A guide to the RMF parameters in the autofit code

The RMF parameter sets used in the calculations are defined in terms of the parameters of the paper Phys. Rev. C**90**, 055302 (2014).

The nonlinear Lagrangian density given in that paper is,

$$\mathcal{L}_{\rm NL} = \mathcal{L}_{\rm nm} + \mathcal{L}_\sigma + \mathcal{L}_\omega + \mathcal{L}_\rho + \mathcal{L}_\delta + \mathcal{L}_{\sigma\omega\rho}, \tag{1}$$

where

$$\mathcal{L}_{\rm nm} = \overline{\psi}(i\gamma^\mu\partial_\mu - M)\psi + g_\sigma\sigma\overline{\psi}\psi - g_\omega\overline{\psi}\gamma^\mu\omega_\mu\psi - \frac{g_\rho}{2}\overline{\psi}\gamma^\mu\vec{\rho}_\mu\vec{\tau}\psi + g_\delta\overline{\psi}\vec{\delta}\vec{\tau}\psi, \tag{2}$$

$$\mathcal{L}_\sigma = \frac{1}{2}(\partial^\mu\sigma\partial_\mu\sigma - m_\sigma^2\sigma^2) - \frac{A}{3}\sigma^3 - \frac{B}{4}\sigma^4, \tag{3}$$

$$\mathcal{L}_\omega = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} + \frac{1}{2}m_\omega^2\omega_\mu\omega^\mu + \frac{C}{4}(g_\omega^2\omega_\mu\omega^\mu)^2, \tag{4}$$

$$\mathcal{L}_\rho = -\frac{1}{4}\vec{B}^{\mu\nu}\vec{B}_{\mu\nu} + \frac{1}{2}m_\rho^2\vec{\rho}_\mu\vec{\rho}^\mu, \tag{5}$$

$$\mathcal{L}_\delta = \frac{1}{2}(\partial^\mu\vec{\delta}\partial_\mu\vec{\delta} - m_\delta^2\vec{\delta}^2), \tag{6}$$

and

$$\mathcal{L}_{\sigma\omega\rho} = g_\sigma g_\omega^2\sigma\omega_\mu\omega^\mu\left(\alpha_1 + \frac{1}{2}\alpha_1{}' g_\sigma\sigma\right) + g_\sigma g_\rho^2\sigma\vec{\rho}_\mu\vec{\rho}^\mu\left(\alpha_2 + \frac{1}{2}\alpha_2{}' g_\sigma\sigma\right) + \frac{1}{2}\alpha_3{}' g_\omega^2 g_\rho^2\omega_\mu\omega^\mu\vec{\rho}_\mu\vec{\rho}^\mu. \tag{7}$$

The parameters are input to the code in the form given in the following table. Each line in the table corresponds to a line in the input. The lines are read in free format.

TABLE I. Parameters read for nonlinear RMF mean field calculations

m_σ	m_δ	m_ω	m_ρ	m_η	m_π
g_σ	g_δ	g_ω	$g_\rho/2$	0.0	0.0
$-A/(\hbar c)$	B	$g_\omega^4 C$	$-A_\delta/(\hbar c)$	B_δ	$g_\rho^4 C_\rho$
$-g_\sigma g_\omega^2\alpha_1/(\hbar c)$	$g_\sigma^2 g_\omega^2\alpha_1'$	$-g_\sigma g_\rho^2\alpha_2/(\hbar c)$	$g_\sigma^2 g_\rho^2\alpha_2'$	$g_\omega^2 g_\rho^2\alpha_3'$	M
0.0	0.0	0.0	0.0	0.0	0.0

The Lagrangian using density-dependent coupling constants dispenses with the nonlinear terms, but defines the meson-nucleon coupling constants as in the following Lagrangian,

$$
\begin{aligned}
\mathcal{L}_{\rm DD} = {} & \overline{\psi}(i\gamma^\mu\partial_\mu - M)\psi + \Gamma_\sigma(\rho)\sigma\overline{\psi}\psi - \Gamma_\omega(\rho)\overline{\psi}\gamma^\mu\omega_\mu\psi - \frac{\Gamma_\rho(\rho)}{2}\overline{\psi}\gamma^\mu\vec{\rho}_\mu\vec{\tau}\psi + \Gamma_\delta(\rho)\overline{\psi}\vec{\delta}\vec{\tau}\psi \\
& + \frac{1}{2}(\partial^\mu\sigma\partial_\mu\sigma - m_\sigma^2\sigma^2) - \frac{1}{4}F^{\mu\nu}F_{\mu\nu} + \frac{1}{2}m_\omega^2\omega_\mu\omega^\mu - \frac{1}{4}\vec{B}^{\mu\nu}\vec{B}_{\mu\nu} + \frac{1}{2}m_\rho^2\vec{\rho}_\mu\vec{\rho}^\mu \\
& + \frac{1}{2}(\partial^\mu\vec{\delta}\partial_\mu\vec{\delta} - m_\delta^2\vec{\delta}^2),
\end{aligned}
\tag{8}
$$

where

$$
\Gamma_i(\rho) = \Gamma_i(\rho_0)f_i(x), \quad \text{with} \quad f_i(x) = a_i\frac{1+b_i(x+d_i)^2}{1+c_i(x+d_i)^2}, \tag{9}
$$

for $i = \sigma, \omega$, and

$$
\Gamma_\rho(\rho) = \Gamma_\rho(\rho_0)e^{-a(x-1)}, \quad \text{with} \quad x = \rho/\rho_0. \tag{10}
$$

The parameters a_i are redundant and are defined in the code by the requirement that

$$
f_i\,(1) = 1.
$$

Some density dependent parameterizations have couplings different from those of the above equations. In particular, the DDHδ parameterization has the same coupling parameters as in Eq. (9) for the mesons σ and ω, but functions $f_i(x)$ given by

$$
f_i(x) = a_i e^{-b_i(x-1)} - c_i(x-d_i), \tag{11}
$$

for $i = \rho, \delta$.

The parameters of the density-dependent parametrizations are input in the form given in the following table. Each line in the table again corresponds to a line in the input. The lines are read in free format.

TABLE II. Parameters read for density-dependent RMF mean field calculations

m_σ	m_δ	m_ω	m_ρ	m_η	m_π
$\Gamma_\sigma\,(\rho_0)$	$\Gamma_\delta\,(\rho_0)$	$\Gamma_\omega\,(\rho_0)$	$\Gamma_\rho\,(\rho_0)\,/2$	0.0	0.0
b_σ	b_δ	b_ω	$-b_\rho$	0.0	0.0
c_σ	c_δ	c_ω	c_ρ	0.0	M
d_σ	d_δ	d_ω	d_ρ	0.0	ρ_0