

A SINGULARLY UNFEMININE PROFESSION★

WHY?

When are you going to write your book?

Bettina Segré

Why don't you tell us about your own experiences?

Why didn't you give up?

UCB women graduate students

Survival mechanism

★ Remark by neighbors' son



~ 20 yrs. of (mostly) positive feedback

- home
- high school
- I'X & Brookhaven

Friend: wish I had had a home like that
math & physics teachers
Dorothy Montgomery

Force	range	strength	particles
strong	10^{-13}cm	1	$p, n, \Lambda, \pi, K \dots$
electromagnetic	infinite	10^{-3}	above + e, μ
weak	10^{-16}cm	10^{-10}	all above + ν
gravitational	infinite	10^{-38}	all

Bob Adair

- Columbia (male) classmates friends from BNL





Columbia \implies Paris

Friendly advice: You won't get into Orsay theory group; get into a lab

Turned down by

- l'X expt: You came to France to get married not to do physics; you did things backwards – correct way is undergraduate school in France and graduate work in US
- l'X theory: Husband already “bought the merchandise” so you must be OK but I already have a student
- Saclay theory: You couldn't get a recommendation from Lederman? (MKG: yes)

Response: go do optical pumping

- Saclay expt: Pregnant – radiation hazards

All: only take (all male) l'X & École Normale graduates

Paris \implies Columbia \implies Orsay exams

Accepted by Orsay theory group

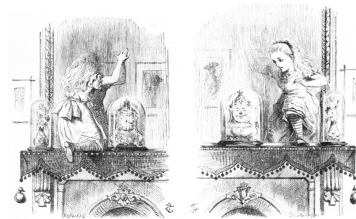
Paris \implies CERN: 1962-72

Babies, K-decays, 2 theses

Commuting to Paris to tutor l'X students

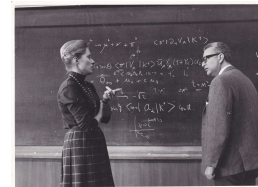
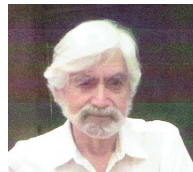


1964: discovery of CP



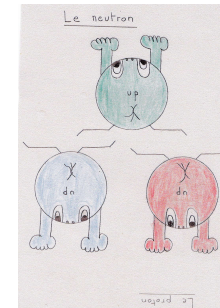
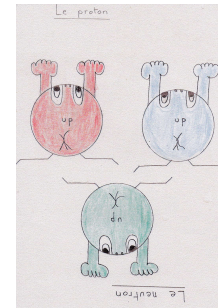
+ Alice \leftrightarrow anti-Alice

& quarks introduced



Flavor symmetry: up ↔ down, proton ↔ neutron

Force	matter	mediator
strong	uuu, ddd, sss	?
electromagnetic	above + e, μ	γ
weak	all above + ν_e, ν_μ	?
gravitational	all	h



New quantum number: color (Pauli principle) $\Omega^- = (s \uparrow s \uparrow s \uparrow)$

Chiral symmetry: left-spinning up ↔ left-spinning down only

or only right-spinning up ↔ down: (almost) massless quarks



Decay $K \rightarrow \pi \mu \nu$: $m_u \ll m_s \ll m_p?$ Yes! (FNAL ICHEP 1972)

Basement (5 people & a dog) up a floor at a time (2 people)

to 4th floor (alone) as a visiting scientist

would have to leave after 6yr staff appt. ?!



1973–74: Fermilab

charm & gauge theories (up ↔ down here but not on moon)

alternating neutral currents ($\Delta Q_{\text{quarks}} = \Delta Q_{\text{leptons}} = 0$)

liberation!

$Q = \text{electric charge}$



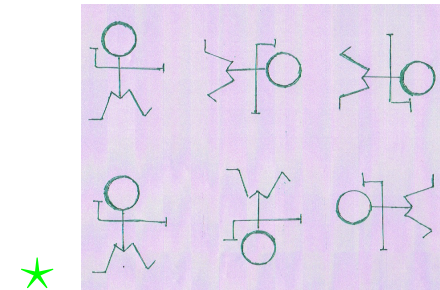
1970: first proof that non-Abelian★ gauge theories make sense★

1972: GWS model revived ⇒ neutral currents

new quark charm solves two problems (GIM & BIM★)

1) decay rate for $K \rightarrow 2\mu$ NOT a billion times too large!

2) ★only if $\sum Q_{\text{quarks}} + \sum Q_{\text{leptons}} = 0$ for GWS



K decays again! Suppression of $K \rightarrow 2\mu$ (& other processes) depends on charm quark mass

Analysis of these processes in GWS with charm á la GIM:

\Rightarrow charm mass ≈ 1.5 times proton mass

Enter QCD: 1969 SLAC (electron) 1971 CERN (neutrino)

scattering by nuclei: \Rightarrow “scaling” \Rightarrow partons

\Rightarrow reality of quarks; interactions weak at high energy

+ (approximate) chiral symmetry of strong interactions

\Rightarrow non-Abelian gauge theory: “Quantum chromodynamics” (charge = color)

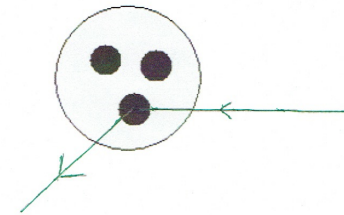
applied to weak decays of strange particles

July, 1974 London ICHEP: Jean Iliopoulos bets a case of wine:

charm within a year

August 1974 “Search for Charm”

MKG & Ben Lee



MKG & BW

sea change

G, L & Jon Rosner

Back to CERN

1974 November revolution: SLAC (electron-positron) BNL (quark-antiquark)

annihilation into J/ψ

(BNL: $p + p \rightarrow J/\psi + \text{stuff}$)

new spin-one state with twice predicted charm mass: charm-anticharm?

MK & John Ellis vs J.C. Ward (“LGR”) charm vs color

1975 more charm-anticharm states

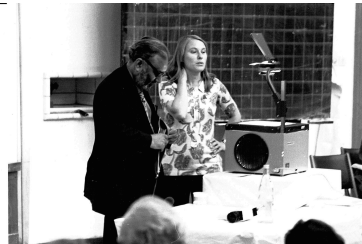
Serge Rudaz @ Cargèse

Long wait for “open” charm (many naysayers) \longrightarrow June 1976

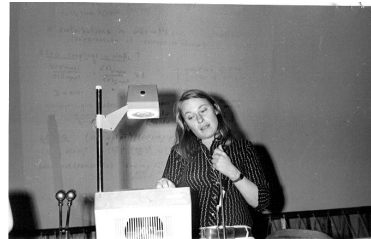
“Charm has been found”

phone call from Ben

neutrino conferences



Aachen 1976



Tblisi 1977

BWL 1935–1977

Search for “open” charm confused by • GLR factor $\sqrt{2}$ mistake!

• new lepton tau (τ): tau mass \approx D mass \approx twice proton mass

$D = c\bar{u}$ or $c\bar{d}$ bound state

τ requires two new quarks: top & bottom (t, b)

$$\sum Q_{\text{quarks}} + \sum Q_{\text{leptons}} = 0$$

\sim 1976 – present

Force	matter	mediator	
strong	$uuu, ddd, sss, ccc, bbb, ttt$	$ggggggggg$	
electroweak	above + $e, \mu, \tau, \nu_e, \nu_\mu, \nu_\tau$	γ, W^\pm, Z	H
gravitational	all	h	

1977: b

1983: W, Z

July 4, 2012: H

1980: g (gluon jets)

1995: t

February 11, 2016: $h?$ (waves)



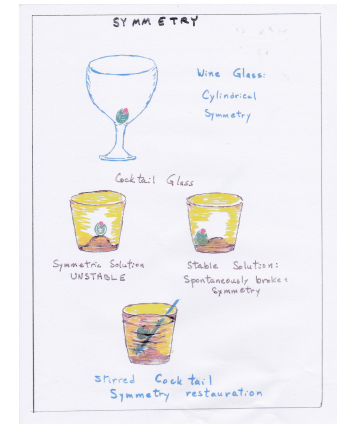
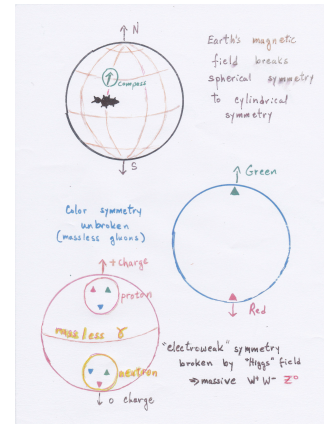
1975 – 1981



Spontaneous symmetry breaking

Higgs particle properties

MK, JE & Dimitri Nanopolous



Gluon jets

MK, JE & Graham Ross

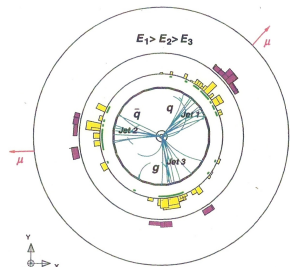
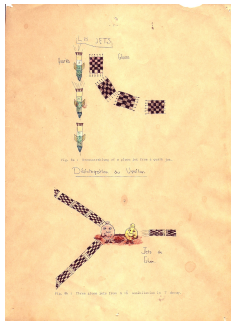


FIG. 1. A three jet event from the OPAL experiment at LEP. The curving tracks from the three jets may be associated with the central detector in the corresponding coloration, where blue is chargeless or chargeless as the middle jet tracks, where the tracks are symmetrical in energy. The 2 and 3 colour masses are indicated, suggesting that there are backscattered jets (likely from a scattered jet), but it is hard to identify in a calculated plane.

jets as seen by Bruno Gaillard & OPAL @ LEP

Bottom quarks and Grand Unified Theories



1861: electricity + magnetism \longrightarrow electromagnetism

1972: weak + electromagnet interactions \longrightarrow electroweak theory (GWS)

1974: electroweak + strong interaction $\xrightarrow{?}$ Grand Unified Theory (Georgi & Glashow)

1977 GG GUT $\Rightarrow m_b/m_\tau = 2$ to 5 (not in abstract) (E,G & Mike Chanowitz)

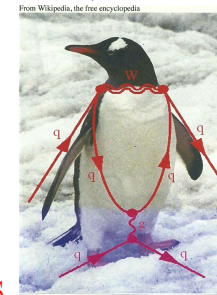
Lederman et al. find $\Upsilon = (b\bar{b})$, $m_\Upsilon/2m_\tau \approx 2.7 \approx m_b/m_\tau$

JE fixes abstract by hand: “to” \rightarrow “60” $\Rightarrow m_b > 5$ trillion times proton mass

GUT & bottom physics (EGN + Rudaz, Buras & B. Gaillard)

proton decay & penguins

Shifman, Vainstein, Zakharov



UNREST

Summers at Fermilab (escape)

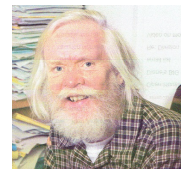
Problems placing students in French labs → Ancey theory group 1979

1979: plenary speaker at European ICHIP, Geneva (QCD)

Lepton-Photon conference, Fermilab (weak interactions)

A woman, a hippy and a schoolboy!

Japanese elder statesman



BUT NOT 1978 Tokyo ICHEP: no one to pay my travel

CERN later agreed to pay (cheapest possible) travel to Ben Lee memorial conference in Seoul just before Tokyo; after complicated arrangements:

“A CERN delegate spot for Tokyo has opened up; would you like to go?” Last straw?

1978: offer from Fermilab

1978–81: Commuting to Annecy & learning SUSY, SUGRA

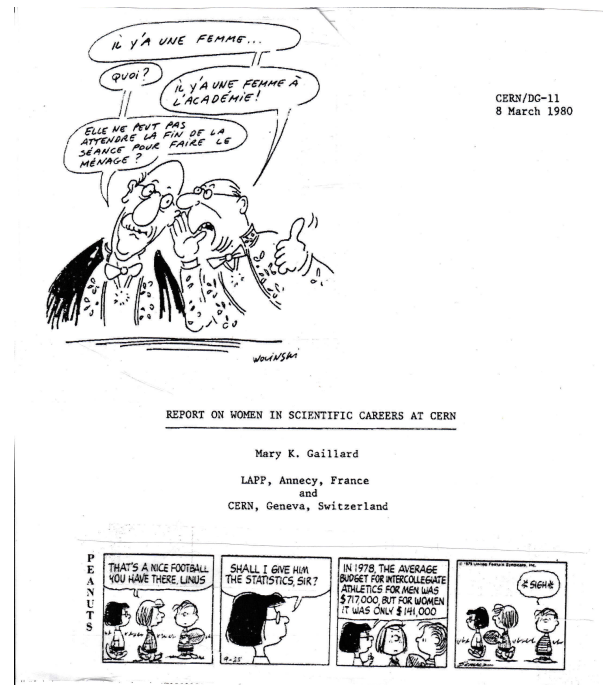
Demanded compensation for daughter's private school, CERN SPS

Harvard Loeb lecturer & UCB Chancellor's lectures ⇒ offer from Berkeley

CERN meeting on women ⇒ CERN report

CERN Fellowship for Anne Davis not Belen Gavela

STILL no theory senior staff/all day nursery school (Belen's PT review)



There's a woman ... What? There's a woman at the Academy!

Can't she wait until the end of the session to clean the room?



Wolinski, died Jan. 7, 2015, at Charlie Hebdo

Positions open for $\left\{ \begin{array}{l} \text{CNRS}\star \text{ theory director}\star \quad \checkmark \\ \text{CERN theory sr. staff} \quad \times \end{array} \right\} \left\{ \begin{array}{l} \text{letters solicited} \\ \text{contrary to custom} \end{array} \right.$

\star (French) National Center for Scientific Research $\star \sim$ Full Professor



Les Houches 1981 14% women!

38/51 (5/7 women) students still active in HEP

Sally Dawson, Belen Gavela, Graciela Gelmini

Anna Hasenfratz, Patricia McBride

Decision: FNAL vs UCB

Left for Berkeley mid Sept. 1981 with 2 children (oldest already at UW)

Bruno Z and dog followed one month later

Standard Model complete as of July 4, 2014

End of story(ies)?

PERSONAL STORY



Lessons for today? “Why didn’t you give up?” (many did)

1962 beginning research: “men do theory; women do experiment” (idle comment)

..... secretary effect

1977 invited talk at DESY “my wife did the right thing” (lab director)

“Imposter syndrome”? (Everybody else is better)

Betty Friedan

PROGRESS!?

1960: 2 women/~60 in Columbia class

2016: ~ 16% women grad physics students

1981: 1 women/~60 on UCB physics faculty

2016: 8/55 active women UCB physics faculty

1991 3/>100 women in NAS physics section

2016: 8/197 women in NAS physics

1983–2009(!) only woman on DOE/NSF/APS

~ 2000–present: many younger women active

... committees

in governance

BUT STILL ...

Reports of put-downs, misogynist comments and (very recently) worse



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PHYSICS STORY



We don't understand

- origin of (tiny) neutrino masses
- nature of dark matter or dark energy!
- how to reconcile quantum mechanics with gravity (superstring theory?)
- hierarchy of fermion masses: $m_{\text{electron}} \approx m_{\text{proton}}/1800 \dots\dots\dots m_{\text{top}} \approx 180 \times m_{\text{proton}}$
- hierarchy of energy scales: value v of Higgs field (10)thousand trillion times smaller than scale of gauge theory unification (strong gravity)★

★ Rationale for SSC ☹️ & LHC: more than SM Higgs?

Ongoing: cosmological observation ✓

“intensity frontier” ✓

energy frontier? technology & politics!

