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

\[ \psi_L = \frac{\nu_L + \bar{\nu}_R}{\sqrt{2}} \quad \text{and} \quad \psi_L = \frac{\nu_L + \bar{\nu}_L}{\sqrt{2}} \]

The first form would imply, for example, that the decays \( \pi^+ \rightarrow \mu^+ \nu_L \), \( \pi^+ \rightarrow \mu^+ \bar{\nu}_R \), 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 \( \frac{4}{\sqrt{2}} \) larger to keep the observed rates of single-neutrino interactions with an internal \( W \) the same. But, to keep the Weinberg angle the same, the coupling constant \( g' \) would also have to be multiplied by \( \frac{4}{\sqrt{2}} \), in disagreement with the observed width of the \( Z^0 \) by 200 \( \sigma \).

Conventional wisdom is that the only experiment which could determine whether or 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.
Thank you.