Parametrizations in MGCAMB

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I. MG MODELS

A. Pure MG models (`MG_flag = 1`)

1. μ, γ parametrization (`pure_MG_flag = 1`)
   - `mugamma_par = 1`: BZ parametrization

$$\mu = \frac{1+\alpha_1 k^2 a^s}{1+\alpha_2 k^2 a^s} \qquad \gamma = \frac{1+\beta_1 k^2 a^s}{1+\beta_2 k^2 a^s}, \tag{1}$$

   with $\alpha_1 = B_1\lambda_{1\_2}$, $\alpha_2 = \lambda_{1\_2}$, $\beta_1 = B_2\lambda_{2\_2}$, $\beta_2 = \lambda_{2\_2}$.
   - `mugamma_par = 2`: Planck parametrization

$$\mu = 1 + E_{11}\Omega_{\rm DE}(a) \qquad \gamma = 1 + E_{22}\Omega_{\rm DE}(a), \tag{2}$$

2. μ, Σ parametrization (`pure_MG_flag = 2`)
   - `musigma_par = 1` : DES parametrization

$$\mu = 1 + \mu_0 \frac{\Omega_{\rm DE}(a)}{\Omega_{\rm DE,0}} \qquad \Sigma = 1 + \Sigma_0 \frac{\Omega_{\rm DE}(a)}{\Omega_{\rm DE,0}}, \tag{3}$$

3. Q,R parametrization (`pure_MG_flag = 3`)
   - `QR_par = 1`: (Q,R)

$$Q = Q_{\rm fix} \qquad R = R_{\rm fix}, \tag{4}$$

   - `QR_par = 2`: (Q_0,R_0,s)

$$Q = 1 + (Q_0 - 1)a^s, \qquad R = 1 + (R_0 - 1)a^s, \tag{5}$$

B. Alternative MG models (`MG_flag = 2`)

1. Linder's γ_L parametrization (`alt_MG_flag = 1`)

$$\mu = \frac{2}{3}\widetilde{\Omega}_m^{\gamma_L}\left[\widetilde{\Omega}_m^{\gamma_L} + 2 - 3\gamma_L + 3(\gamma_L - 0.5)\widetilde{\Omega}_m\right] \qquad \gamma = 1, \tag{6}$$

   where $\widetilde{\Omega}_m = (\Omega_b + \Omega_c)/[\Omega_b + \Omega_c + (1-\Omega_b-\Omega_c)a^3]$.

C. QSA models of Universal coupling (`MG_flag = 3`)

1. f(R) (`QSA_flag = 1`)

$$\mu(a,k) = \frac{1}{1-1.4\times 10^{-8}\lambda_{1\_2}a^3}\frac{1+B_1\lambda_{1\_2}k^2a^s}{1+\lambda_{1\_2}k^2a^s} \qquad \gamma(a,k) = \frac{1+B_2\lambda_{2\_2}k^2a^s}{1+\lambda_{2\_2}k^2a^s}, \tag{7}$$

   where $\lambda_{1\_2} = \frac{B_0}{2}\frac{c^2}{{H_0}^2}, \lambda_{2\_2} = B_1\lambda_{1\_2}$, with $B_1 = \frac{4}{3}, B_2 = 0.5, s = 4$, c is the speed of light.

2. scalar-tensor theories (`QSA_flag = 2,3,4`)

$$\mu = \left(1 + \frac{2k^2\beta^2}{k^2 + m^2a^2}\right) \qquad \gamma = \left(\frac{1 - \frac{2k^2\beta^2}{k^2+m^2a^2}}{1 + \frac{2k^2\beta^2}{k^2+m^2a^2}}\right), \tag{8}$$

where β and m are two phenomenological functions.

- symmetron model (`QSA_flag = 2`)

$$\beta = \beta_\star\sqrt{1 - \left(\frac{a_\star}{a}\right)^3} \qquad m = \frac{H_0}{c}\frac{1}{\xi_\star}\sqrt{1 - \left(\frac{a_\star}{a}\right)^3} \tag{9}$$

- dilaton model (`QSA_flag = 3`)

$$\beta = \beta_0 \exp\left(S/(2R-3)(a^{2R-3} - 1)\right) \qquad m = \frac{H_0}{c}\frac{1}{\xi_0}a^{-R}, \tag{10}$$

- Hu-Sawicki f(R) model (`QSA_flag = 4`)

$$\beta = \beta_0 \qquad m = m_0\left(\frac{4\Omega_\Lambda + \Omega_m a^{-3}}{4\Omega_\Lambda + \Omega_m}\right)^{(n+2)/2} \tag{11}$$

where $\beta_0 = \frac{1}{6}$, and $m_0 = H_0\sqrt{\frac{4\Omega_\Lambda+\Omega_m}{(n+1)f_{R_0}}}$.

D. QSA models of CDM-only coupling (`MG_flag = 4, CDM_flag = 1`)

The functional forms of β and m are the same as those in I C.

1. symmetron model (`QSA_flag = 2`)
2. dilaton model (`QSA_flag = 3`)
3. Hu-Sawicki f(R) model (`QSA_flag = 4`)

E. direct $\mu - \Sigma$ parametrization (`MG_flag = 5`)

The model options in this way of parametrization are the same as those in the other corresponding cases in this version release.

1. pure MG models (`muSigma_flag = 1`)
2. alternative MG models (`muSigma_flag = 2`)
3. QSA models of Universal coupling (`muSigma_flag = 3`)
4. cubic-spline method for μ and Σ with $\mu - \Sigma$ parametrization (`muSigma_flag = 4`)

F. cubic-spline method for μ and Σ with $\mu - \gamma$ parametrization (`MG_flag = 6`)

For both MG functions μ and Σ, 10 input nodes are uniformly distributed in the redshift range: $z \in$ [0,3], i.e. (`MGCAMB_Mu_idx(2)` ... `MGCAMB_Mu_idx(11)`; `MGCAMB_Sigma_idx(2)` ... `MGCAMB_Sigma_idx(11)`), and one input node is set at $z = 4$ (`MGCAMB_Mu_idx(1)`, `MGCAMB_Sigma_idx(1)`).

II. DE MODELS

1. ΛCDM (`DE_flag = 0`)

2. wCDM (`DE_flag = 1`)

3. (w_0, w_a)CDM (`DE_flag = 2`)

4. cubic-spline method for Ω_x (`DE_flag = 3`):
   9 input nodes are uniformly distributed in the redshift range: $z \in$ (0,3], i.e. (`Funcofw(2)` ... `Funcofw(10)`), and one input node is set at $z = 4$ (`Funcofw(1)`). Besides, the last node at $z = 0$ (`Funcofw(11)`) is internally fixed by $\Omega_{\rm DE}$ in the code, i.e. the DE density fraction today.