NEUTRAL PION DECAYS INTO 2 PHOTONS BUT NOT 3

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Reference: Tom Lancaster and Stephen J. Blundell, *Quantum Field Theory for the Gifted Amateur*, (Oxford University Press, 2014), Problem 15.1.

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Under charge conjugation, the electromagnetic field A^μ transforms into its negative, so that $(A_\mu)_C = -A_\mu$. As a result, the photon is an eigenstate of charge conjugation with eigenvalue -1. Since charge is conserved in a particle decay, if the initial particle is an eigenstate of C, the final state, which can consist of more than one particle, must also be an eigenstate of C with the same eigenvalue. The neutral pion π^0 has eigenvalue +1, so it is possible for it to decay into two photons, each with eigenvalue -1, since $+1 = (-1)\times(-1)$. However, it cannot decay into 3 pions since the decay

$$\pi^0 \rightarrow \gamma + \gamma + \gamma \tag{1}$$

has a final state of eigenvalue $-1 = (-1)\times(-1)\times(-1)$.