The XXX-th International Workshop on High Energy Physics,
IHEP, Protvino, Russia , June 23-27, 2014

Half a Century with QUARKS!

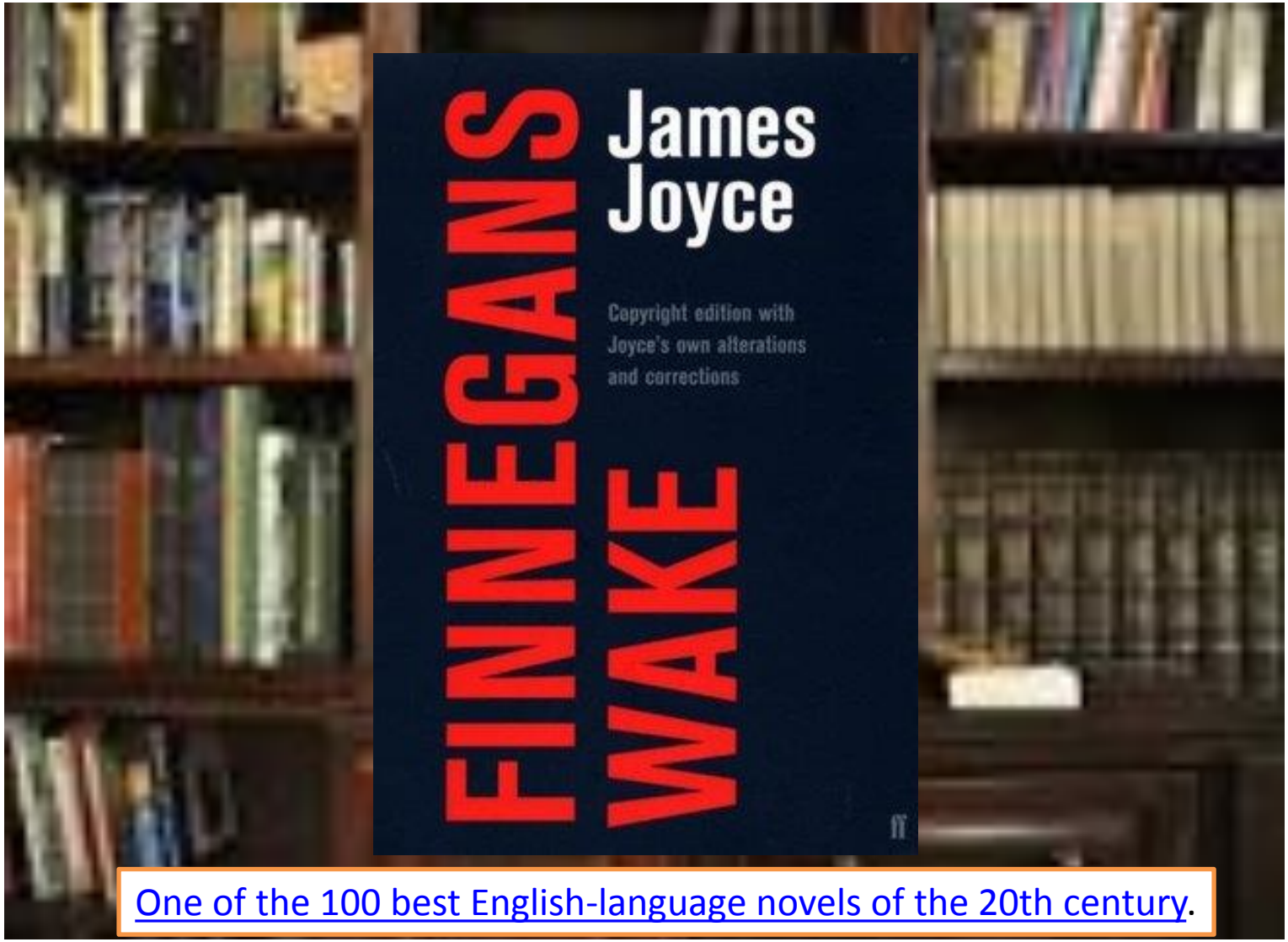
Vladimir A. Petrov,
Institute for High Energy Physics, Protvino

BRIEF HISTORY

- (1963)1964 - the rise and propagation of the idea
- 1965 – colouring
- 1967-1973 – experimental “proof” that quarks exist
- 1973 – formulation of the strong interaction theory as $SU_{flavour}(3) \times SU_{colour}(3)$, QCD
- 1974 – first heavy quark
- 1977 – second heavy quark
- 1995 – third heavy quark (long and torturous search)
- QCD = $SU_{flavour}(6) \times SU_{colour}(3)$
- 2014 – still with 6 coloured quarks

Enjoy coloured quarks!

Finnegans Wake.
By James Joyce. 1939



One of the 100 best English-language novels of the 20th century.

Finnegans Wake
(excerpt from Book II)

Finnegan's Wake
Tim Finnegan lived on Walker Street
And a gentle, Irishman, mighty odd;

The fall (bababadalgharaghtakamminarronnkonnbronntonnerronntuonnthunntrovarrhounawnskawntoohoohoordenenthurnuk!) of a once wallstrait oldparr is retaled early in bed and later on life down through all christian minstrelsy. The great fall of the offwall entailed at such short notice the pftjschute of Finnegan, erse solid man, that the humptyhillhead of humself prumptly sends an unquiring one well to the west in quest of his tumptytumtoes: and their upturnpikepointandplace is at the knock out in the park where oranges have been laid to rust upon the green since devlinsfirst loved livvy.

The Picture and the Letter: Male and Female Creativity in James Joyce's *Finnegans Wake*

William L. Miller
1996
Australian Defence Force Academy
University of New South Wales

This thesis is submitted in total fulfilment of the requirements for the degree of
Doctor of Philosophy
to the Australian Defence ForceAcademy,
University of New South Wales

Finnegans Wake. Episode 12

“ … So sailed the stout ship Nansy Hans. From Liff away.For Nattenlaender. As who has come returns. Farvel, farerne! Good-bark, goodbye!

Now follow we out by Starloe!

— **Three quarks for Muster Mark!**

Sure he hasn’t got much of a bark

And sure any he has it’s all beside the mark…”

Three quarks for Muster Mark!

Quark = Curd? Quark= Nonsense? ...**Squawk** :a loud, harsh or discordant noise made by a bird or a person.

Muster ≠ Mister! Muster ≠ Master!

Muster,...: a number of things or persons assembled on a particular occasion; a collection, as a muster of peacocks—*Johnson,* 1755

Three quarks...

James Finnegans Wake Joyce

New York 1939:

Exercise in multiplication :

$3 \times 3 = 9$

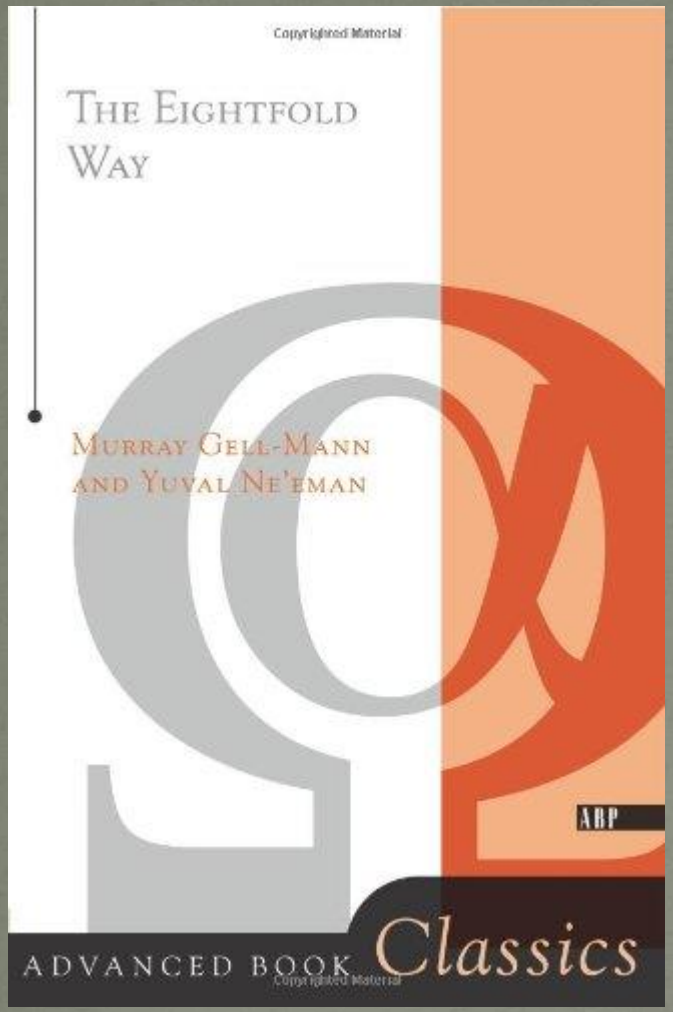
$3 \times 3 \times 3 = 27$

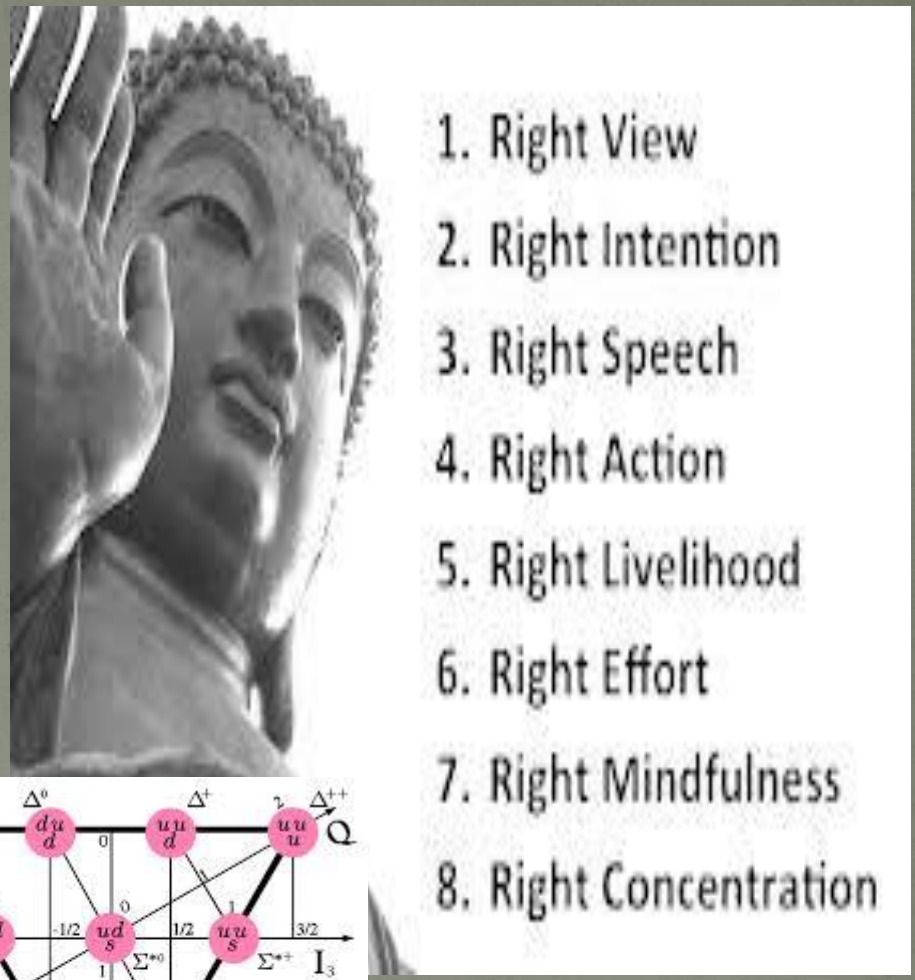
Caltech, Pasadena, California 1964

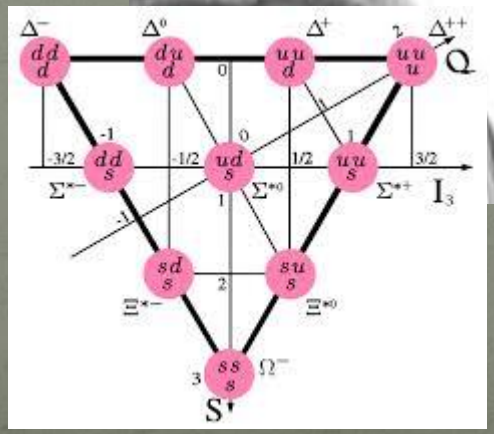
$$3 \otimes \overline{3} = 8 \oplus 1$$

$$3 \otimes 3 \otimes 3 = 10 \oplus 8 \oplus 8 \oplus 1$$

Eightfold Way to Unitary Symmetry







1837 citations according to SPIRES

Volume 8, number 3 PHYSICS LETTERS 1 February

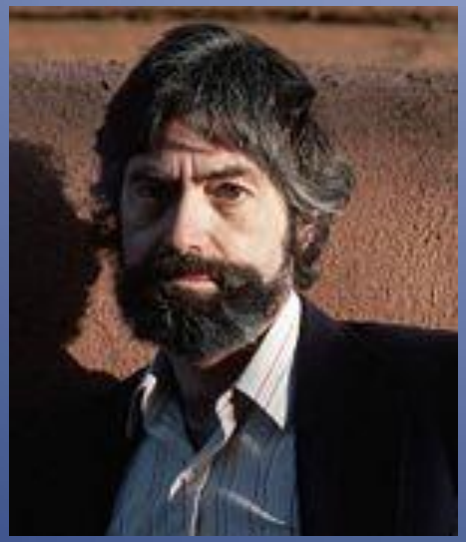
A SCHEMATIC MODEL OF BARYONS AND MESONS *

M. GELL-MANN
California Institute of Technology, Pasadena, California

Received 4 January 1964

These ideas were developed during a visit to Columbia University in March 1963; the author would like to thank Professor Robert Serber for stimulating them.

New players



- **Zweig, George**

Two topics in elementary particle physics:
The reaction $\gamma n \rightarrow \pi N$ at high energies.
K leptonic decay and partially conserved currents.
Dissertation (Ph.D.), California Institute of Technology.
Item Type:
Thesis (Dissertation (Ph.D.))
Degree Grantor:
California Institute of Technology
Division:
Physics, Mathematics and Astronomy
Major Option:
Physics
Thesis Availability:
Public (worldwide access)
Research Advisor(s):
Feynman, Richard Phillips (advisor)
Gell-Mann, Murray (advisor)
Tollestrup, Alvin V. (advisor)
Thesis Committee:
Unknown, Unknown

"Murray says your okay, you must be okay"

Defense Date:

- **1 January 1964**

VOLUME 12, NUMBER 6 PHYSICAL REVIEW LETTERS 10 FEBRUARY 1964

NONLEPTONIC WEAK DECAYS AND THE EIGHTFOLD WAY*

Murray Gell-Mann
California Institute of Technology, Pasadena, California
(Received 2 January 1964)

172 citations according to SPIRES

AN SU_3 MODEL FOR STRONG INTERACTION SYMMETRY AND ITS BREAKING

G. Zweig *)
CERN - Geneva

Only certain SU_3 representations, quantum numbers, and decays are allowed,

constraints not found in the Eightfold Way.

A B S T R A C T

Both mesons and baryons are constructed from a set of three fundamental particles called aces. The aces break up into an isospin doublet and singlet. Each ace carries baryon number $\frac{1}{3}$ and is consequently fractionally charged. SU_3 (but not the Eightfold Way) is adopted as a higher symmetry for the strong interactions. The breaking of this symmetry is assumed to be universal, being due to mass differences among the aces. Extensive space-time and group theoretic structure is then predicted for both mesons and baryons, in agreement with existing experimental information. An experimental search for the aces is suggested.

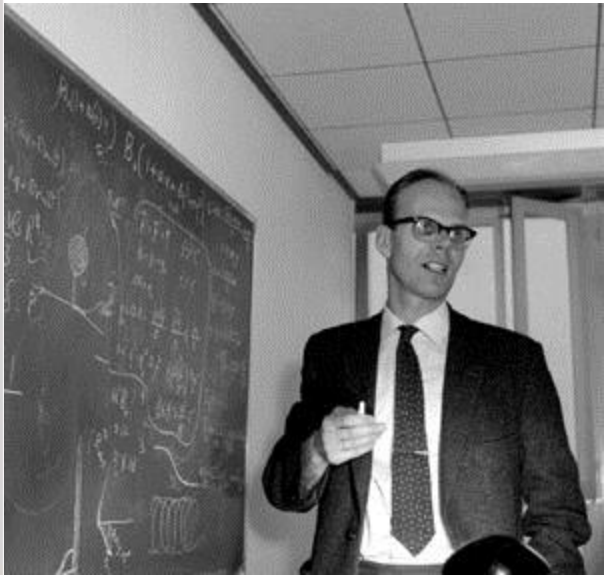
I ….kept exploring this idea (of aces-V.P.) in the spring of 1963.

*) This work was supported by the Air Force Office of Scientific Research and the National Academy of Sciences - National Research Council, U.S.A.

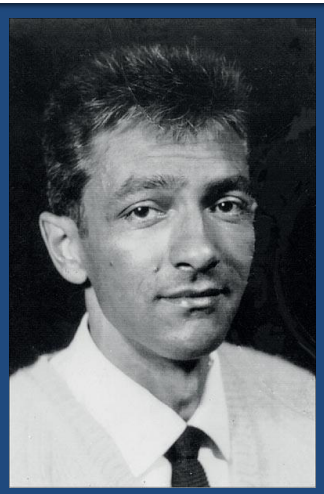
8182/TH.401
17 January 1964

17 January 1964

Leon Van Hove



Who Was the First?!



André Petermann
(1922-2011)

8.B

Nuclear Physics **63** (1965) 349–352; © *North-Holland Publishing Co., Amsterdam*

Absent in SPIRES

PROPRIÉTÉS [illegible]TRANGETÉ ET UNE FORMULE DE MASSE POUR LES MÉSONS VECTORIELS

A. PETERMANN
CERN, Genéve 23

Reçu le 30 décembre 1963

Abstract: A mass-formula for vector mesons is proposed, and the role of strangeness in mass-formulae discussed.

Il est à noter que si l'interaction électromagnétique était présente, nous serions dans l'obligation de considérer 3 spineurs s, ŝ et s′, c'est-à-dire l'isospineur (ŝ, s) avec $S = 0$ et l'isoscalaire s′ avec $|S| = 1$.

On voit alors que les soi-disant particules élémentaires telles que N, Ξ, Σ etc., sont des objets compliqués, en réalité des états fortement liés de particles spinorielles élémentaires.

… les particules s doivent alors avoir des valeurs non entières de la charge.

$$Q = I_z + \frac{1}{2}(B + S) = I_z + \frac{1}{2}Y,$$

First Searches for Quarks

A search

for stable quarks of charge $-\frac{1}{3}$ or $+\frac{1}{3}$ and/or stable di-quarks of charge $-\frac{2}{3}$ or $+\frac{1}{3}$ or $+\frac{4}{3}$ at the highest energy accelerators would help to reassure us of the non-existence of real quarks.

Experiment SERP-E-002
1968-Februray 1969

Search for Quarks with Fractional Charges

The Magnificent Triplet