance" cross section specific to the process. As an application, we calculate the QCD predictions for the Q^2 dependence of deep inelastic lepton-hadron scattering and of one-particle inclusive e^+e^- annihilation cross sections. Our results for electroproduction agree with those obtained with the operator product expansion technique. Physical quantities in scattering are related to the corresponding ones in annihilation by analytic continuation, whereas the Gribov-Lipatov relation is strongly violated.

A generalisation of DGLAP equation

The faith in supersymmetry



Weinberg 1976: the "hierarchy" problem

Veltman, Maiani, Witten 1980: may be solved by supersymmetry

GAUGE MODELS WITH SPONTANEOUSLY BROKEN LOCAL SUPERSYMMETRY

R. BARBIERI
Scuola Normale Superiore, Pisa, Italy and INFN, Sezione di Pisa, Italy

S. FERRARA
CERN, Geneva, Switzerland

and

C.A. SAVOY
Département de Physique Théorique, Université de Genève, Switzerland

Received 3 August 1982

An effective low-energy lagrangian for gauge theories based on local supersymmetry spontaneously broken at an intermediate energy between the weak interaction and the Planck scale is obtained. The derivation uses the general coupling of the Yang–Mills matter system to $n = 1$ supergravity. As illustrative examples of this framework we exhibit realistic models of supersymmetric QED and of the electroweak theory with supersymmetry breaking induced by purely gravitational effects.

$M_{Pl} \to \infty$ at fixed gravitino mass

THE MUON ANOMALOUS MAGNETIC MOMENT IN BROKEN SUPERSYMMETRIC THEORIES

R. BARBIERI
Scuolo Normale Superiore, Pisa, Italy
and INFN, Pisa, Italy

and

L. MAIANI
Istituto di Fisica "G. Marconi", Università di Roma, Rome, Italy
and INFN, Rome, Italy

Received 16 June 1982

We consider the one-loop corrections to the muon anomalous magnetic moment in a class of spontaneously broken supersymmetric gauge theories. We add to the well known contributions from photon, W and Z exchange the effects of the corresponding fermionic superpartners, photino, w-ino and z-ino, and that of the massless goldstino. We reobtain the bound $\mu \gtrsim 15$ GeV for the common mass of the scalar partners of the muon and the neutrino, as well as an excluded region in the $\mu - \tilde{M}_\omega$ plane, $\tilde{M}_\omega$ being the w-ino mass. Consideration of goldstino exchange gives rise to the new bound $d \gtrsim 1350$ GeV^2 for the order parameter d of supersymmetry breaking. The addition of a gaugino Majorana mass is also considered. In conjunction with chiral breaking scalar particle mixing, such a mass term leads to model dependent corrections linear in the muon mass.

?

$$a_\mu^{SM} = 11659180.2 \pm 4.2 \pm 2.6 \pm 0.2$$
$$a_\mu^{exp} = 11659208.9 \pm 5.4 \pm 3.3$$

?

UPPER BOUNDS ON SUPERSYMMETRIC PARTICLE MASSES

R. BARBIERI

CERN, Geneva, Switzerland
and Dipartimento di Fisica, Università di Pisa, INFN, Sezione di Pisa, Italy

G.F. GIUDICE

International School for Advanced Studies, Trieste, Italy
and INFN, Sezione di Trieste, Italy

Received 31 August 1987
(Revised 12 October 1987)

Based on the "naturalness" criterion, upper bounds on all superparticle masses as functions of the top quark mass are derived. These bounds give an objective criterion to test (or disprove) the idea of low-energy supersymmetry, as implemented in supergravity models. These bounds strongly differentiate weakly interacting superparticles, like charginos or neutralinos, lighter than 100–200 GeV, from strongly interacting ones, like gluinos or squarks which can become heavier than 1 TeV.

$m_h^2(a_i)$ $\Delta = Max_{a_i} \frac{d\log(m_h^2)}{d\log(a_i)}$ $1/\Delta \equiv$ "fine tuning"

The supersymmetric Higgs for heavy superpartners

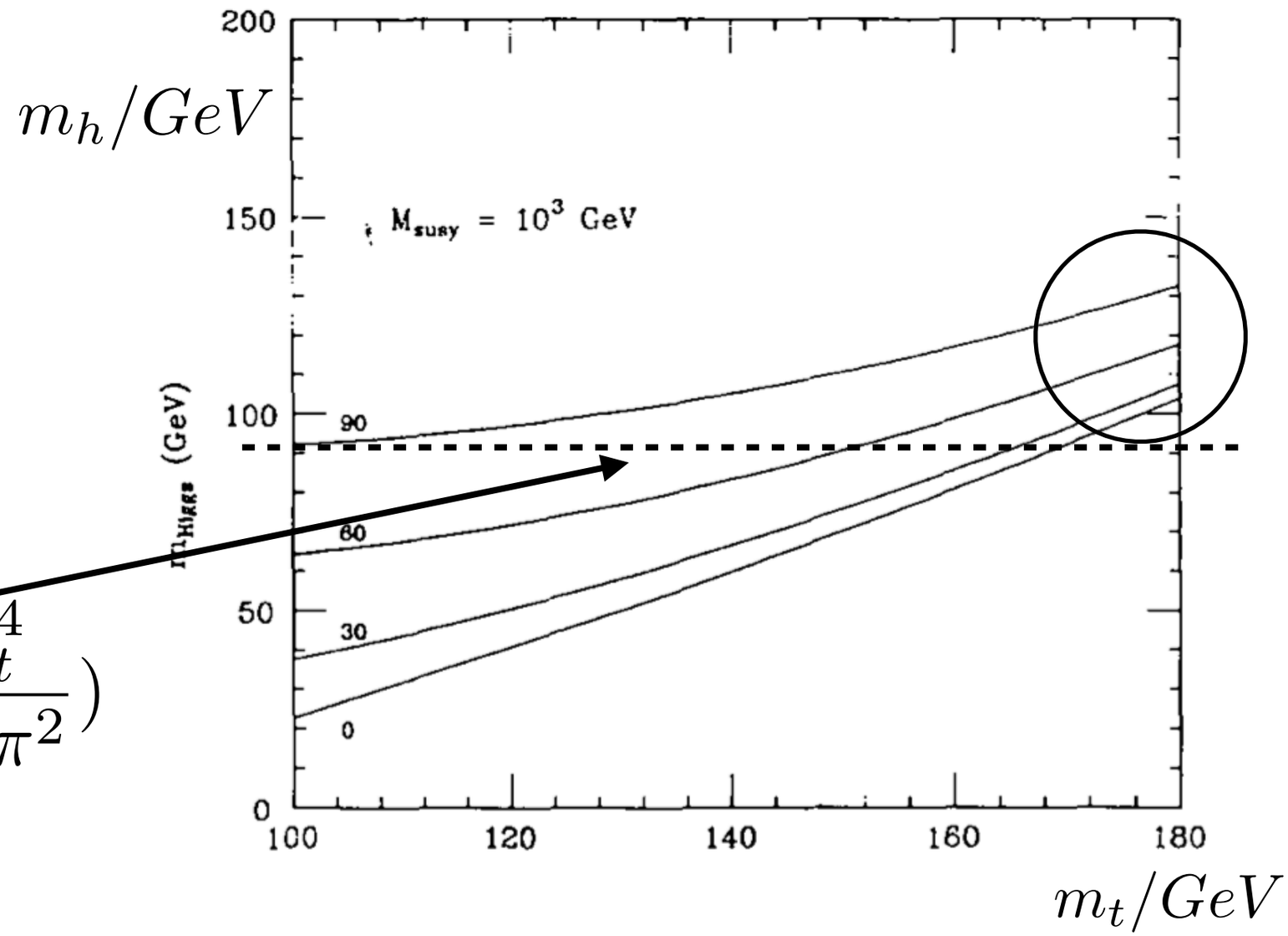
R. Barbieri, M. Frigeni
Dipartimento di Fisica, Università di Pisa and INFN, Sezione di Pisa, Pisa, Italy

and

F. Caravaglios
Scuola Normale Superiore, Pisa and INFN, Sezione di Pisa, Pisa, Italy

Reccived 7 January 1991

$$m_h = tree \overset{<}{+} O(\frac{y_t^4}{16\pi^2})$$



Production and leptonic decays of charginos and neutralinos in hadronic collisions

R. Barbieri [1], F. Caravaglios [1,2], M. Frigeni [1] and M.L. Mangano [1,2]

[1] *Dipartimento di Fisica and Istituto Nazionale di Fisica Nucleare, Pisa, Italy*
[2] *Scuola Normale Superiore, Pisa, Italy*

Received 19 April 1991
(Revised 21 June 1991)
Accepted for publication 17 July 1991

We study multi-lepton final states arising from the decay of charginos and neutralinos produced in hadronic collisions at current and future center-of-mass energies. We compare the signals predicted by Minimal Supersymmetry with the main Standard Model backgrounds, namely vector boson and heavy quark production.

Violations of lepton flavour and CP in supersymmetric unified theories ⋆

Riccardo Barbieri [a], Lawrence Hall [b], Alessandro Strumia [a]

[a] *Dipartimento di Fisica, Università di Pisa, and INFN, Sezione di Pisa, I-56126 Pisa, Italy*

[b] *Department of Physics, University of California at Berkeley, CA 94720, USA*

Received 23 January 1995; accepted 26 April 1995

Abstract

As a consequence of the large top quark Yukawa coupling, supersymmetric unified theories with soft supersymmetry breaking terms generated at the Planck scale predict lepton flavour and CP violating processes with significant rates.

The flavour violating parameters of the low energy theory are derived in both SU(5) and SO(10) theories, and are used to calculate the rate for $\mu \to e\gamma$. The sensitivity of the search for $\mu \to e\gamma$ is compared with that for $\mu \to e$ conversion in atoms, $\tau \to \mu\gamma$ and the electric dipole moment of the electron. The experimental search for these processes is shown to provide a very significant test of supersymmetric unification, especially in SO(10) but also in SU(5).

Precision at LEP (and beyond)

First LEP collisions: August 1989

Vacuum polarization effects of new physics on electroweak processes

G. Altarelli
CERN, CH-1211 Geneva 23, Switzerland

and

R. Barbieri
Dipartimento di Fisica, Università di Pisa, I-56100 Pisa, Italy
and INFN, Sezione di Pisa, I-56010 Pisa, Italy

Received 28 September 1990

The effects of new physics on vacuum polarization corrections to electroweak processes can in general be parametrized in terms of six real constants, in the limit of neglecting terms which vanish for $\Lambda \to \infty$, with Λ being the scale of new physics. Three of these parameters can be reabsorbed in the definitions of α, G_F and m_Z, while the remaining three are observables. On the basis of simple models, it is shown that all three can be important and should be kept in a model-independent analysis of the data. This is equivalent to treating Δr, $\Delta\rho$ and $\bar{s}_W^2$ (an effective $\sin^2\theta_W$ for on-shell Z couplings) as independent observables. By now available data allow a separate model-independent determination of these quantities. Implications for technicolour and supersymmetric models and anomalous γWW or ZWW couplings are discussed.

$$\epsilon_1, \epsilon_2, \epsilon_3, (\epsilon_b)$$

Where is the top quark?

The corrections growing like powers of m_t^2 (and m_h^2) from the "gauge-less" limit of the SM

Two-loop heavy-top effects in the Standard Model

Riccardo Barbieri [a,b,c], Matteo Beccaria [a,b], Paolo Ciafaloni [a,b], Giuseppe Curci [b,a] and Andrea Viceré [d,b]

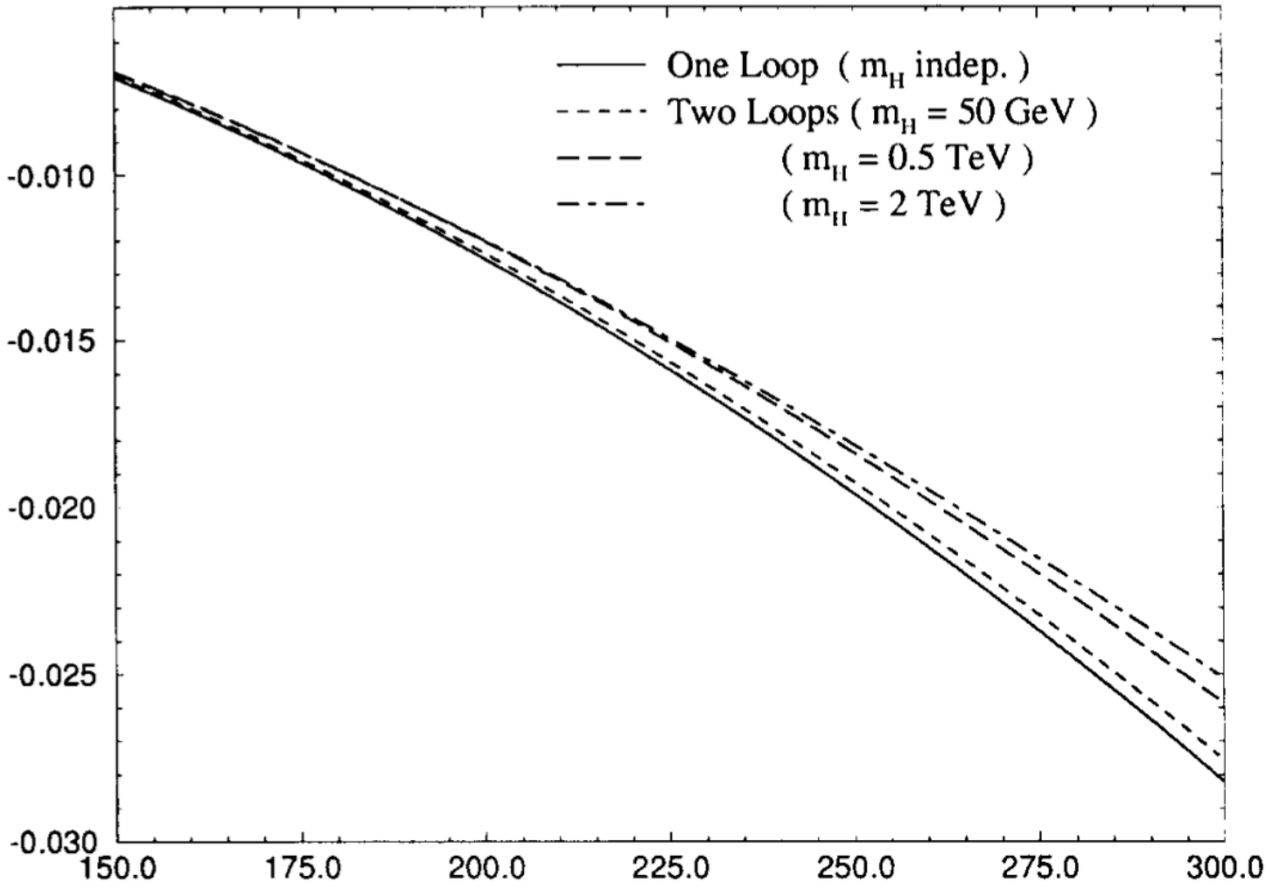
[a] *Dipartimento di Fisica dell'Universitá di Pisa, Piazza Torricelli 2, I-56100 Pisa, Italy*
[b] *INFN, Sezione di Pisa, Via Livornese 582 / a, I-56010 S. Piero a Grado (Pisa), Italy*
[c] *Theory Division, CERN, CH-1211 Geneva 23, Switzerland*
[d] *Scuola Normale Superiore, Piazza dei Cavalieri 7, I-56100 Pisa, Italy*

Received 23 December 1992
Accepted for publication 10 June 1993

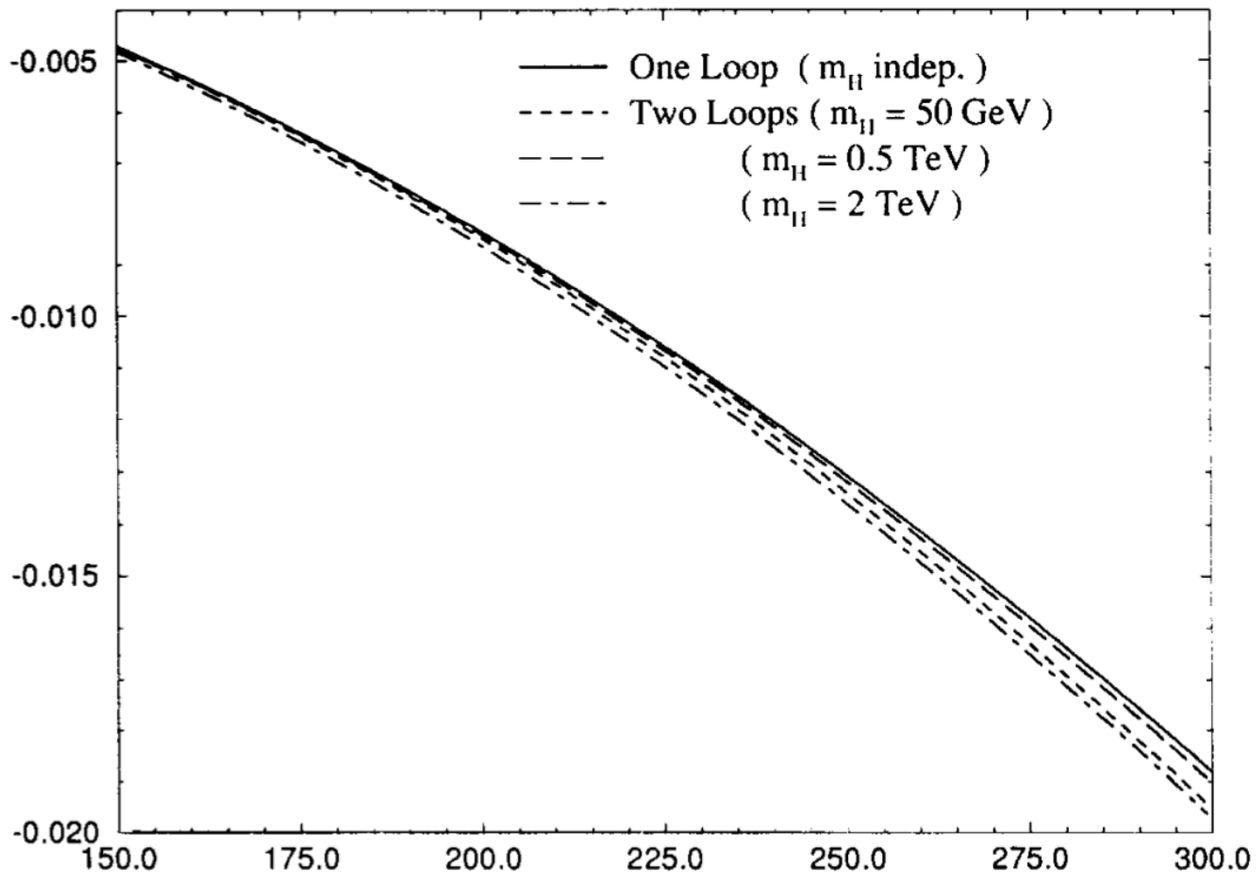
We give a detailed description of the calculation in the Standard Model of all the m_t^4 radiative correction effects to the electroweak precision observables for arbitrary values of the Higgs mass.

Where is the top quark?

$\rho - 1$



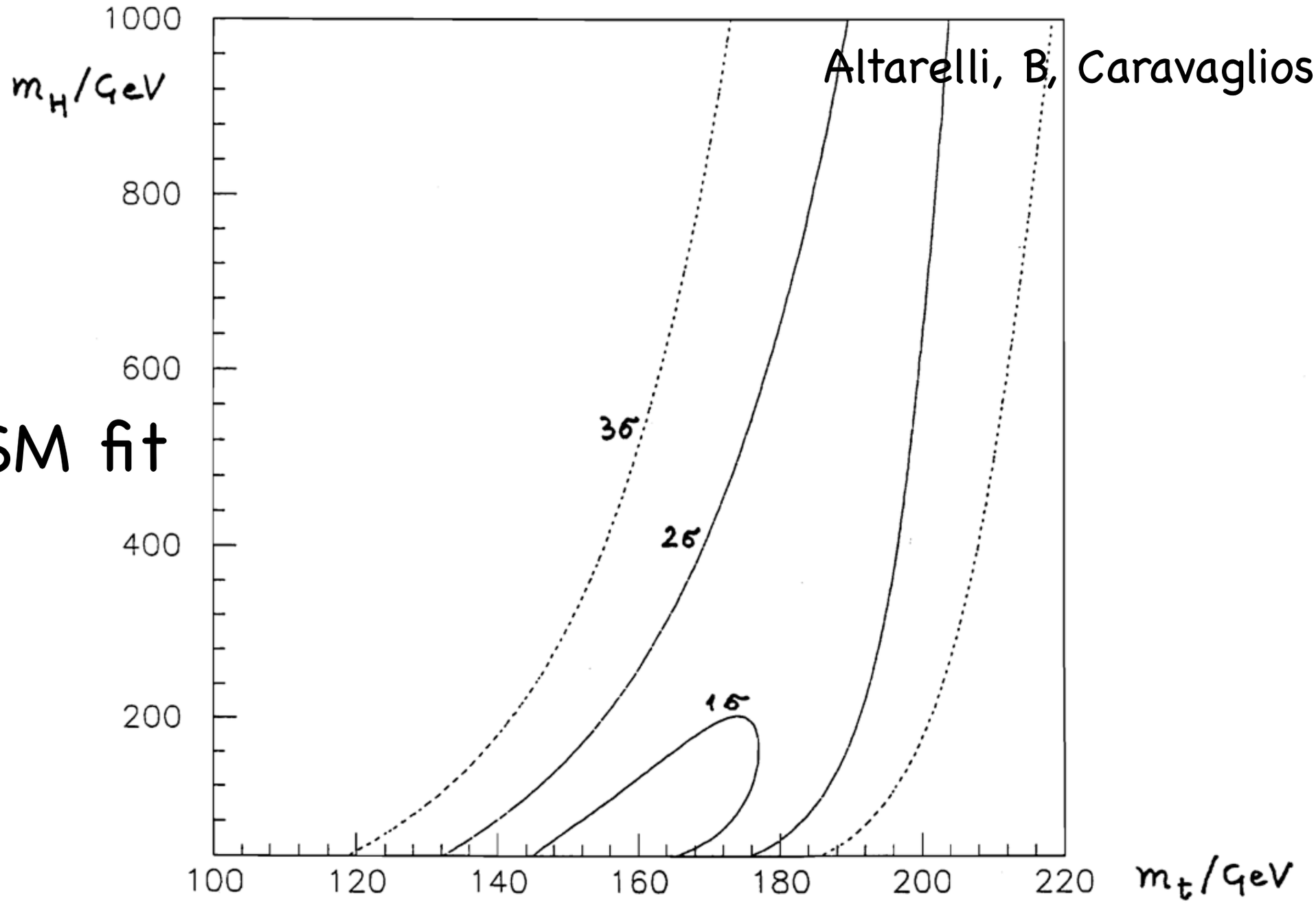
$Z \to b\bar{b}$



m_t/GeV

La Thuile, April 1994

pure SM fit



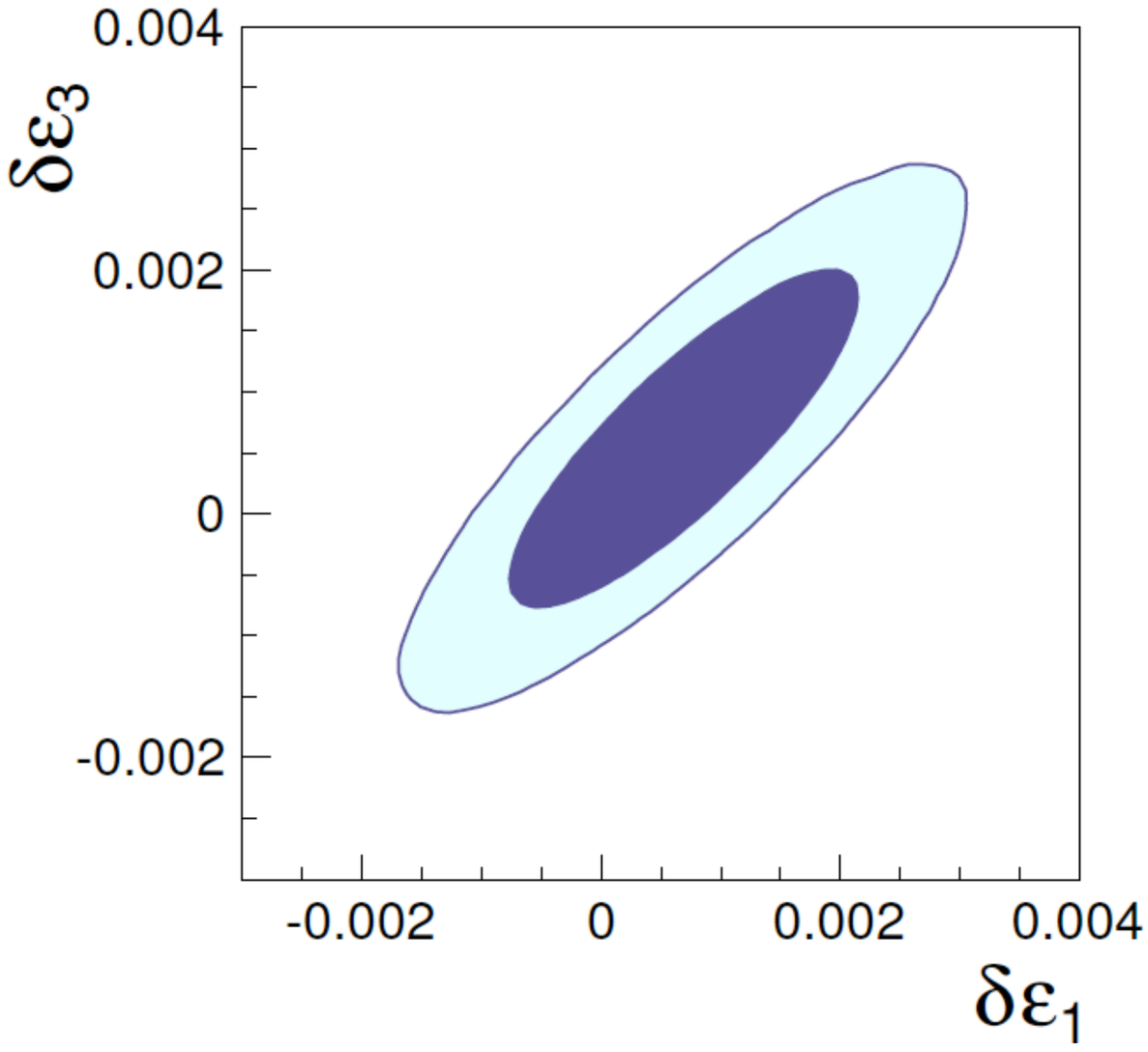
compared with $m_t = 174 \pm 10^{+13}_{-12}\ GeV$ in the first CDF paper

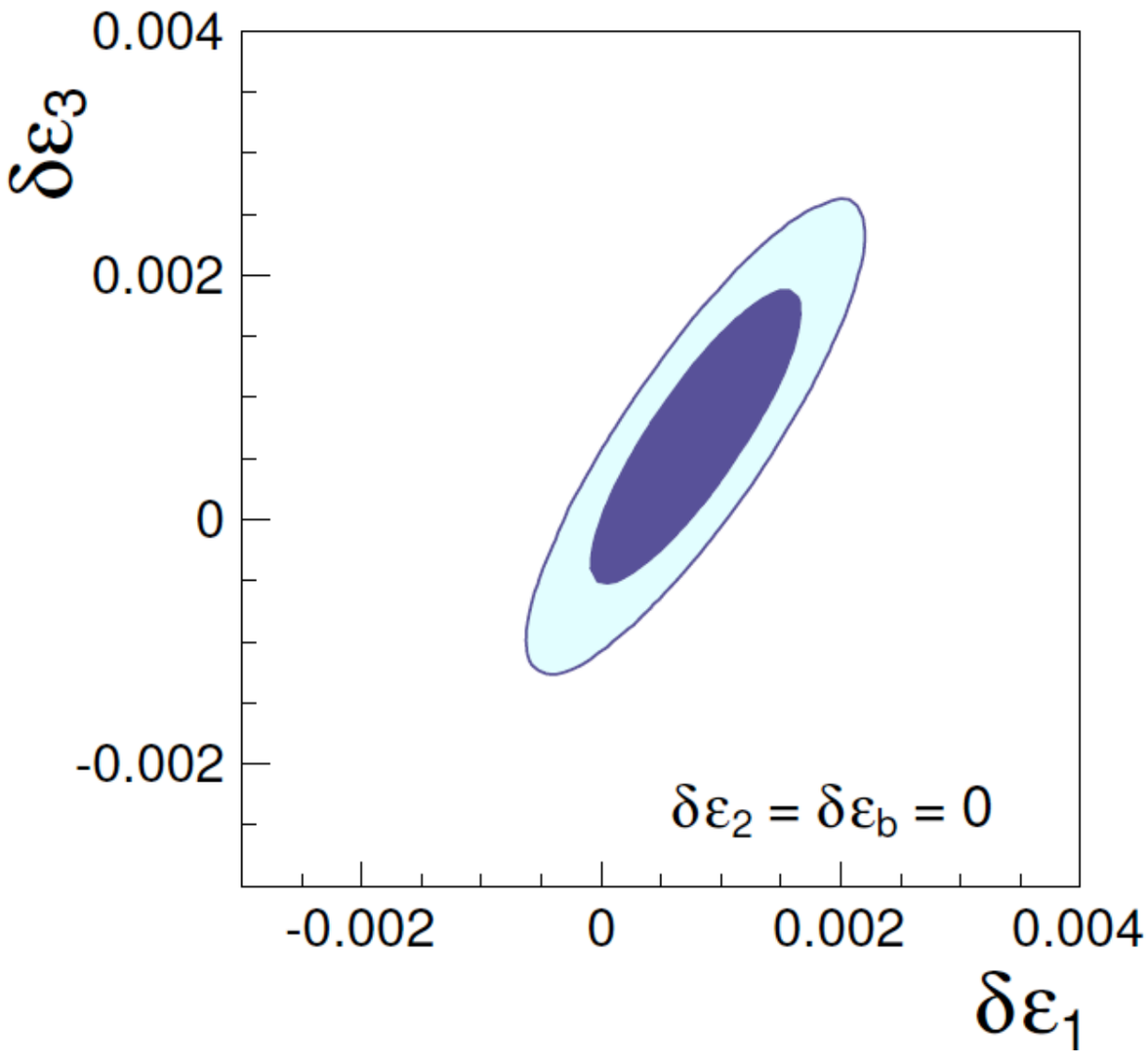
that appeared in PRD in Sept 1994

Currently

$$\epsilon_1^{SM} = 5.21 \cdot 10^{-3},\ \epsilon_3^{SM} = 5.28 \cdot 10^{-3}$$

$$\delta\epsilon_i = \epsilon_i - \epsilon_i^{SM}$$





Ciuchini et al, 2013

Miscellanea

NEUTRINO OSCILLATIONS IN THE EARLY UNIVERSE

R. BARBIERI

Dipartimento di Fisica, Università di Pisa
and
INFN, Sezione di Pisa, Italy

A. DOLGOV

Institute of Theoretical and Experimental Physics, Moscow, USSR

Received 18 June 1990

We study the possible distortions of the evolution of the early universe caused by the oscillations of a standard neutrino (ν_e, ν_μ or ν_τ) into a light "sterile" neutrino state, a gauge group singlet ν_s. The effects on the standard big bang nucleosynthesis are considered in the full space of the mixing parameters ($\delta m^2, \sin 2\theta$). A significant portion of this parameter space is thereby excluded, or at least made highly improbable.

What is behind flavour?

Predictions from a $U(2)$ flavour symmetry in supersymmetric theories ⋆

Riccardo Barbieri [a], Gia Dvali [b], Lawrence J. Hall [c]

[a] *Physics Department, University of Pisa and INFN Sez. di Pisa, I-56126 Pisa, Italy*

[b] *CERN, Geneva, Switzerland*

[c] *Theoretical Physics Group, LBNL, and Physics Department, University of California, Berkeley, CA 94720, USA*

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Editor: H. Georgi

(B-decay anomalies?!?!)

Summary

1970-1974	QED at higher loops
1975-1980	QCD beyond the partons
1981-on	supersymmetry
1989-1995	EW precision