PARAMETER CARD

starevol4.00 - Jan 2023

variable	**values**	meaning
		evolutionary sequences
maxmod	$0 \rightarrow n$	Number of models in the current sequence, (0) stops the calculation.
imodpr	11, 12, 33	Activate flame routines (12 no printings), (33) save more models during. pulse/DUP
mtinit	$M_\odot$	Initial stellar mass.
zkint	$Z_{\rm tab}$	Metallicity to be selected in the Livermore opacity tables , to be selected accordingly to the chosen solar calibration.
		equation of state
addH2	f, t	Inclusion of H_2.
addHm	f, t	Inclusion of H^-.
Tmaxioh	$\sim 1 \times 10^5$	Temperature above which H is considered completely ionized (if ionizHe = f).
Tmaxiohe	$\sim 5 \times 10^5$	Temperature above which He is considered completely ionized (if ionizHe = f).
ionizHe	f, t	Inclusion of He partial ionization (should put t if atomic diffusion active).
ionizC	f, t	Inclusion of C partial ionization (should put t if atomic diffusion active).
ionizN	f, t	Inclusion of N partial ionization (should put t if atomic diffusion active).
ionizO	f, t	Inclusion of O partial ionization (should put t if atomic diffusion active).
ionizNe	f, t	Inclusion of Ne partial ionization (should put t if atomic diffusion active).
		gravitation
lgrav	1, 2, 3, 4	Different prescriptions for $\varepsilon_{\rm grav}$. $1: \varepsilon_{\rm grav} = -De_{\rm int}/Dt - PD(1/\rho)/Dt$ $2: \varepsilon_{\rm grav} = -c_P DT/Dt + Q/\rho\,(DP/Dt)$ $4: \varepsilon_{\rm grav} = -De_{\rm int}/Dt - 4\pi P\,\partial(r^2V)/\partial m_r$
lnucl	t, f	$\varepsilon_{\rm nuc}$ calculated at each iteration (t) or only once the model has converged (f).
		convection
alphac	α_c	$\alpha_c = \Lambda/H_P$ classical MLT free parameter with the pressure scale height (obtained from solar calibration, check "How to Starevol" document).
dtnmix	f, t, g, u	f : instantaneous mixing, lmix NOT activated t : time-dependent convective mixing lmix NOT activated g : idem f but lmix activated u : idem t but lmix activated
mixopt	f, t	Convective zone homogenized at each iteration during the convergence (t) or only when the structure has converged (f).
hpmlt	$1 \rightarrow 6$	Different MLT formalisms with the pressure scale height. 1 : Cox & Guili formalism (sometimes more stable; first sequence) 3 : Kippenhahn formalism (usually used) $2 \rightarrow 4$: idem ($1 \rightarrow 3$) but using time dependent MLT 5 : Convection model with compression effects Forestini, Lumer, Arnould (1991,A&A,252,127) 6 : Rotationally modified convection following Augustson & Mathis (2019) Currently not used !
nczm	$-9 \rightarrow 99$	Merge (remove) convective zones that are separated by less (which extent is less) than nczm shells. If nczm < 0 the procedure applies only in the envelope.
ihro	f, t	MLT with H_P (f) or H_ρ (t) prescription.
~~iturb~~	0, 1	Inclusion (1) or not (0) of a turbulent flux in the convective energy balance. (with the H_ρ MLT prescription only) Currently not used !
etaturb	$\eta_{\rm turb}$	Parameter to compute the turbulent flux of the convective cells. (with the H_ρ MLT prescription only) According to Maeder (1987), etaturb should be of the order of 1000.
fover	$f_{\rm over}$	With lover$\in [23, 32]$, corresponds to Herwig's overshoot parameter $f_{\rm over}$. With lover$\in [33, 39]$ or $\in [70-73]$, corresponds to the penetration depth $d_{\rm ov}$ for Baraffe 2017, Augustson & Mathis 2019, Korre 2019. (0.0325: Li Cluster PMS)

variable	values	meaning
`alphatu`	$\alpha_{\rm turb}$	$\alpha_{\rm turb} = \Lambda/H_\rho$ classical MLT free parameter with the density scale height or free parameter for convective cells with H_P and hpmlt=5 (check "How to Starevol" document for $\alpha_{\rm MLT}$ values).
`novopt`	0, 1, 2	Treatment of the step overshooting (if $\neq 0$); radial upward extension limited by $\alpha_{\rm over,up} H_P$ (1) or the minimum of $\alpha_{\rm over,up} H_P$ and $\alpha_{\rm over,up} r$ (2).
`aup`	$\alpha_{\rm over,up}$	Radial downward extension in case of step overshooting, characterizes core overshooting.
`adwn`	$\alpha_{\rm over,down}$	Radial upward extension in case of step overshooting, characterizes envelope undershooting.
`idup`	0, 1, 2, 3	(1) find neutrality of the gradients (AGB phase only), (2) call to convzone stopped after iterations, (3) : (1) + (2), (5) : overshoot below envelope (`lover` = 23) activated during AGB phase only.
atmosphere		
`tau0`	$\tau_0 \lesssim 0.1$	Fixed optical depth of the last numerical shell (to set when starting a model).
`ntprof`	0, 1 $\rightarrow$ 8	Boundary condition : (0) grey atmosphere (1) analytic fit (2) no atmosphere (3) Siess et al. 2000 fit (4) PHOENIX realistic atmosphere model (5) Krishna-Swami 1966 fit (6) CMFGEN atmosphere models (massive stars) Currently not used ! (7) TLUSTY atmosphere models (massive stars) Currently not used ! (8) Vernazza et al. (1981) analytic fit as quoted in Spnoi et al. (2019) Currently not used !
`taulim`	$> \tau_0$	Optical depth above which the Eddington (grey) approximation is used (to set when starting a model).
mass loss		
`mlp`	0, 1 $\rightarrow$ 30	Mass loss prescription (if $\neq 0$) . 1,2 : Reimers (1975) : RGB 3,4 : de Jager (1988 A&AS, 72, 259) for log(Teff)>3.7, Crowther (2001) for log(Teff)<3.7. Massive stars 5,6 : Vassiliadis & Wood (1993, ApJ 413, 641) : AGB, no delay of the onset of the super-wind phase 55,56 : Vassiliadis & Wood (1993, ApJ 413, 641) : AGB, original prescription 7,8 : Blocker (1995, A&A 297, 727) : AGB 9,10 : Arndt (1997, A&A 327, 614) : AGB 11,12 : Schaller et al. (1992) : Massive stars and WR phase 13,14 : Chiosi (1981, A&A 93, 163) : Massive O stars 15,16 : Vink et al. (2001) for log(Teff)>4.0969, de Jager (1988,A&A,72,259) for 4.0969>log(Teff)>3.7, Crowther (2001) for log(Teff)<3.7, Nugis & Lamers (2000) for $H_{\rm surf}$ <0.4 and log(Teff)>4.0. Massive stars, MS, post-MS, RSG and WR phase 17,18 : user defined, equal to `massrate` (Accretion) 19,20 : Crowther (2000) : for RSG 21,22 : Van Loon et al. (2005) : for AGB and RSG 23,24 : Cranmer & Saar (2011) : for cool PMS (23 only), MS and RGB stars (if rotation and a convective envelope) 25,26 : Graefener (2021) : VMS at LMC metallicity 27,28 : Sanders & Vink (2022) : VMS stars 29,30 : Sabhahit et al. (2023) : VMS stars at low Z If mlp is odd, mass is removed in shells above m=0.95*mtot. If mlp is even, shells are removed.

variable	values	meaning
etapar †	$\eta_{\rm Reimers}$	Free parameter of the Reimers (1975) mass loss prescription.
dmlinc †	> 1 or < 1	Factor by which the mass loss rate is artificially multiplied.
clumpfac	< 1	Factor by which the Vink et al. (2001) mass loss is artificially multiplied to take into account the effects of clumping.
zscaling	f, t	If t, multiply the mass loss rate by a factor $(Z/Z_\odot)^{0.8}$, where $Z_\odot$ is the solar metallicity.
		nuclear
nucreg	$0 \to 3$	Treatment of the nucleosynthesis. 0 : no nucleosynthesis (nuclear energy production $\varepsilon_{\rm nuc}$ calculated) 1 : nucleosynthesis calculated after convergence 2 : idem 1 but convective zones treated radiatively 3 : nucleosynthesis calculated at each iteration during the convergence process
nuclopt	i,j,h,n,m,c,l, u,p,f	i : mix unstable nuclei inside convective zones even if $\tau_{\rm decay} \ll \tau_{\rm conv}$ j : i + deactivate special treatment of Li, Be and B during HBB (see diffusion.f) h : deactivate processes linked to HBB n : compute neutron equilibrium abundance after nucleosynthesis m : homogenize neutron abundances in the convective zones c : authorize coupled resolution of mixing and nucleosynthesis if the luminosity variation is > ftnuc and the star is not undergoing a TP (for p injection) l : if decoupling hypothesis not satisfied (see ftnuc), model is recomputed with a smaller timestep else time step is not allowed to increase u : active URCA terms (Eloc and Econv) p : if diffzc = f, convection zone can be treated as radiative (partialmix on) f : do none of the above
tolnuc	> 0	Tolerance on mass fraction conservation in the nuclear subroutine tolerance = $10^{-10}\times$ tolnuc.
ftnuc †	< 1	Check that the nucleosynthesis does not modify too much the energetics. Maximum authorized change in the nuclear luminosity : $\left\lvert 1 - \frac{L_{\rm nuc}(X^{n+1})}{L_{\rm nuc}(X^n)} \right\rvert <$ ftnuc
Znetmax	> 0	Nuclear charge (Z) of the last considered species (only for large networks).
		diffusion
idiffcc	f, t	Computation of slow particle transport processes (diffusion).
diffnuc	1, 2, 3	Computation of slow particle transport processes (if $\neq 0$, default : 2), before (1), after (2) or before and after (3) the nucleosynthesis.
idiffty	$4, 8 \to 15$	Rotational mixing. 4 : mixing recipe used in Charbonnel ApJ 1995 8 : chemical mixing + AM transport Talon 1997 9 : AM transport only, Talon 1997 10 : (8)+(lmicro = 2) 11 : (lmicro = 3) + chemical mixing + AM transport Maeder,Zahn 1998 13 : (11) + non stationary terms in for AM transport (include everything) 14 : Ω evolves as a results of structural changes, evolution with $j_k = cste$ 15 : (13) + additional viscosity nu_add
diffzc	f, t	Compute convective mixing as a diffusive process (implies radiative nucleosynthesis).
diffst	> 1	Factor by which the evolution timestep is reduced to compute the diffusion.
zgradmu	f, t	Computation of angular momentum and chemical transports including the feedback on molecular weight when idiffty = 8,9 or 11.
nu_add	$\nu_{\rm add}$	Additional viscosity in $\mathrm{cm^2/s}$ (idiffty=15).
del_zc	< 1	Minimum value allowed for $\nabla_{\rm RAD}$.
ledouxmlt	f,t	Use Ledoux criterion. In the semiconvective zone mixing is treated diffusively.
Tfix	$T_{\rm fix}$	Fixation point of the turbulence function of temperature.

variable	values	meaning
`om_turbul`	$\Omega_{\rm turbul}$	Coefficient entering the expression of the turbulent diffusion coefficient for chemicals according to Richard et al. 2005, ApJ 619, 538, Equation 2. Multiplicative factor compared to the He atomic diffusion coefficient. Dturbul is proportional to om_turbul*DHe0.
`n_turbul`	$n_{\rm turbul}$	Exponent indicating the density dependence of the turbulent diffusion coefficient for chemicals according to Richard et al. 2005, ApJ 619, 538, Equation 2. Dturbul is proportional to $1/\rho^{\rm n\_turbul}$.
`PM_turbul`	$PM_{\rm turbul}$	Coefficient entering the turbulent diffusion coefficient expression according to Proffitt & Michaud (1991a) as expressed in Richard et al. 2005, ApJ 619, 538, Equation 3. Dturbul2 is proportional to PM_turbul*ρ^{-3}.
		rotation
`omegaconv`	f,t,s,m	Treatment of AM transport in convective zone (f=exclude convective core and envelope ONLY - t=include ALL conv. zones, s = solid-body rotation in the entire star (routine rot_sol - m = no AM transport but chemical mixing).
`Dh_prescr`	name	Prescription for horizontal diffusion coefficient Dh. Zahn1992 : Zahn 1992 Maeder03 : Maeder 2003 MPZ_2004 : Mathis, Palacios & Zahn 2004 Maeder06 : Maeder 2006 Mathis16 : Mathis 2017, $\tau = 1/S$ Mathis02 : Mathis 2017, $\tau = 1/(2\Omega + S)$ Mathiepi : Mathis 2017, $\tau = 1/N_\Omega$
`dm_ext`	> 1	Parameter used to smooth the diffusion coefficient at the limit of the convective core.
`Dv_prescr`	name	Prescription for vertical diffusion coefficient Dv. Za92 : Zahn 1992 TZ97 : Talon & Zahn 1997 (do not use with `Dh_prescr`=Mathis16) Ma97 : Maeder 1997 Pr16 : Mathis et al. 2018 (TB updated - not fully functional yet)
`om_sat`	08-15	Saturation value for the dynamo-generated magnetic field (in solar angular velocity).
`D_zc`		Diffusion coefficient in the convective zone.
`disctime`		Defines the duration of the disk-locking phase during the pre-main sequence. Expressed in years. (usually $2.5{\times}10^6$ for rapid rotation and $5{\times}10^6$ for median and slow rotation)
`thermal_ equilibrium`	f,t	Starting from thermal equilibrium in the computation of angular momentum transport.
`diffvr`	$\rm V_{init}$	Initial velocity in km.s^{-1} (if no magnetic braking).
`idiffvr`	$0 \rightarrow 9$	Prescription for braking at the stellar surface. (0) no torque applied (1) constant rotation speed (2) power law for breaking : $\Omega = \Omega_0 (t/t_0)^n$ (3) Skumanich breaking law : $\Omega = (p\,\Omega_0^{-1} + {\rm cte})^{-1/({\rm p}-1)}$ (4) constant angular velocity (5) torque applied α ${\Omega_S}^3$ (6) constant specific angular momentum (7) gfdsf (8) Matt et al. 2012 (with `mlp` = 23,24) (9) Matt et al. 2015
`idiffex`		Exponent intervening in the breaking law (if `idiffvr`=2,3).
`diffcst`		Constant intervening in the different braking laws. Examples : (a) 4e47 with `idiffvr` = 5 for a solid body rotating 1M$_\odot$ model, (b) $\simeq$ 2e48 for a differentially rotating model. (c) $\simeq$ 3e30 with `idiffvr` = 9. (Hardcoded for `idiffvr` = 8). (corresponds to the value of K*2/3 if Matt 2015 is used, solar case : $5{\times}10^{30}$erg)
`breaktime`		If idiffvr = 3 date in years from which the breaking of the star starts when Skumanich braking law is used. If idiffvr $\neq$ 3 corresponds to the angular velocity of the disk (and thus the stellar surface) during the disc-locking phase on the PMS. Expressed in s^{-1}.

variable	**values**	meaning
		time-dependent convection
`nmixd`	$0, 1 \rightarrow 5$	Computation of time-dependent mixing (tdm) and nucleosynthesis (if $\neq 0$). (1) core only (2) envelope only (3) core & envelope (4) all convective zones (5) through all the star
`itmind`	> 1	Minimum number of iterations for tdm computations.
`itmaxd`	< 99	Maximum number of iterations for tdm computations.
`rprecd`	ϵ_{diff}	Precision to be reached on the abundances for the solution to converge.
`nretry`	various	Parameter used in different contexts according to the selected values. 1 : used in the call of the opacity routine kappa to include the computation of molecular opacities (= opamol in kappa.f) 4 : used in structure to redefine thermodynamic quantities at convective boundaries in case of rotating models where the effective gravity accounts for centrifugal forces other : number of shells in the shock neighbourhood (in case of Super AGB stars)
		extra mixing
`lover`	23 - 71	Overshoot prescription. 23 : below convective envelope 24 : above core 25 : below pulse 26 : above pulse 27 : above core and below envelope (=23+24) 28 : below and above pulse (=25+26) 29 : treat all cases (=27+28) 30 : overshoot below all convective zones 31 : overshoot above all convective zones 32 : overshoot everywhere (=30+31) 33 : overshoot Baraffe 2017 34-36 : overshoot dependent of rotation Augustson & Mathis 2019 below the base of the CZ (34), above the base of the CZ (35), or both (36) 37-39 : overshoot dependent of rotation Korre 2019 below the base of the CZ (37), above the base of the CZ (38), or both (39) 41-43 : IGW from the envelope only (41), from the core (42), or from both (43) 60,61 : parametric turbulence Richard 2005 set at a temperature threshold (60), or at the base of the CZ (61) 70 : 34 + 60 71 : 34 + 61
`lthal`	0 - 1	Thermohaline mixing (0 = off, 1 = on).
`ltach`	41 - 44	Tachocline mixing. 41 : independent of time Brun 1999 43 : dependent of time Brun 1999
`lmicro`	2 - 6	Atomic diffusion. 2 : Chapman & Cowling 3 : Montmerle & Michaud 1976, Paquette 1986, partial ionization 4 : Thoul 1994, Paquette 1986, partial ionization 5 : Montmerle & Michaud 1976, Paquette 1986, total ionization 6 : Thoul 1994, Paquette 1986, total ionization
		accretion
`iaccr`	$0, 1 \rightarrow 4$	Computation of the accreted matter profile (if $\neq 0$) without (1, 2) or with (3, 4) shear energy production rate ε_{shr} with two different normalizations : 1 or 3 : $\text{M}_{\text{acc}} = \int \frac{\text{facc}}{1+\text{facc}}\,\text{dm}$ 2 or 4 : $\text{M}_{\text{acc}} = \int \text{facc dm}$ (reference)

variable	values	meaning
`accphase`	$0,\, 1 \rightarrow 8$	Different computations of the accreted matter profile. if 0 : accretion model, including D burning (suited for PMS phase) if $[1,4]$: accretion inside the star (planet accretion) if 5 : uniform accretion from the surface with facc =`ric` (`menv` unknown) if 6 : uniform accretion from the surface $M_\star$ to `menv` (facc unknown) if 7 : uniform accretion from the surface $M_\star$ to $M_\star -$ `menv` (facc unknown) if 8 : uniform accretion from the surface $M_\star$ to `menv`$\times M_\star$ (facc unknown)
`itacc`	$0 \rightarrow 4$	If `accphase` = 0, different prescriptions for ^{2}H mixing in case of accretion. If `itacc` = 0, matter pills up at the surface of the star. If `itacc` > 0, matter mixing with the surface layers.
`massrate`	≥ 0	Mass accretion rate in $M_\odot\, yr^{-1}$.
`massend`	$M_{\star,\max}$	Accretion is stopped when $M >$ `massend`.
`menv`	$M_{\star,\max}$	Mass is deposited from `menv` to the surface (works with `accphase` = 6).
`ric`	$\mathcal{R}i_{\rm conv}$	Richardson number for convective regions.
`prrc`	$\mathcal{P}e$	Peclet number characterizing the thermal behavior of the accreted matter.
`xiaccr`	$0 \leq \xi \leq 1$	Angular momentum fraction actually accreted inside the star.
`fdtacc`	≥ 1	Factor by which the evolution timestep is modified in case of non-convergence of the accretion procedure (case `accphase`=0).
`alphaccr`	$0 \leq \alpha_{\rm acc} \leq 1$	Fraction of the accretion luminosity deposited in the star.
		hydrodynamics
`hydrodynamics`	0, 1, 2, 3	Hydrodynamics off (0) on (1), (2) and (3) idem but with rotational forces included.
`ivisc`	0, 1, 2	Prescriptions for the artificial viscosity. 0 : no artificial viscosity 1 : $P_{\rm visc} = q_0\, l^2 \rho\, (D \ln \rho / Dt)^2$ 2 : $P_{\rm visc} = q_0\, l^2 \rho^3\, (4\pi\, \partial(r^2 v)/\partial m_r)^2$ 3 : $P_{\rm visc} = q_0\, l^2 \rho\, \lvert{\rm div}\, v\rvert (dv/dr - 1/3\, {\rm div}\, v)$
`q0` †	$q_0 \simeq 1 - 2$	Parameter of the artificial viscosity.
`mcut`	$0 \leq m_{\rm cut} \leq M_\star$	Mass cut above which artificial viscosity is activated.
		shell masses
`maxsh`	$0 \ldots n$	Maximum number of shells that can be changed by the mesh laws.
`nresconv`	$-9 \rightarrow 99$	Spatial resolution increased in at least `nresconv` shells around a convective boundary - if `nresconv` < 0 zonetest NOT activated else zonetest activated (better to put at 0 if atomic diffusion active).
`dlnvma`	$\left\{\dfrac{\Delta X}{X}\right\}_{\max} < 1$	Spatial resolution : maximum relative variation in {X}=$\{u, r, \ln f, T, L_r, P, \varrho, M_r\}$ between 2 adjacent shells.
`dlnvmi`	$\left\{\dfrac{\Delta T}{T}\right\}_{\min}$	Luminosity profile constrain if $\Delta T/T$ is larger than `dlnvmi`.
`dlnenuc` †	$\triangle\varepsilon_{\rm nuc,max}$	Equivalent to `dmrma`, but for $\varepsilon_{\rm nuc}$ specifically.
`dmrma`	$\triangle m_{\max}$	Maximum increase of relative mass allowed between adjacent shells.
`dmrmi`	$\triangle m_{\min}$	Minimum increase of relative mass allowed between adjacent shells.
		time-step
`dtin`	$\triangle t_{\rm in}$	Initial evolution timestep of a model sequence. (if zero, use previous evolution time step)
`dtmin`	$\triangle t_{\min}$	Minimum evolution timestep allowed.
`dtmax`	$\triangle t_{\max}$	Maximum evolution timestep allowed.
`facdt`	> 1	Factor by which the evolution timestep is increased (in case of convergence) or reduced (by 2, in case of crash).
`fkhdt` †	≤ 1	Fraction of the Kelvin-Helmholtz timescale considered as maximum evolution timestep allowed, only for contracting phases (i.e. nphase = 1, 3, 5 and 7).
`ishtest`	f, t	Next evolution timestep estimated by the dependent variable evolution rate in all the shells (f) or just in shells where nuclear burning occurs (t).
`fts` †	< 1	Relative maximum change of dependent variable values allowed in each shell between two consecutive models (to estimate the evolution timestep).
`ftsh` †	< 1	The evolution timestep is not allowed to be larger than `ftsh` times the nuclear timescale corresponding to H burning (where $\varepsilon_{\rm nuc}$ is maximum). When nphase=7, `ftsh` controls Ne burning.

variable	values	meaning
`ftshe` †	< 1	Same as `ftsh`, but corresponding to He burning.
`ftsc` †	< 1	Same as `ftsh`, but corresponding to C burning.
`ftst` †	< 1 < 1	- Controls the max. temperature increase allowed between 2 consecutive models. - Controls the increase in nuclear luminosities associated with the different burning modes (H,He and C).
`ftacc` †	< 1 < 1	Same as `ftsh`, but corresponding to the accretion timescale (if `iaccr`>0). Also controls the flame speed (activated if `imodpr`=11).
	iterations	
`itermin`	> 2	Minimum number of iterations to converge a model.
`itermax`	< 999	Maximum number of iterations to converge a model.
`itermix`	$-99 \rightarrow 99$	Maximum number of iterations over which mixing procedure is applied at each iteration (if `mixopt` is true). If `itermix`< 0 initial abundances restored after the `itermix` iterations.
`icrash`	< 10 $-10 <$	In case of crash, the evolution timestep is reduced `icrash` times and increased 9−`icrash` times. Negative values of `icrash` force the time step to increase |`icrash`| times and then decreased 9−|`icrash`| times.
`numeric`	$1 \rightarrow 4$	1 : convergence not followed in the surface layers where $T <$ `tmaxioHe` 2-3 : first order spatial derivatives (zi=$\frac{1}{2}$, zj=$\frac{1}{2}$) 2-4 : $1/\kappa_i = \mathsf{zi}/\kappa_{i-\frac{1}{2}} + \mathsf{zj}/\kappa_{i+\frac{1}{2}}$ other values : second order spatial derivatives and $\kappa_i = \kappa_{i-\frac{1}{2}}^{\mathsf{zi}} \kappa_{i+\frac{1}{2}}^{\mathsf{zj}}$
`icorr`	f,i,m,h,a,b,t	f : do not activate parameter adjustments in case of crash i : f + increase tolerance on velocity m : f + mesh disabled after 1 crash h : f + deactivate acceleration routine after 2 crashes (iacc=f) a : f + constraint time-step during third dredge-up and set egrav and its derivatives at 0 in the atmosphere b : set egrav and its derivatives at 0 in the atmosphere t : constraint time-step during third dredge-up and check that pressure is a decreasing function of mass
	tolerances	
`tol_u`	$\epsilon\,(u)$	Tolerance to be reached by the dependent variable u for the model to converge.
`tol_lnr`	$\epsilon\,(\ln r)$	Same as `tol_u`, but for dependent variable $\ln r$.
`tol_lnf`	$\epsilon\,(\ln f)$	Same as `tol_u`, but for dependent variable $\ln f$.
`tol_lnT`	$\epsilon\,(\ln T)$	Same as `tol_u`, but for dependent variable $\ln T$.
`tol_l`	$\epsilon\,(l)$	Same as `tol_u`, but for dependent variable l.
	convergence	
`phi`	$0 \leq \varphi \leq 1$	Correction apply to the linear extrapolation to determine the initial guess structure ($x^{n+1} = x^n + \mathtt{phi} \times [x^n - x^{n-1}] \times \Delta t^{n+1}/\Delta t^n$).
`alpha`	$0 \rightarrow 1$	Fraction of the Newton-Raphson correction actually applied in all the shells for each dependent variable that is considered for the first four iterations.
`iacc`	f, t	Allow or not the current `alpha` value to be modified for all the dependent variables every four iterations (after the first four ones).
`alphmin`	$0 \rightarrow 1$	Minimum value allowed for `alpha` (if `iacc` is true).
`alphmax`	$0 \rightarrow 1$	Maximum value allowed for `alpha` (if `iacc` is true).
`sigma`	$0 \leq \sigma \leq 1$	Numerical scheme. 0 : explicit scheme $0 < \sigma < 1$ semi-implicit 1 : implicit scheme
`vlconv`	f,t	Treatment of equation of transport. f : $\partial \ln \mathrm{T}/\partial \ln \mathrm{P} = \nabla_{\rm conv}$ or $\nabla_{\rm rad}$ t : $L = L_{\rm rad} + L_{\rm conv}$

† if set to zero, not accounted for

~~word~~ : parameter not used (i.e. should be removed)

`partialmix` : convective zone treated as radiative if $\tau_{\rm conv} \gg$ `dtn` (see `nuclopt`)

`lmix` : solution accepted only if during the last 2 iterations the convective boundaries have NOT changed (and the tolerance fulfilled) (see `dtnmix`)

VARIABLES NAMES

variable name	Centered variables shell [i+1/2]	symbol
rho	density	ρ
T	temperature	T
P	pressure	P
eint	internal energy	$E_{\rm int}$
abad	adiabatic gradient	$\nabla_{\rm ad}$
cp	specific heat a constant P	$c_{\rm P}$
enupla	plasma neutrino energy loss rate	ε_ν
enucl	nuclear energy production rate	$\varepsilon_{\rm nuc}$
egrav	gravothermal energy production rate	$\varepsilon_{\rm grav}$
khimu	$\chi_\mu = \frac{\partial \ln P}{\partial \ln \mu}\Big\vert_{\rho,T}$	χ_μ
khirho	$\chi_\rho = \frac{\partial \ln P}{\partial \ln \rho}\Big\vert_{\mu,T}$	χ_ρ
khit	$\chi_T = \frac{\partial \ln P}{\partial \ln T}\Big\vert_{\mu,\rho}$	χ_ρ
ksirho	$\xi_\rho = \frac{\partial \ln P}{\partial \ln \rho}\Big\vert_{T}$	ξ_ρ
phiKS	$\varphi = \frac{\partial \ln \rho}{\partial \ln \mu}\Big\vert_{P,T} = -\frac{\chi_\mu}{\zeta_\rho} = -\phi$	φ
deltaKS	$\delta = -\frac{\partial \ln \rho}{\partial \ln T}\Big\vert_{P,\mu} = \frac{\zeta_T}{\zeta_\rho}$	δ
ksiT	$\xi_T = \frac{\partial \ln P}{\partial \ln T}\Big\vert_{\rho}$	ξ_T
zrho	$\zeta_\rho = \chi_\rho + \chi_\mu \xi_\rho$	ζ_ρ
zt	$\zeta_T = \chi_T + \chi_\mu \xi_\rho$	ζ_T
V_circ	horizontal component of the meridional circulation	$V_{\rm circ}$
xKt	thermal diffusivity : Flux $= -K_T \rho c_P \dfrac{\partial T}{\partial r}$	K_T
rhmoy	average density $\frac{1}{M}\int \varrho\, {\rm d}m$	ϱ_m
	Edge/interface variables shell [i]	
m	mass	M_r
u	velocity	u_r
r	radius	r
lum	luminosity	L_r
gmr	gravitational field	$\dfrac{\mathcal{G}M_r}{r^2}$
hp	pressure scale height	$\rm H_P$
ht	temperature scale height	$\rm H_T$
crzc	shell type (radiative, conv., semi, thermohaline, ...)	
abrad	radiative gradient	$\nabla_{\rm rad}$
abla	effective temperature gradient	∇_*
abel	temperature gradient of the convective cell	∇_{el}
	rotation - mixing - diffusion variables [i]	
omega	rotation rate	Ω
theta	derivative of rotational rate	θ
ur	vertical component of the meridional circulation	U_r
lambda	integration variable	Λ
aux	integration variable	$\mathcal{A}$
grav	normalized gravitational field	g
epsmoy	average nuclear energy production $\frac{1}{M}\int \varepsilon_{\rm nuc} {\rm d}m$	ε_m
D	all diffusion coefficients : cd, Dconv, Dsc, Dherw, coefDtacho, Dhd, Dthc, xNt, xNu, xNr, Dhold, Dh	D
viscosity	xnum, xnuvv, xnumol, xnurad	ν

Index