Photons, neutrinos, and optical activity
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abstract
We compute the one-loop helicity amplitudes for low-energy $\nu \gamma \rightarrow \nu \gamma$ scattering and its crossed channels in the standard model with massless neutrinos. In the center of mass, with $\sqrt{s} = 2\omega \ll 2m_e$, the cross sections for these $2 \rightarrow 2$ channels grow roughly as $\omega^6$. The scattered photons in the elastic channel are circularly polarized and the net value of the polarization is non-zero. We also present a discussion of the optical activity of a sea of neutrinos and estimate the values of its index of refraction and rotary power.
$\nu\gamma \rightarrow \nu\gamma$

$\sqrt{s} = m_e$

$d\sigma/dz \text{ (pb)}$

$z = \cos\theta$
$\nu\gamma \rightarrow \nu\gamma$

Graph showing the relationship between $\sigma (10^{-30} \text{pb})$ and $\sqrt{s}/m_e$.
\( \gamma \gamma \rightarrow \nu \bar{\nu} \)

\[ \sqrt{s} = m_e \]

\[ d\sigma/dz \ (\text{pb}) \]

\[ z = \cos \theta \]
\( \gamma \gamma \rightarrow \nu \bar{\nu} \)
$P(z)$

$\sqrt{s} = m_e$

$\sqrt{s} = 20 \text{ GeV}$

$z = \cos \theta$