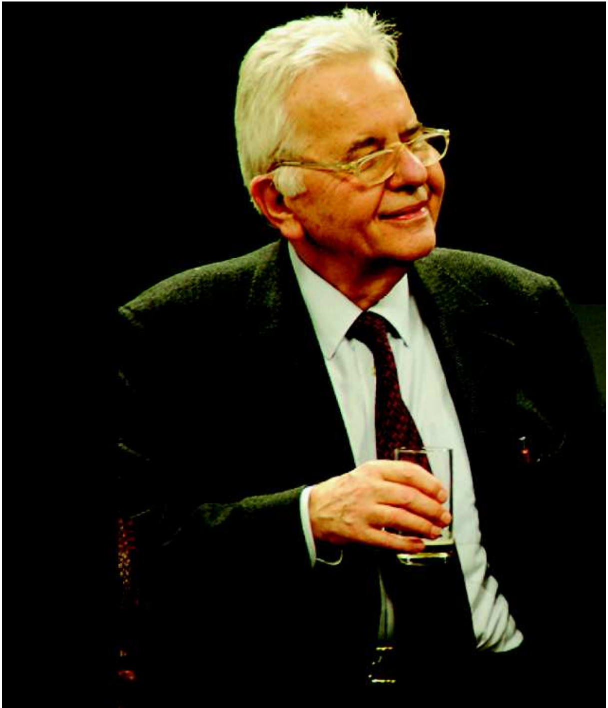

SYMMETRIES AND THE WEAK INTERACTIONS

Cabibbo Memorial Symposium

Rome, Nov. 12 2010

A talk about History

by a non-historian

Three parts:

1) The space-time symmetries

2) The global internal symmetries

3) The gauge symmetries

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- (v) J. Schwinger, S. Bludman, S.L. Glashow
- (vi) S.L. Glashow and M. Gell-Mann, Ann. of Phys. **15**, 437 (1961)

2) **Global Internal Symmetries:**

$$\mathcal{L}_W = \frac{G}{\sqrt{2}} J^\mu(x) J_\mu^\dagger(x)$$

We consider this theory to all orders in the strong interactions but to lowest order in the weak (and e.m.) interactions.

$\Rightarrow$ The hadronic part of $J^\mu(x)$ is an operator acting in the space of states of the **strong interactions.**

The object of the game is to identify this operator.

The hadronic part of $J^{\mu}(x)$ has a strangeness conserving piece $\Delta S = 0$ and a strangeness changing one which was soon found, experimentally, that it satisfied $\Delta S < 2$.

I will not tell the story of the $\Delta S = 0$ piece.

Gershtein+Zel'dovich, Feynman+Gell-Mann, Gell-Mann+Lévy, Goldberger+Treiman, Nambu, Gell-Mann, Adler, Weisberger, ...

The $\Delta S \neq 0$ piece:

$$SU(2) \rightarrow \mathcal{G}$$

(i) B. d'Espagnat and J. Prentki, *Nucl. Phys.* **6**, *596 (1958)*.

Hierarchy of Interactions:
-The very strong interactions, invariant under $\mathcal{G}$.
-The medium strong interactions, break $\mathcal{G}$ but leave isospin and strangeness invariant.
-The e.m. interactions, conserve only electric charge and strangeness.
-The weak interactions, invariant under a different $SU(2)$ of $\mathcal{G}$.

(ii) M. Gell-Mann and M. Lévy, *Nuov. Cim.* **16**, *705 (1958)*.

Note added in proof. Should this discrepancy be real ($g_V \neq 1$) it would probably indicate a total or partial failure of the conserved vector current idea. It might also mean, however, that the current is conserved but with $g_V < 1$. Such a situation is consistent with universality if we consider the vector current for $\Delta S = 0$ and $\Delta S = 1$ together to be something like:

$$GV_\alpha + GV_\alpha^{(\Delta S=1)} = G_\mu \bar{p} \gamma_\alpha (n + \epsilon \Lambda)(1 + \epsilon^2)^{-1/2} + \ldots$$

and likewise for the axial vector current. If $(1 + \epsilon^2)^{-1/2}$ =0.97, then ϵ^2=.06, which is of the right order of magnitude for explaining the low rate of β decay of the Λ particle. **There is, of course, a renormalization factor for that decay, so we cannot be sure that the low rate really fits in with such a picture.**

(iii) S.L. Glashow and M. Gell-Mann, *Ann. of Phys.* **15**, *437 (1961)*.

In the last part of this paper they consider an $SU(2)$ algebra of the weak currents, but only in view of constructing a Yang-Mills theory. They notice the theoretical difficulties (non-conservation of the currents) and the phenomenological ones (strangeness changing neutral currents). No attempt to go further. Subsequently, neither of them refers to this paper for the form of the current.

(iv) B. d'Espagnat and J. Prentki, *Nuov. Cim.*, **24**, *497 (1962)*.

The Unitary Symmetry and a Connection between the $|\Delta S| \neq 1/2$ and $|\Delta I| = 2$ Rules.

They consider non-leptonic decays (because of a wrong exp??), but they write: ..... a) It is not at all proved that the strong interactions really have anything to do with SU_3, b) even if they have, **the statement that the same is true, in some way, for weak interactions is just a guess**...

(v) N. Cabibbo, *Phys. Rev. Lett.*, **10**, *531 (1963)*.

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- Discussion on citations

There are few articles in the scientific literature in which one does not feel the need to change a single word and Cabibbo's is definitely one of them. With this work he established himself as one of the leading theorists in the domain of weak interactions.