Effective Field Theory Parameters

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In these notes I define the parameters used to make known the effective field theory interaction used in dmf90factor. As a shorthand, "the code" will refer to the dmf90factor program.

The code uses the EFT coefficients in explicit proton-neutron couplings, i.e. the interaction is defined by:

$$\sum_{x=p,n} \sum_{i=1,15} c_i^x \mathcal{O}_i \tag{1}$$

and the 15 momentum dependent operators are:

$$\mathcal{O}_1 = 1_\chi 1_N \tag{2}$$

$$\mathcal{O}_2 = (v^\perp)^2 \tag{3}$$

$$\mathcal{O}_3 = i\vec{S}_N \cdot \left(\frac{\vec{q}}{m_N} \times \vec{v}^\perp\right) \tag{4}$$

$$\mathcal{O}_4 = \vec{S}_\chi \cdot \vec{S}_N \tag{5}$$

$$\mathcal{O}_5 = i\vec{S}_\chi \cdot \left(\frac{\vec{q}}{m_N} \times \vec{v}^\perp\right) \tag{6}$$

$$\mathcal{O}_6 = \left(\vec{S}_\chi \cdot \frac{\vec{q}}{m_N}\right)\left(\vec{S}_N \cdot \frac{\vec{q}}{m_N}\right) \tag{7}$$

$$\mathcal{O}_7 = \vec{S}_N \cdot \vec{v}^\perp \tag{8}$$

$$\mathcal{O}_8 = \vec{S}_\chi \cdot \vec{v}^\perp \tag{9}$$

$$\mathcal{O}_9 = i\vec{S}_\chi \cdot \left(\vec{S}_N \times \frac{\vec{q}}{m_N}\right) \tag{10}$$

$$\mathcal{O}_{10} = i\vec{S}_N \cdot \frac{\vec{q}}{m_N} \tag{11}$$

$$\mathcal{O}_{11} = i\vec{S}_\chi \cdot \frac{\vec{q}}{m_N} \tag{12}$$

$$\mathcal{O}_{12} = \vec{S}_\chi \cdot \left(\vec{S}_N \times \vec{v}^\perp\right) \tag{13}$$

$$\mathcal{O}_{13} = i\left(\vec{S}_\chi \cdot \vec{v}^\perp\right)\left(\vec{S}_N \cdot \frac{\vec{q}}{m_N}\right) \tag{14}$$

$$\mathcal{O}_{14} = i\left(\vec{S}_\chi \cdot \frac{\vec{q}}{m_N}\right)\left(\vec{S}_N \cdot \vec{v}^\perp\right) \tag{15}$$

$$\mathcal{O}_{15} = -\left(\vec{S}_\chi \cdot \frac{\vec{q}}{m_N}\right)\left(\left(\vec{S}_N \times \vec{v}^\perp\right) \cdot \frac{\vec{q}}{m_N}\right) \tag{16}$$

Each of these operators as written has one of several different sets of dimensions. To match, each operator coefficient must therefore have a conjugate set of dimensions to bring $c_x^i \mathcal{O}_i$ to the proper dimensionality. The code reads the 15 coefficients c_x^i as dimensionless parameters which here we will label a_x^i. The appropriate scaling factors are then added by a combination of the WIMP-mass m_χ, the target-nucleus-mass m_N, and a standard-model weak interaction mass scale $m_v = 246.2$ GeV.

The 5 parameters with dimension 1 are (1, 4, 7, 8, 12):

$$c^x_{1,4,7,8,12} = \frac{4 m_N m_\chi}{m_v^2} a^x_{1,4,7,8,12} \tag{17}$$

$$\tag{18}$$

The 2 parameters with dimension $1/GeV$ are (6, 15):

$$c^x_{6,15} = \frac{4 m_\chi}{m_v^2} a^x_{6,15} \tag{19}$$

$$\tag{20}$$

The 7 parameters with dimension $1/GeV^2$ are (3, 5, 9, 10, 11, 13, 14):

$$c^x_{3,5,9,10,11,13,14} = \frac{4 m_\chi}{m_N m_v^2} a^x_{3,5,9,10,11,13,14} \tag{21}$$

$$\tag{22}$$