

$$v_{\min}(E_{\mathrm{R}}) = \sqrt{\frac{m_{\mathcal{N}} E_{\mathrm{R}}}{2 \mu_{\chi \mathcal{N}}^2}} \left(1 + \frac{\mu_{\chi \mathcal{N}} \delta}{m_{\mathcal{N}} E_{\mathrm{R}}} \right)$$