Lepton pair production in neutrino–nucleus scattering

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Outline

1. Motivation
2. Calculations
3. Experimental consequences
4. Conclusions

Motivation

New light gauge bosons

What does it mean 'light'?

$\leq$1 GeV

New gauge bosons to account for:

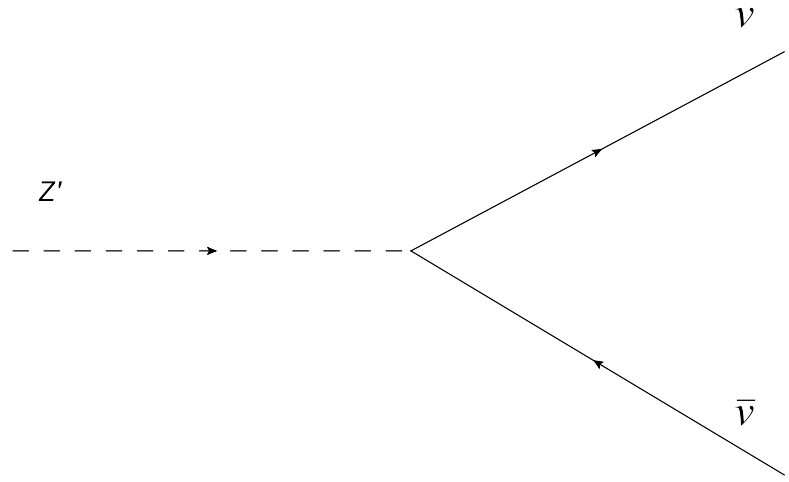
The anomalous muon magnetic moment

Semileptonic decays of B mesons

Dip in the spectrum of the diffuse neutrino flux (IceCube)

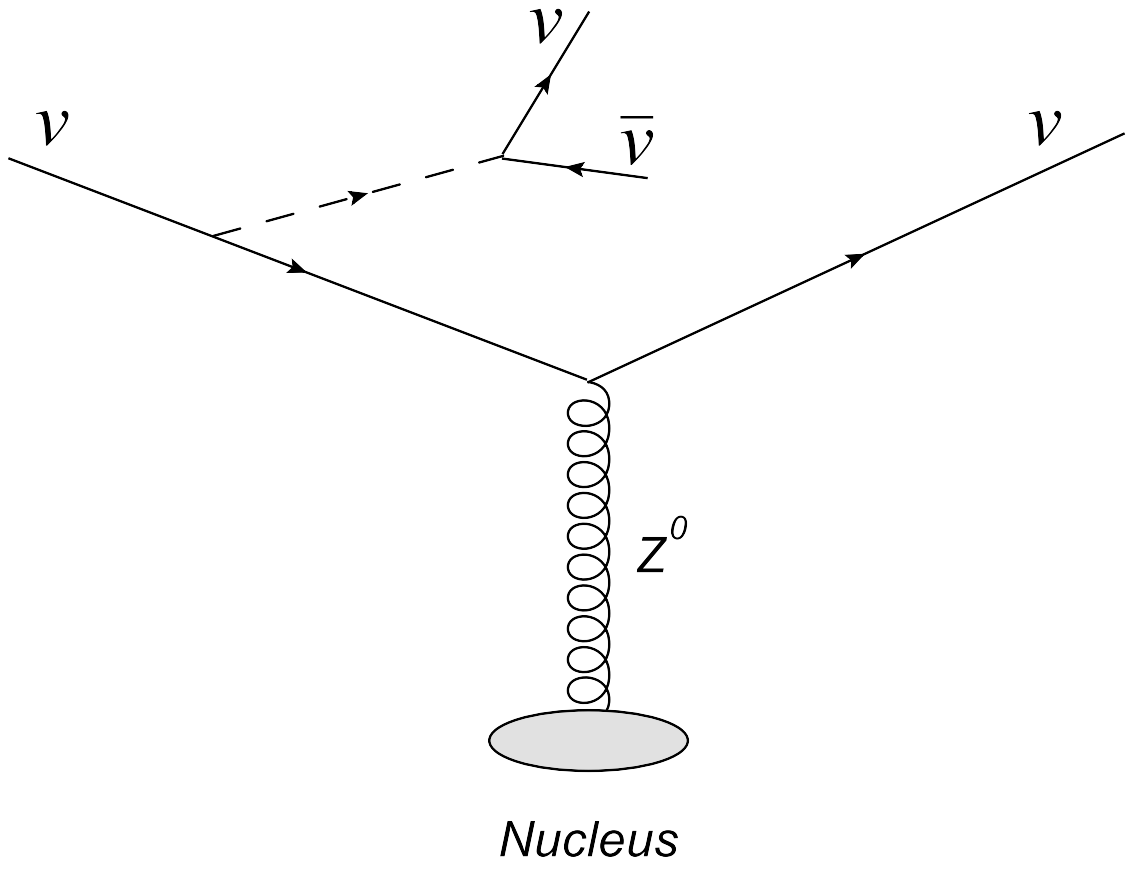
Decay of ^{12}Be producing e^+e^- pairs

Z' bosons interacting only with neutrinos (neutrinofilic)



$$\mathcal{L}_e = -e\,\bar{u}_\nu \gamma_\mu (g_V - g_A \gamma_5) u_\nu Z'^\mu. \tag{1}$$

Neutrino nucleus scattering is considered
Initial state emission of neutrino pairs through Z'-strahlung



Z' escapes the experimental setup undetected

Convolution of the Z'-spectrum with the SM neutrino cross section

$$\sigma_{new} = \int_{x_{min}}^{x_{max}} f_{Z'/\nu}(x,s)\sigma_{SM}(xs)dx \tag{2}$$

One has to know the function $f_{Z'/\nu}(x,s)$

$$f_{Z'/\nu}(x,s) = \frac{\alpha}{2\pi}(g_V^2 + g_A^2)\frac{1+(x+m_Z^2/s)^2}{1-x-m_Z^2/s}\ln\frac{s}{m_Z^2}$$

In the limit $g_V \to 1$, $g_A \to 0$ and $m_Z \to 0$ one obtains the well know QED result:

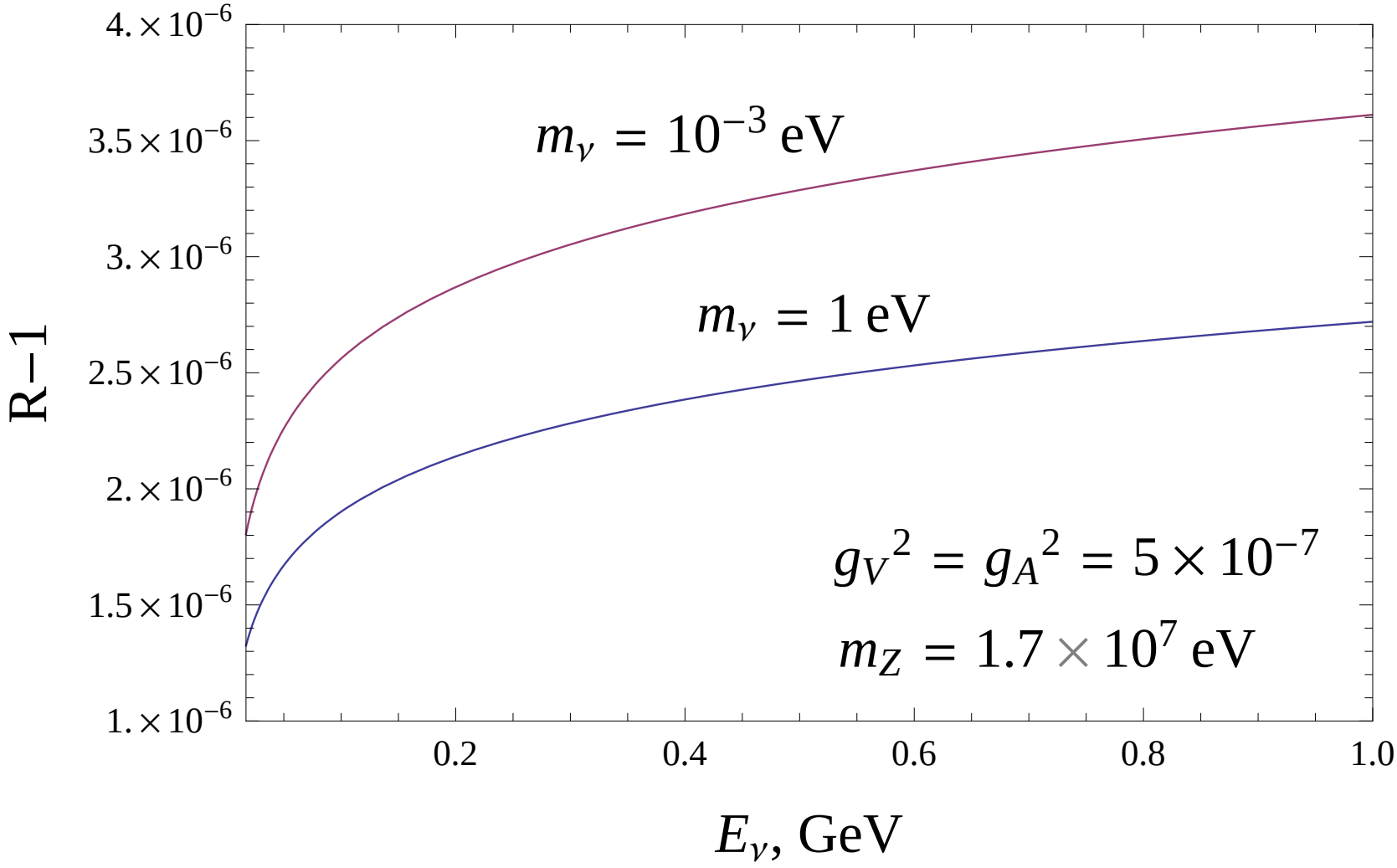
$$f_{\gamma/e}(x,s) = \frac{\alpha}{2\pi}\frac{1+x^2}{1-x}\ln\frac{s}{m_e^2}$$

Ratio of the cross sections at $s \ll m_W^2$

$$R = \frac{\sigma_{SM} + \sigma_{new}}{\sigma_{SM}} = \frac{\sigma_{\text{measured}}}{\sigma_{SM}}$$

$$R \approx 1 + \alpha(g_V^2 + g_A^2) \ln\left(\frac{s}{m_Z^2}\right) \ln\left(\frac{s}{m_\nu^2}\right)$$

Results


$4.\times10^{-6}$
3.5×10^{-6}
$3.\times10^{-6}$
2.5×10^{-6}
$2.\times10^{-6}$
1.5×10^{-6}
$1.\times10^{-6}$
R−1
0.2
0.4
0.6
0.8
1.0
E_ν, GeV
$m_\nu = 10^{-3}$ eV
$m_\nu = 1$ eV
$g_V{}^2 = g_A{}^2 = 5\times10^{-7}$
$m_Z = 1.7\times10^7$ eV

Conclusions

1. Neutrino pair production through a new light neutral gauge boson is studied.
2. For presently considered values of the new parameters the impact on a neutrino flux is $\sim 10^{-6}$.
3. The equivalent spectrum of the bosons for a neutrino beam is calculated.

Thank you!