Past Experiments Exclude Light Majorana Neutrinos

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http://kirkmcd.princeton.edu/examples/majorana.pdf

http://kirkmcd.princeton.edu/examples/majorana_170307.pptx

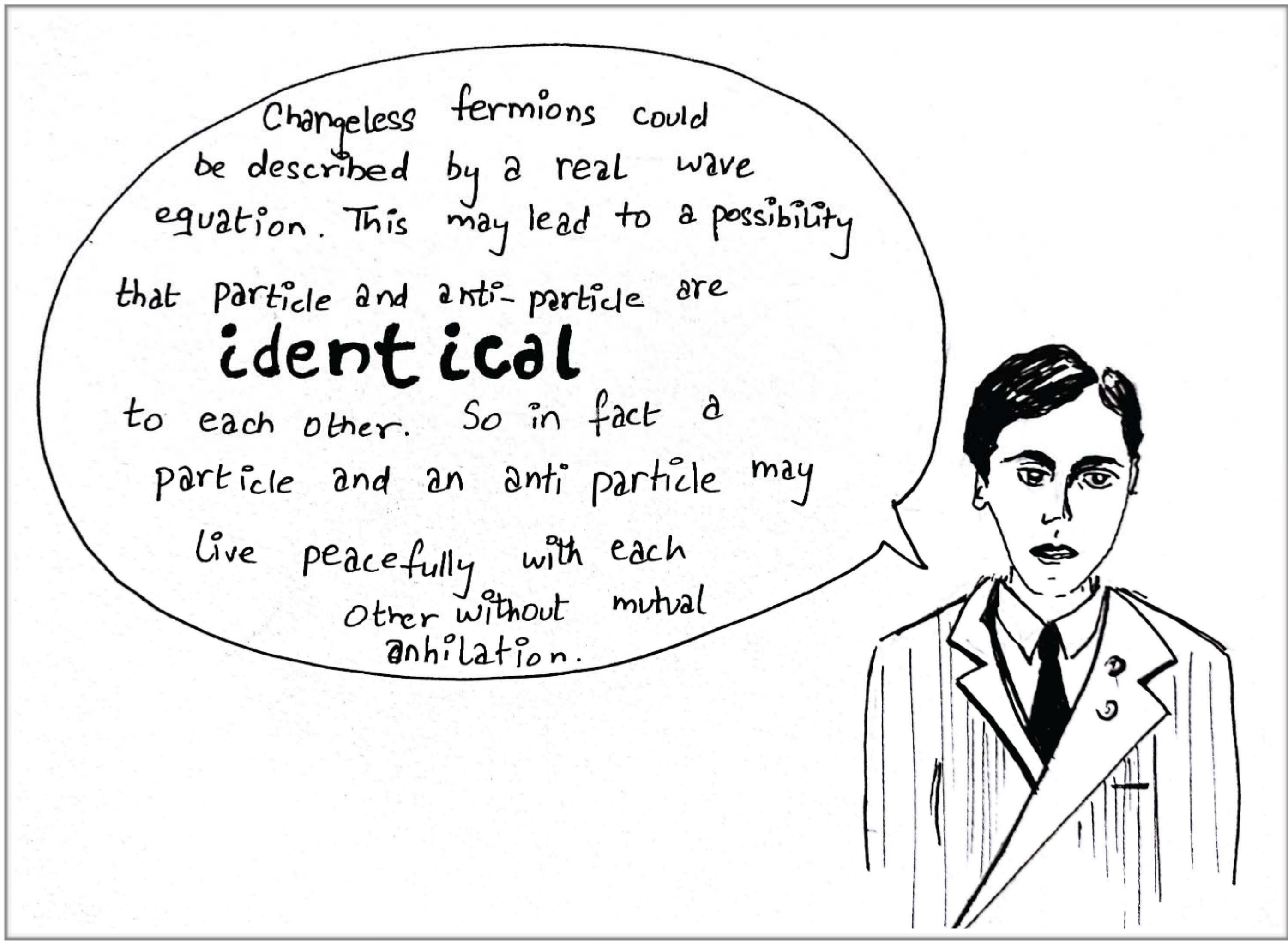
http://kirkmcd.princeton.edu/examples/majorana_poster_lp17_v9.pptx

http://kirkmcd.princeton.edu/~mcdonald/examples/majorana_170811.pptx

In 1937, Majorana gave a "symmetric theory of electrons and positrons," in which there might be no distinction between spin-1/2 particles and antiparticles.

E. Majorana,

*Nuovo Cimento **14**, 171 (1937)*



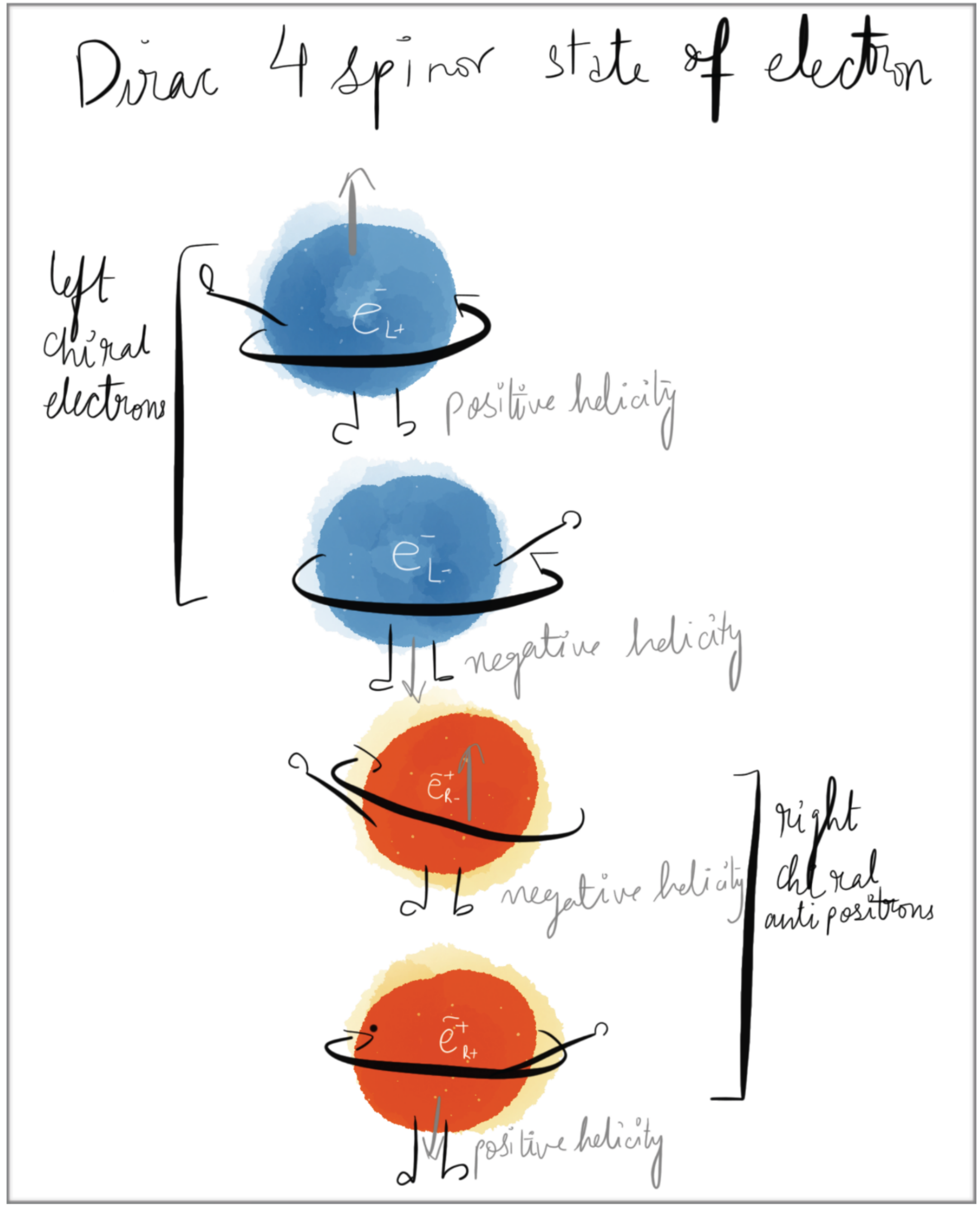
Majorana noted that this theory doesn't apply to charged particles like electrons and positrons, but might apply to neutrinos.

However, in a gauge theory, interacting fermions and antifermions have different quantum numbers, and cannot form Majorana states.

Interacting neutrinos carry nonzero weak isospin and weak hypercharge in the Glashow-Weinberg-Salam model, and antineutrinos carry the opposite "charges".

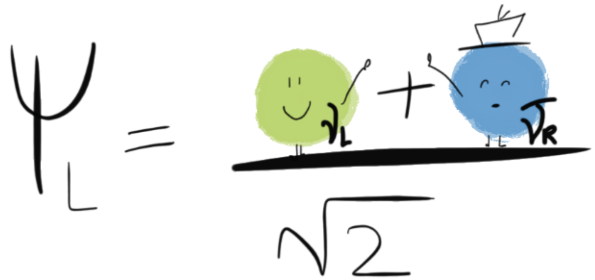
Hence, these neutrinos cannot form Majorana states (unless one only considers electric-charge conjugation as defining particles and antiparticles).

A typical Dirac spinor state describing a physical electron.



The literature appears to consider two different possible forms for the hypothetical Majorana neutrino states (in terms of 4-spinors), .

$$\psi_L = \frac{\nu_L + \bar{\nu}_R}{\sqrt{2}}$$



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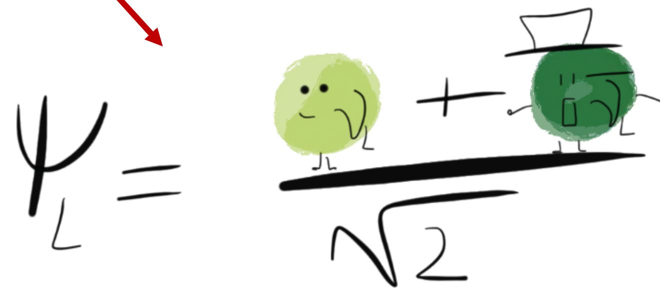

The first form would imply, for example, that the decays $\pi^+ \to \mu_R^+ \nu_L$, $\pi^+ \to \mu_R^+ \bar{\nu}_R$, could occur with roughly equal rates, and hence conventional neutrino beams would be 50:50 neutrino and antineutrino, contrary to experiment

The second form would imply that the electroweak coupling constant g would have to be $\sqrt[4]{2}$ larger to keep the observed rates of single-neutrino interactions with an internal W the same. But the, to keep the Weinberg angle the same, the coupling constant g′ would also have to be multiplied by $\sqrt[4]{2}$, in disagreement with the observed width of the Z^0 by 200 σ.

Conventional wisdom is that the only experiment which could determine whether of not neutrinos are Majorana states is neutrinoless double-beta decay. However, this view was developed before the W and Z gauge bosons were discovered, and it has been overlooked that experiments on the decay of the W and Z strongly exclude that the known light neutrinos are Majorana states (while permitting Majorana mass terms, neutrinoless double beta decay, and the see-saw mechanism).

Thank you.