Survey

and

Consequences

M. Barnett – November 2014

PDG Survey on Printed Products

At the 2012 Advisory Committee, we proposed a survey on the future of the Book and Booklet.
(The Diary was discontinued due to budget cuts).

An amazing 6172 readers responded, demonstrating the very high value our community places on PDG products.

(We sent out one email; no reminders).

PDG Survey on Book, Booklet and APP

Comparing surveys in 2000 and in 2014

THE QUESTION: Is having a copy of the full-sized book (booklet) essential to your work or study?

Yes, it is essential.
No, I do not need it.
Having the full-size book is useful, but I could live without it or live with a reduced book.

TOTAL Responses: 2450 in 2000 and 6172 in 2014

Reader Comments: 1226 in 2000 and 1491 in 2014

PDG Survey on Book, Booklet and APP

2000	2014	PREFERENCE FOR BOOK (in %)
9	32.1	Not needed
----	26.1	Satisfied with reduced book (not asked in 2000)
52	23.5	Like but could do without
39	18.4	I need the book

⇨ 82% would at least accept reduced book

BOOK	BOOKLET	PREFERENCE in 2014 (in %)
32.1 ⇔	18.5	Not needed
26.1	29.9	Satisfied with reduced book(let)
23.5	18.4	Like but could do without
18.4	33.2	I need the book(let)

⇨ 81% want some booklet

Future of Book and Booklet

Book:

a) Keep book as is (Where is funding?
How control size to avoid binding issues?)

b) Discontinue (Not the preference of 68%)

d) Reduce content & size. Split the book. Collab
Still some cost, but perhaps some funding agency will bear this much reduced cost.
(possibly print data listings on demand)

e) Print book every 4-6 years.

Future of Book and Booklet

Booklet:

a) Keep booklet as is (How control size to avoid binding issues?) Collab

b) Discontinue (Not the preference of 82%)

c) Reduce content & size (Which content? How satisfy readers?).

Booklet

Issue with Booklet is not cost.

It is the number of pages and eventual binding issues.

Summary Tables grow every edition

(and baryon resonances already removed).

Also, it would be nice to reduce pages, so ordinary binding could be used.

Booklet

PAGES in Booklet

9 Electroweak Model
7 CKM
5 CP Violation
7 Neutrino Mass…
5 Structure Functions
6 Big Bang Cosmology
15 Passage of Particles through Matter
19 Particle Detectors (accel & non-accel.)
14 Statistics
9 Kinematics

New Higgs and Dark Energy → 1 page each.

11. STATUS OF HIGGS BOSON PHYSICS

Written November 2013 by M. Carena (FNAL and the University of Chicago), C. Grojean (ICREA at IFAE, Universitat Autònoma de Barcelona), M. Kado (Laboratoire de l'Accélérateur Linéaire, LAL and CERN), and V. Sharma (UC San Diego).

I. Introduction

The observation by ATLAS [1] and CMS [2] of a new boson with a mass of approximately 125 GeV decaying into $\gamma\gamma$, WW and ZZ bosons and the subsequent studies of the properties of this particle is a milestone in the understanding of the mechanism that breaks electroweak symmetry and generates the masses of the known elementary particles (In the case of neutrinos, it is possible that the EWSB mechanism plays only a partial role in generating the observed neutrino masses, with additional contributions at a higher scale via the so called see-saw mechanism.), one of the most fundamental problems in particle physics.

In the Standard Model, the mechanism of electroweak symmetry breaking (EWSB) [3] provides a general framework to keep untouched the structure of the gauge interactions at high energy and still generate the observed masses of the W and Z gauge bosons by means of charged and neutral Goldstone bosons that manifest themselves as the longitudinal components of the gauge bosons. The discovery of ATLAS and CMS now strongly suggests that these three Goldstone bosons combine with an extra (elementary) scalar boson to form a weak doublet.

This picture matches very well with the Standard Model (SM) [4] which describes the electroweak interactions by a gauge field theory invariant under the $SU(2)_L \times U(1)_Y$ symmetry group. In the SM, the EWSB mechanism posits a self-interacting complex doublet of scalar fields, and the renormalizable interactions are arranged such that the neutral component of the scalar doublet acquires a vacuum expectation value (VEV) $v \approx 246$ GeV, which sets the scale of electroweak symmetry breaking.

Three massless Goldstone bosons are generated, which are absorbed to give masses to the W and Z gauge bosons. The remaining component of the complex doublet becomes the Higgs boson – a new fundamental scalar particle. The masses of all fermions are also a consequence of EWSB since the Higgs doublet is postulated to couple to the fermions through Yukawa interactions. However, the true structure behind the newly discovered boson, including the exact dynamics that triggers the Higgs VEV, and the corresponding ultraviolet completion is still unsolved.

Even if the discovered boson has weak couplings to all known SM degrees of freedom, it is not impossible that it is part of an extended symmetry structure or that it emerges from a light resonance of a strongly coupled sector. It needs to be established whether the Higgs boson is solitary or whether other states populate the EWSB sector.

Further discussion and references may be found in the full *Review of Particle Physics.*

26. DARK ENERGY

Written November 2013 by M. J. Mortonson (UCB, LBL), D. H. Weinberg (OSU), and M. White (UCB, LBL).

26.1. Repulsive Gravity and Cosmic Acceleration

In the late 1990s, supernova surveys by two independent teams provided direct evidence for accelerating cosmic expansion [8,9], establishing the cosmological constant model (with $\Omega_{\rm m} \approx 0.3$, $\Omega_\Lambda \approx 0.7$) as the preferred alternative to the $\Omega_{\rm m} = 1$ scenario. Shortly thereafter, CMB evidence for a spatially flat universe [10,11], and thus for $\Omega_{\rm tot} \approx 1$, cemented the case for cosmic acceleration by firmly eliminating the free-expansion alternative with $\Omega_{\rm m} \ll 1$ and $\Omega_\Lambda = 0$. Today, the accelerating universe is well established by multiple lines of independent evidence from a tight web of precise cosmological measurements.

As discussed in the Big Bang Cosmology article of this *Review* (Sec. 22), the scale factor $R(t)$ of a homogeneous and isotropic universe governed by GR grows at an accelerating rate if the pressure $p < -\frac{1}{3}\rho$. A cosmological constant has $\rho_\Lambda =$ const. and pressure $p_\Lambda = -\rho_\Lambda$ (see Eq. 22.10), so it will drive acceleration if it dominates the total energy density. However, acceleration could arise from a more general form of "dark energy" that has negative pressure, typically specified in terms of the equation-of-state-parameter $w = p/\rho$ ($= -1$ for a cosmological constant). Furthermore, the conclusion that acceleration requires a new energy component beyond matter and radiation relies on the assumption that GR is the correct description of gravity on cosmological scales.

26.2. Theories of Cosmic Acceleration

A cosmological constant is the mathematically simplest, and perhaps the physically simplest, theoretical explanation for the accelerating universe. The problem is explaining its unnaturally small magnitude, as discussed in Sec. 22.4.7 of this *Review*. An alternative (which still requires finding a way to make the cosmological constant zero or at least negligibly small) is that the accelerating cosmic expansion is driven by a new form of energy such as a scalar field [13] with potential $V(\phi)$. In the limit that $\frac{1}{2}\dot\phi^2 \ll |V(\phi)|$, the scalar field acts like a cosmological constant, with $p_\phi \approx -\rho_\phi$. In this scenario, today's cosmic acceleration is closely akin to the epoch of inflation, but with radically different energy and timescale.

More generally, the value of $w = p_\phi/\rho_\phi$ in scalar field models evolves with time in a way that depends on $V(\phi)$ and on the initial conditions $(\phi_i, \dot\phi_i)$; some forms of $V(\phi)$ have attractor solutions in which the late-time behavior is insensitive to initial values. Many forms of time evolution are possible, including ones where w is approximately constant and broad classes where w "freezes" towards or "thaws" away from $w = -1$, with the transition occurring when the field comes to dominate the total energy budget. If ρ_ϕ is even approximately constant, then it becomes dynamically insignificant at high redshift, because the matter density scales as $\rho_{\rm m} \propto (1+z)^3$.

Further discussion and references may be found in the full *Review of Particle Physics.*

PDG App(s)

Two thirds of respondents said app was either important or very important. (6172 respondents)

Comments from survey were emphatic:

Reduced printed products are dependent on producing replacement app(s).

PDG App(s)

- ***Summary Tables***

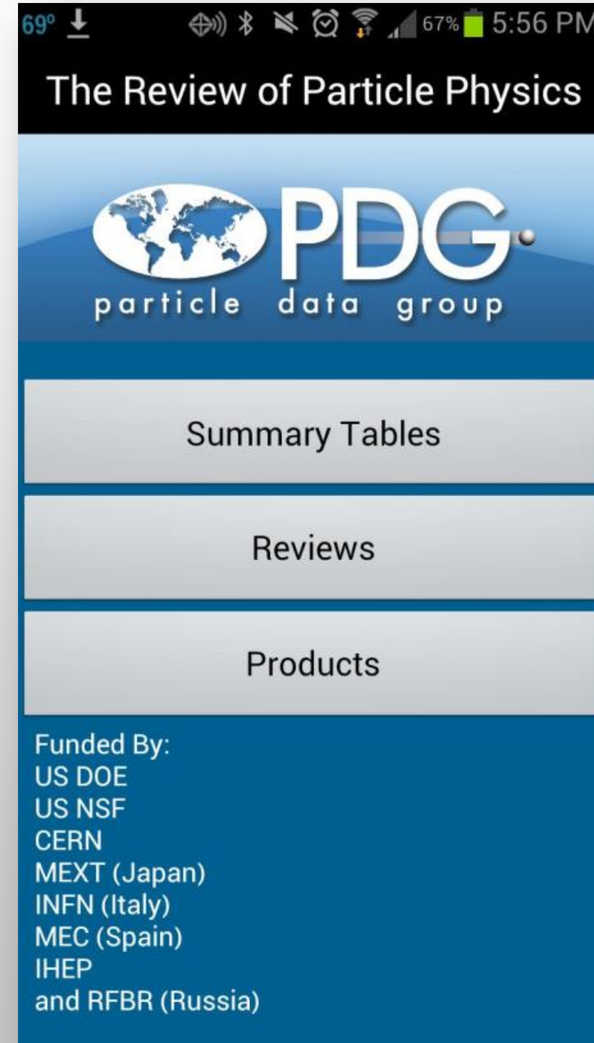
  Basically easy;
  just formatting for readability

- ***Review articles***

  Even easier except for formatting tables

- ***pdgLive***

  Not easy. Major programming to connect to database and to present on-the-fly.
  Proposal to DOE was tabled so far.



10. ELECTROWEAK MODEL AND CONSTRAINTS ON NEW PHYSICS

Revised Nov. 2013 by J. Erler (U. Mexico) and A. Freitas (Pittsburgh U.).

10.1. Introduction

The standard model of the electroweak interactions (SM) [1] is based on the gauge group SU(2) × U(1), with gauge bosons W_μ^i, $i = 1,2,3$, and B_μ for the SU(2) and U(1) factors, respectively, and the corresponding gauge coupling constants g and g'. The left-handed fermion fields of the i^{th} fermion family transform as doublets $\Psi_i = \binom{\nu_i}{\ell_i^-}$ and $\binom{u_i}{d_i'}$ under SU(2), where $d_i' \equiv \sum_j V_{ij}\, d_j$, and V is the Cabibbo-Kobayashi-Maskawa mixing matrix. [Constraints on V are discussed in the Section on "The CKM Quark-Mixing Matrix". The extension of the mixing formalism to leptons is discussed in the Section on "Neutrino Mass, Mixing, and Oscillations".] The right-handed fields are SU(2) singlets. In the minimal model there are three fermion families.

A complex scalar Higgs doublet, $\phi \equiv \binom{\phi^+}{\phi^0}$, is added to the model for mass generation through spontaneous symmetry breaking with potential given by,

$$V(\phi) = \mu^2 \phi^\dagger \phi + \frac{\lambda^2}{2}(\phi^\dagger \phi)^2. \tag{10.1}$$

For μ^2 negative, ϕ develops a vacuum expectation value, $v/\sqrt{2} = \mu/\lambda$, where $v \approx 246$ GeV, breaking part of the electroweak (EW) gauge symmetry, after which only one neutral Higgs scalar, H, remains in the physical particle spectrum. In non-minimal models there are additional charged and neutral scalar Higgs particles [3].

After symmetry breaking the Lagrangian for the fermions, ψ_i, is

$$\begin{aligned}\mathscr{L}_F = & \sum_i \overline{\psi}_i \left(i \not\partial - m_i - \frac{m_i H}{v} \right) \psi_i \\ & - \frac{g}{2\sqrt{2}} \sum_i \overline{\Psi}_i\, \gamma^\mu\, (1-\gamma^5)(T^+ W_\mu^+ + T^- W_\mu^-)\, \Psi_i \\ & - e \sum_i Q_i\, \overline{\psi}_i\, \gamma^\mu\, \psi_i\, A_\mu - \frac{g}{2\cos\theta_W} \sum_i \overline{\psi}_i\, \gamma^\mu (g_V^i - g_A^i \gamma^5)\, \psi_i\, Z_\mu\, .\end{aligned} \tag{10.2}$$

Here $\theta_W \equiv \tan^{-1}(g'/g)$ is the weak angle; $e = g \sin\theta_W$ is the positron electric charge; and $A \equiv B\cos\theta_W + W^3 \sin\theta_W$ is the photon field (γ). $W^\pm \equiv (W^1 \mp iW^2)/\sqrt{2}$ and $Z \equiv -B\sin\theta_W + W^3\cos\theta_W$ are the charged and neutral weak boson fields, respectively. The Yukawa coupling of H to ψ_i in the first term in $\mathscr{L}_F$, which is flavor diagonal in the minimal model, is $g m_i / 2M_W$. The boson masses in the EW sector are given (at tree level, *i.e.*, to lowest order in perturbation theory) by,

$$M_H = \lambda\, v, \tag{10.3a}$$

$$M_W = \frac{1}{2} g\, v = \frac{e\, v}{2\sin\theta_W}, \tag{10.3b}$$

$$M_Z = \frac{1}{2}\sqrt{g^2 + g'^2}\, v = \frac{e\, v}{2\sin\theta_W \cos\theta_W} = \frac{M_W}{\cos\theta_W}, \tag{10.3c}$$

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