ADD-ON

to KEPLER Manual Version 1 May 1991

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Contents

1 Undocumented Parameters (by value)

P	name	default	description
355	`xlanger1`	0.0d+0	Langer mass loss rate parameter 1
356	`xlanger2`	0.0d+0	Langer mass loss rate parameter 2
357	`iburnye`	0	If `1` initialize ISE zones with ye taken from the BURN network.
358	`relmult`	0.0d0	Multiplier on GR corrections. GR is turned off if set to `0.0d0`
359	`geemult`	1.0d0	Multiplier on gravitational constant
350	`grbparm`	0.0d0	Energy deposition for GRB modeling. The source code says "`the following is a kludge for grb modelling only. Do not use any other place. Using this with nuclear burning on will double count neutrino losses`". It also sets `xk1=xkmin` for zone `jm-1`.
351	`swmult`	0.0d0	It does not appear to actually do anything
352	`tsharp`	0.0d0	A parameter for Type Ia SNe simulations

2 New Parameters (by value)

P	name	default	description
137	`nadapb`	0	turns on adaptive BURN network adjustment if `1`, off if `0`.
363	`xmlossn`	0.0D0	multiplier on Niewenhuijzen & de Jager mass loss rate
364	`nangmix`	0	turn rotational mixing on (1) or off (0)
365	`angfmu`	1.0D0	molecular weight sensitivity of rotational mixing processes; affects Eddington-Sweet circulation and Goldreich-Schubert-Fricke instability; If a negative sign is added, these instabilities are completely switched off when the "μ-current" exceeds the destabilizing circulation velocity, otherwise they are just reduced by a factor of one plus the ratio of the two circulation velocities.
366	`angfc`	1.0D0	efficiency of chemical mixing by rotational instabilities
367	`angfjc`	1.0D0	efficiency of angular momentum transport by (semi)convection
368	`angrcrit`	2.5D+03	critical Reynolds number (affects secular shear instability)
369	`angric`	2.5D-1	critical Richardson number (do noch change)
370	`angfjdsi`	1.0D0	general efficiency multiplier for dynamical shaer instability
371	`angfjshi`	1.0D0	general efficiency multiplier for Solberg-Høiland instability
372	`angfjssi`	1.0D0	general efficiency multiplier for secular shear instability
373	`angfjez`	1.0D0	general efficiency multiplier for Eddington-Sweet circulation
374	`angfjgsf`	1.0D0	general efficiency multiplier for Goldreich-Schubert-Fricke instability
375	`fmin`	1.0D0	under-relaxation factor on the corrections taken each iteration in the Henyey-solver. The maximum number of iteration is now `itmax (p 5)/fmin`.
376	`ncnvout`	0	write out (1) or not (0) the STERN convection plot file

377	`kaptab`	1	select opacity table: 0: old 1: OPAL'96 2: OPAL'96 only in H-rich regions 3: Potekhin et al. 2006 (condall06, $10^{-6} < \rho < 10^{9}$) 4: Itoh et al. 2008 ($10^{0} < \rho < 10^{12.8}$) The tables 3 and 4 for are implemented by Laurens Keek for use in thick NS crust models. NOTES: Itoh '08 is officially only valid for liquids ($\Gamma < 180$), but Laurens removed the check for this. Otherwise you revert to the old opacities at the edges of your model, which is probably not any better. Itoh maps isotopes onto 11 isotopes (heaviest is iron); Potekhin uses a mean ion approach.
378	`fkapz`	1.0D0	multiplier on metallicity used in OPAL opacities
379	`zfakexp`	0.5D0	metallicity-dependence of the mass loss: $\kappa = \kappa_0 \cdot (Z/Z_\odot)^{\texttt{zfakexp}}$ • For non-WR stars all metals (everything but H and He) are considered. • For WR stars only the Fe and Ni abundance is considered.
380	`angsmt`	1.0D0	secular rotational mixing processes may not change by more than that per time-step
381	`nangsmg`	2	smooth some gradients used for computation of the rotational instabilities over that much grid points on either side. A Gaussian smoothing profile is used
382	`angsml`	1.0D-3	secular rotational mixing processes may change by at least that fraction for the local zonal diffusion time-scale
383	`angsmm`	1.0D-3	secular rotational mixing processes may change by at least that fraction of the total diffusion coefficient
384	`ipapsize`	6120792	paper size in points (inch/72). First 4 digits give width, last 4 digits give height. A value of 0 selects DIN A4 paper size. The default value is letter paper size.

385	`hstatxm`	1.D99	interior mass coordinate (g) above which hydrostatic stratification is assumed.
386	`hstatym`	-1.D99	surface mass coordinate (g) above which hydrostatic stratification is assumed
387	`xmlossw`	0.0D0	multiplier on WR mass loss rate
388	`iold`	0	set to 1 to use old physics
389	`rhotrans`	1.0D-7	Some SNIa stuff. *Ask Stan.*
390	`nwndout`	0	write out wind data to wind file PROBNAME.wnd every nwndout cycles. Set to zero to turn off.
391	`kapverb`	0	verbostiy of opacity subroutine. Zero gives no messages.
392	`xl0limf`	4.0D0	multiplier on limiting flux in radiation flux limiter.
393	`xl0limk`	0.0D0	limiting flux multiplied by $\exp\left\{\frac{4\pi\ \mathtt{rn}^2\ \mathtt{xl0limk}}{\kappa\ \mathtt{xm}}\right\}$.
394	`llimout`	1	limit to radiative flux of outer zone only if set to 1 (old behavior), otherwise limit to flux of the hotter zone (upper or lower).
395	`nenout`	0	write out total energies in file PROBNAME.ent every nenout cycles. Set to zero to turn off.
396	`ipromin`	1	minimum zone for procuction factor/yield plot
397	`ipromax`	99999	maximum zone for procuction factor/yield plot
398	`iprownd`	1	take into account wind when computing production factors/yields if set to 1, ignore if set to 0.

399	`iproyld`	0	determines the BURN abundance plot type (plot 9). The following plot types are currently supported: 0 total decayed mass fractions relative to solar ("production factors") see `profmin (p 413)` and `profmax (p 414)` 1 decayed isotope masses in solar masse (yield); see `proymin (p 402)` and `proymax (p 403)` 2 undecayed isotope masses in solar masses (yield) see `proymin (p 402)` and `proymax (p 403)` 3 decayed isotope mass fraction see `proamin (p 415)` and `proamax (p 416)` 4 undecayed isotope mass fraction see `proamin (p 415)` and `proamax (p 416)` 5 elemental decayed production factor relative to solar see `profmin (p 413)` and `profmax (p 414)` 6 decayed mass of all elements in solar masses (yield) see `proymin (p 402)` and `proymax (p 403)` 7 decayed mass fraction of all elements see `proamin (p 415)` and `proamax (p 416)` 101 values in `burnamax`, undecayed isotope mass draction 102 values in `burnmmax`, mass coordiantes 103 values in `ibcmax`, cycle numbers Stable isotopes are drawn as filled dots, unstable ones a circles.
400	`minapro`	-1000	minimum mass number for production factor/yield plot; automatic determination if set LE -99.

401	`maxapro`	-1000	maximum mass number for production factor/yield plot; automatic determination if set LE -99.
402	`proymin`	1.D-10	minimum value for yield in BURN plot types 1, 2 and 6 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
403	`proymax`	1.D3	maximum value for yield in BURN plot types 1, 2 and 6 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
404	`xkdmin`	1.d-20	minimum value for density used in subroutine kappa.
405	`h1hdep`	1.d-2	central hydrogen abundance at which the #hdep dump is made.
406	`he4hedep`	1.d-2	central helium abundance at which the #hedep dump is made.
407	`nenuout`	0	cycle frequency used to write enu data file.
408	`optconv`	2./3.	minimum optical depth below (i.e., outside of) which zone are not allowed to become convective.
409	`rloss`	1.d99	maximum radius beyon which zones are removed from star (similar to vloss, p 271). Isotope masses are added to the wind arrays, `wind` and `windb`.
410	`tloss`	-1.d99	minimum temperature below which zones are removed from star (similar to tloss, p 409). Isotope masses are added to the wind arrays, `wind` and `windb`.
411	`tapprox`	-1.d99	minimum temperature for change to approx network. Operates similar to the `approx` command in link decks.

412	`semilan`	0.0D0	α efficiency parameter for semiconvection according to Langer et al. (1983, A&A 126, 207), generalized for general EOS by replacing in Eq. (10) $\nabla_{\rm L} - \nabla$ by $\nabla_{\rm S} - \frac{d\log\rho}{d\log P}(\Gamma_3 - 1)$. For an ideal gas with radiation the second term of the new expression is equal to $\nabla - \frac{\phi}{\delta}\nabla_\mu$, giving the original realtion from Langer et al. (1983). If `semilan` ≤ 0 the original prescription of Weaver, Zimmerman, & Woosley (1983) is used. Overshooting also is still treated that way.
413	`profmin`	1.D-4	minimum value for production factor in BURN plot types 0 and 5 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
414	`profmax`	1.D3	maximum value for production factor in BURN plot types 0 and 5 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
415	`proamin`	1.D-12	minimum value for the mass fraction BURN plot types 3, 4 and 7 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
416	`proamax`	1.D3	maximum value for the mass fraction BURN plot types 3, 4 and 7 (`iproyld (p 399)`). Automatic determination if set to 0.D0. If set to a negative value it forces (negated) this value, even if not required to show the data.
417	`yelimb`	0.497D0	minimum value of `yeburn` below which no BURN coprocessing is considered. Use this parameter in conjunction with `netmax` (p 240).
418	`irecb`	0	record maximum abundances in BURN network (and save in the restart dumps) if set to 1. See also new plots and terminal commands.

419	`bmasslow`	-1.D99	mass coordiante below which no BURN coprocessing is considered. This parameter is automatically changed (increased only) if a zone reaches a Y_e value below `yelimb` (p 417) (in the APPROX network) or the network number in the APPROX network rises above `netmax` (p 240). It is then set to just below the upper edger (in interior mass coordiante) of the cell.
420	`si28dep`	1.D-4	central ^{28}Si mass fraction at which the #`sidep` dump is made, if the mass fractions of ^{16}O and ^{4}He are below 0.01.
421	`ivspecl`	0	version of the special rate set to use. Currently `0` gives the lower limit rate set (as used by Hoffman et al. 2000) and `1` uses the NACRE rate set. `2` uses the standard rate set plus the upper bound of ^{22}Ne(α,n) and ^{22}Ne(α,γ) (constant 7% BR) as determined by Wischer (Aug 2000). `3` uses the NACRE rate set plus the upper bound of ^{22}Ne(α,n) as determined by Rayet et al. (2000). `4` uses the standard rate set plus the CF88 ^{22}Ne(α,γ) and ^{22}Ne(α,n) rates. `6` uses the standard rate set plus the ^{22}Ne(α,n) rate from Jaeger et al. (2001) and the ^{22}Ne(α,γ) rate lower limit from Kaepeller, i.e. dropping the 633 resonance, and moving the 828 keV resonance to 832 keV with a strength of 118 meV. `8` is same as above, but uses the *high* limit ^{22}Ne(α,n) rate of Jaeger et al. (2001). `10` is same as above, but uses the *lower* limit ^{22}Ne(α,n) rate of Jaeger et al. (2001).
422	`ivrate`	1	version of the APPROX network rate subroutine to use. Currently `0` gives the WW95 rate set, `1` uses the rath00 rate set including the C12(α,γ) rate form Buchmann et al. (2000) + Buchmann, priv. comm. (Jul 2000), and `2` uses the NACRE rate set. On restart of older programs a value of `0` is initialized. `ivrate` values of `3`, `4`, and `5` use the rath00 rate set but the *adopted*, *high*, and *low* values of Kunz et al. (2002, ApJ). This also selects these rates in the rath00 rate set BURN coprocessing "special" subroutine `specl0` (see `specl.f` and `specl0.f`.)

423	`magnet`	0	magnetic fields according to Spruit (2001), in prep., are included if set to `1`. In this case, in semiconvective regions only the N_μ^2 limiting case of Spruit's description is considered. If set to `2`, in semiconvective regions the geometric mean between the N_μ^2 limiting case and Schwarzschild convection is assumed (recommended by Spruit). If set to `3`, N_μ^2 is multiplied by `0.1`. If set to `4` an old buggy case is reproduced in which η_1 does not include the second term in the max statement of equation (36) of Spruit 2002, A&A, 381, 923. If set to `5` an old buggy case is reproduced in which q_1 is missing a factor $(\Omega/N_T)^{1/4}$.
424	`nosht`	2	convective zones are bound by overshooting layer only of they are at least `nosht` zones thick. This is to prevent the numerical "spaghetti" instability. Old dumps are restart with the previous standard value of `nosht`
425	`alpth`	1.	efficiency factor for thermohaline convection. If set to zero no thermohaline convection is considered. Thermohaline convections occurs in regions with destabilizing composition gradient, but stabilizing temperature gradient (salt finger instability). The implementation in KEPLER is according to Braun (1997, PhD thesis) and Kippenhahn et al. (1980)
426	`abarstep`	1.d99	no rezoning is performed when the region under consideration contains a step in ABAR of more than `abarstep`.
427	`zbarstep`	1.d99	no rezoning is performed when the region under consideration contains a step in ZBAR of more than `zbarstep`.
428	`xmustep`	1.d99	no rezoning is performed when the region under consideration contains a step in the mean molecular weight, μ =ABAR/(1+ZBAR) of more than `xmustep`.
429	`netmin`	1	minimum APPROX network number until which BURN coprocessing is followed. This is usefull in combination with `iburnye` so that BURN is still active when switching to QSE.

430	`awcorot`	-1.0D0	make the outermost `ymcorot` (p 431) rotate with angular velocity `awcorot`. Off if $< 0.0D0$.
431	`ymcorot`	-1.0D0	make the outermost `ymcorot` totate with angular velocity `awcorot` (p 430). Off if $< 0.0D0$.
432	`nstrout`	0	write out structure data every `nstrout` time steps. No data is written if `nstrout` is 0.
433	`mixcycl`	0	do mixing at beginning (`mixcycl` $= 1, 2$) or at end of cycle (`mixcycl` $= 0$; default behavior). `mixcycl` > 0 is *extremely* helpful to prevent fatal crashes due do mixing after a too long time step, e.g., off-center burning shells that burn inward. `mixcycl` $= 1$ uses always the new time step (`dt`) for mixing, `mixcycl` $= 2$ uses the old time step (`dtold`; magnitude of mixing consistent with `mixcycl` $= 0$) for mixing unless a backup occurs, then also the current time-step of the backup cycle (`dt`) is used. When a backup occurs, the original mass fractions are restored and the star is re-mixed with the new time-step. Effective diffusion coefficients as used for the mixing are stored in the restart dump.
434	`lburn`	0	substitute BURN network for APPROX network (including energy generation, $\bar{A}$, $\bar{Z}$, ...) when set to `1`. Abundances are mapped to APPROX abbundances for plot/edit purposes only.
435	`lbbkup`	2	This parameter is regulates the behavior of `lburn`. A value of `lbbkup` $= 1$ enforces only one BURN inversion cycle. If there is a backup in BURN when using LBURN, the cycle will enconter a backup. A value of `lbbkup` $= 2$ allows backups in BURN but will generate a cycle backup if the maximum number of "*negative abundance BURN backups*" is exceeded. The *old* defailt behavior (`lbbkup` $= 0$) is to allow backups in BURN, but end KEPLER if it encounters "*excess negative abundance BURN backups*". Since `lbbkup` $= 2$ does not seem to cause problems, this has been set as the new default value as of 20090716 (KEPLER version 16.79)
436	`rlossmin`	1.D0	minimum radius for which to apply `vloss` (p 271).
437	`lcout`	0	number of outer layes to be written in light curve output file.

438	`xmagfmu`	1.D0	multiply μ-gradient by this factor.
439	`xmagft`	1.D0	multiply T-gradient by this factor.
440	`xmagfnu`	1.D0	multiply eddy viscosity by this factor.
441	`xmagfdif`	1.D0	multiply eddy diffusivity by this factor.
442	`dxncbkup`	1.D-7	backup if abundance change vector `dy` returned from `subroutine burn` implies a mass non-conservation larger than dxncbkup.
443	`iplotb`	0	if BURN is used, in abundance plot, PLOT 3, plot BRUN abundaces instead of APPROX/QSE/NSE abundaces. IF set to 1, only plot BURN abunances in the APPROX regime, if set to 2, plot BURN abundances everywhere where BURN is used, i.e., above `bmasslow`, and if set to 3, plot BURN abundances everywhere.
444	`minzone`	1	Do not rezone the innermost `minzone` zones. The `old` default is to not rezone the innermost zone. A value of `minzone` = 0 allows to rezone the innermost zone.
445	`zonemmax`	1.D99	do not dezone zones bigger than `zonemmax`.
446	`tenubar`	-1.D0	electron anti-neutrino temperature (MeV) for core collapse neutrino flux. Use `tenu (p 289)` instead if `tenubar` is negative.
447	`levcnv`	1	number of levels per dex for `cnv` output file.
448	`mingain`	-1	log of minimum energy generation (nuclear + neutrinos) for `cnv` output file.
449	`minloss`	-1	log of minimum energy loss (nuclear + neutrinos) for `cnv` output file.
450	`minnucl`	-1	log of minimum nuclear energy loss for `cnv` output file.
451	`ddmin`	-1.D0	minimum density for dezoning.
452	`iazonef`	1	allow (1) or disallow (0) adzoning.
453	`dynfac`	1.D0	multiplier on dynamic time-scale used to determine whether to treat problem (zones) as "dynamic" or "static" in `subroutine update`. A value of "0.D0" means that all zones are always treated hydrostatic.
454	`h1hburn`	0.4	hydrogen mass fraction at which to make the `#hburn` dump.

455	`c12heign`	0.01	carbon mass fraction at which to make the `#heign` dump.
456	`he4hebrn`	0.5	helium mass fraction at which to make the `#heburn` dump.
457	`zonermin`	-1.	minimum zone thickness below which no adzoning is allowed.
458	`zonermax`	-1.	maximum zone thickness above which no dezoning is allowed.
459	`xmixnova`	0.	extent (in mass) of a linear composition gradient between substrate and newly accreted material. The surface material is taken from `compsurf`/`compsurfb`, the substrate material from outermost layer of the hydrogen-free core ($X < 10^{-5}$).
460	`accmass`	0.	set mass of the accreted zones if positive. If negative, the mass of the acceted zone is -`accmass`×`totm (q 17)`. If zero the mass of the new zone is that of the current outermost zone. The mass of the new zone is, however, limited to not be different from the outermost zone by more than a factor `accmassf (p 461)`.
461	`accmassf`	1.4142	The mass of newly accreted zone is may not differ by more than a factor `accmassf` from the current outermost zone. In combination with `accmass (p 460)` this can be used to accrete a "ramp" of changing zone masses. Good either for well resolved interfaces or fine surface zoning.
462	`vinstopm`	1.d99	upper mass (g) limit for which infall velocity is checked to determine whether #presn has been reached.
463	`lowamul`	0	minimum mass number for which weak rates are modified.
464	`pdmult`	1.	multiplier on positron decay/electron capture rate for `lowamul (p 463)`≤`ihwamul (p 466)`.
464	`edmult`	1.	multiplier on electron decay rate for `lowamul (p 463)`≤`ihwamul (p 466)`.
466	`ihwamul`	0	maximum mass number for which weak rates are modified.
467	`kapburn`	0	when set to 1 use BURN abundances to compute opacity.

468	`fackap`	1.	multiply opacity and its derivatives by `fackap`.
469	`awwkloss`	1.D99	remove all outer shells that have an angular velocity `angwwk` times bigger than Keplerian velocity.
470	`lossrot`	0	if set to 1 use Langer's (1998) formular for rotationally enhanced mass loss.
471	`ymjkep`	-1.d99	reduce angular momentum to keplerian angular momentum in the surface layes down to an exterior mass of `ymjkep` (if it excessd keplerian rotation). This is uefule for some accretion problems of for mapping stars with too much rotation into KEPLER, e.g, from merging binaries.
472	`maxzone`	0	Do not rezone outermost `mazxone` zones. The implicit default for old runs was 2, which is used when restarting an old run.
473	`cfakexp`	0.d0	metalicity dependent mass loss scaling with C abundance for cool Pop III stars. If underabundant in C and Fe relative to total metallicity, reduce mass loss by abundance fraction of C+Fe relative to its solar value, to power `cfakexp`/
474	`minnucg`	-1	log of minimum nuclear energy generation for `cnv` output file.
475	`mingaind`	21	log of minimum energy generation (nuclear + neutrinos) per cm for `cnv` output file.
476	`minlossd`	21	log of minimum energy loss (nuclear + neutrinos) per cm for `cnv` output file.
477	`minnucgd`	21	log of minimum nuclear energy generation per cm for `cnv` output file.
478	`minnucld`	21	log of minimum nuclear energy loss per cm for `cnv` output file.
479	`tweakmin`	0.5	minimum temperature (10^9 K) for weak rates. For some problems, like XRB, this should be set to a lower value.
480	`centmult`	0.0	Multiplier on simplistic centrifugal force (just use j^2/r^3).
481	`mixout`	0	write out mixing file every `mixout` cycles.
482	`irprox`	1	if `1` use RPROX network when in right temperature and hydrogne mass fraction regime (default); if `0` *never* use RPROX; if `2` use RPROX network independent of `yp` mass fraction; if `3` *always* use rprox network.

483	`n14pg`	0	If set to one, multiply the first term of the CF88 N14(p,g) rate by 0.54. This is to account for new measurements.
484	`r3amult`	1.	multiplyer on triple-alphareaction rate. Is used in both APPROX and BURN networks. If `-1.D0` use rate by Ogota, fit by Richard Cybert, added 20091006.
485	`ibwarn`	1	show warning messages for bad rates in `subroutine rateb` if set to `1` (default) or suppress them if set to 0.
486	`ifallbk`	0	switch on fallback if > 0. Fallback rate is stored in `fbrate (q98)` and total fallback mass in `fallback (q99)`. A value of `1` switches on simple outflow condition. A value of `2` switches on pressure matching (experimental).
487	`xnumu12`	0.0D0	neutrino magnetic moment in units of $10^{-12}\mu_{\rm B}$. Changes neutrino loss rates (only plasma neutrinos for now).
488	`nzsave`	0	number of older z files to save. They are named *z1, *z2, ...
489	`axion`	0.0D0	axion mass in eV. Add energy loss similar to neutrino loss. The loss rate is proportional to the square of `axion`.
490	`zmhiconv`	1.0D99	maximum mass for convection (in g).
491	`rnhiconv`	1.0D99	maximum radius for convection (in cm).
492	`icutbin`	1	truncate binary output files on restart/generation if set to 1 (one). This is done at the end of the first time step, before new records are written to the binary output files.
493	`nconvers`	¡most recent version of	version of the convection output file. This is to allow compatibility of newer KEPLER versions with older runs - do not change the data file version during the run. Usually you would not want to change the value of this paramter by hand unless you really know what your are doing. PURPOSE: When starting an old run with a newer version of KEPLER, ir will continue to appaned data in the old output format.

494	`nwndvers`	¡most recent version of	version of the wind output file. This is to allow compatibility of newer KEPLER versions with older runs - do not change the data file version during the run. Usually you would not want to change the value of this paramter by hand unless you really know what your are doing. PURPOSE: When starting an old run with a newer version of KEPLER, ir will continue to appaned data in the old output format.
495	`h1hign`	1.D-2	mass fraction of ^{1}H burnt to write out the `#hign` dump. KEPLER set `h1init (q 101)` to the initial value found at the end of the first time step at the center and computes the burnt hydrogen mass fraction relative to that.
496	`wimp`	0.0D0	WIMP mass in GeV. WIMP annihilation is disabled if set to `0.D0`.
497	`ipdtmin`	0	minimum time between plot outputs in seconds. This is useful to limit outpu in interactive mode, especially on remote hosts so that the run is not slowed down by the graphicalk output.
498	`minneug`	-1	log of minimum neutrino energy generation (deposition?) for `cnv` output file.
499	`minneul`	-1	log of minimum neutrino energy loss (deposition?) for `cnv` output file.
500	`minneugd`	21	log of minimum neutrino energy generation (deposition?) per cm for `cnv` output file.
501	`minneuld`	21	log of minimum neutrino energy loss per cm for `cnv` output file.
501	`minneuld`	21	log of minimum neutrino energy loss per cm for `cnv` output file.
502	`wimpsip`	1.D-43	spin-*in*dependent cross section of WIMPs on protons in cm^2.
503	`wimpsin`	1.D-43	spin-*in*dependent cross section of WIMPs on protons in cm^2.
504	`wimpsdp`	1.D-38	spin-dependent cross section of WIMPs on protons in cm^2.
505	`wimpsdn`	1.D-38	spin-dependent cross section of WIMPs on protons in cm^2.
506	`wimprho0`	1.D13	WIMP density in GeV/cm^3.
507	`wimpv0`	1.D6	WIMP velocity dispersion in cm/s.

508	`wimpvelo`	0.D0	velocity of star relative to WIMP dark matter halo in cm/s.
509	`iwimpb`	1	Use BURN abunances (`1`) or APPROX abundances (`0`) for WIMP cross section calculation.
510	`angw0`	0.D0	angular velocity of the inner `angw0m` (p 511) mass.
511	`angw0m`	-1.D0	mass coordinate (not including `summm0`) for which inner angular velocity `angw0` (p 510) is set. A negative value disables setting of inner region angular velocity (default).
512	`angjacc`	0.D0	specific angular momentum of newly accreted material.
513	`zoneymax`	1.D99	do not dezone zones with `xm(i)/ym(i)` > `zoneymax`.
514	`accdepth`	0.D0	depth where mass is to be accreted. If set to $0.D0$ zones are accreted at the surface (traditional behavior). If < 0 accrete a zone with mass fraction `-accdepth`=(ym)/`totm0`. If > 0 accrete at location `accdepth`=(ym).
515	`pulse051`	0.D0	initial pulsar rotational energy in "Bethe" (B). Energy is deposited in the innermost `pulsnz (p 517)` zones. If set to 0.D0 no pulsar energy deposition is implemeneted. Radioactive ^{56}Ni decay is used instead.
516	`pulsb15`	0.D0	pulsar is the magnetic field in 1×10^{15} Gauss. If set to `0.D0` no pulsar energy deposition is implemented. See `pulse015 (p 515)`.
517	`nzpuls`	10	number of zones over which to distribute pulsar energy. If set to `0` no pulsar energy deposition is implemented. See `pulse015 (p 515)`.
518	`fracadz`	2.D0	maximum ratio of mass accreting zone before it is forced to `adzone`.

519	`losseadv`	1	include energy term from advection in mass loss. `0` to switch off. `1` for average of zone interface values (recommended). `2` a simple symmetric scheme that is second order for equidistant zone masses. `3` use average gradient and zone center pressure. `4` use second-order gradient and zone center pressure. `5` for downward differencing (poor choice). `6` for upward differencing (poor choice). `7` use downward boundary value only (seems sub-optimal choice). `8` use upward boundary value only (seems sub-optimal choice).
520	`iacceadv`	1	include energy term from advection in accretion. `0` to switch off. See `losseadv (p 519)` for values.
521	`iaccadv`	1	do advection of composition if set to `1`. If set to `0`, composition is not advected; this can be useful for setting up initial models for accretion problems.
522	`tnumin`	1.D7	minimum temperature for neutrino losses if APPROX and BURN are not active.
523	`isurf`	0	Do atmosphere model for boundary pressure and temperature if set to `1`. **** In development. ****
524	`nlogout`	1	output log file if `1`.
525	`ipnuc`	1	do nuclear burning/energy generation. Same use of `jshell0` and `jshell1` as `ipup`.
526	`ipnu`	1	do neutrino losses. Same use of `jshell0` and `jshell1` as `ipup`.
527	`amasslow`	-1.d99	minimum mass for APPROX network. Similar to `bmasslow`.
528	`umasslow`	-1.d99	minimum mass for neutrino losses. Similar to `bmasslow`.

529	idecmode	1	mode for "decretion" model. No decretion if idecmode is 0. If set to 1 decreted mass will be added to decmass (q 130) otherwise to summ0 (p 61). It will always also be added to xmdec (q 129).
530	decrate	0.D0	rate of mass decretion from inner zone. Use accretion rate if set to a negative values.
531	fracdec	1.D0	fraction of mass if inner zone for dezoning if in decretion mode.
532	jmdec	1	zone from which to remove mass.
533	lumdata	1	use PROBNAME.lum file for base luminosity. The file contains a comment line with version information, then a line with the number of entries (I6), then the data in two columns: time in seconds and base luminosity xlum0 in erg per second (2E13.6)
534	acctimef	1.d0	multiply accretion time and time scale by this factor for accretion data from a file. This is to simulate redshift time delay.
535	xl0timef	1.d0	multiply base luminosity time and time scale by this factor for accretion data from a file. This is to simulate redshift time delay. Usually you would use this in combination with acctimef (p 534)
536	nsekout	0	Write out like file for NuGrid.
537	iadapv	1	Verbosity of adapent output. Be quite of set to 0.
538	ittyv	1	Verbosity of tty output. Be quite of set to 0.
539	ihe4cc	1	switch on charged current neutrino reactions on ^{4}He if set to 1. This reaction was added to KEPLER on 20110317.
540	inuenc	1	Switch on neutral current due to electron neutrinos if set to 1. This reaction was added to KEPLER on 20110317 to allow for hard electron neutrinos due to oscillations.
541	inuebnc	1	Switch on neutral current due to electron anti-neutrinos if set to 1. This reaction was added to KEPLER on 20110317 to allow for hard electron neutrinos due to oscillations.
542	ibdatov	0	allow bdat rates to overwrite any specl#.f rates if set to 1. If set to 0, only rates 21 and 22 will be overwritten. For any other value, at the present, all bdat rates will be overwritten if hard-coded.

543	`h1hm2`	2.d-2	mass fraction of ^{1}H burnt to write out the `#hm2` dump. KEPLER set `h1ini (q 101)` to the initial value found at the end of the first time step at the center and computes the burnt hydrogen mass fraction relative to that.
544	`h1hm5`	5.d-2	mass fraction of ^{1}H burnt to write out the `#hm5` dump. KEPLER set `h1ini (q 101)` to the initial value found at the end of the first time step at the center and computes the burnt hydrogen mass fraction relative to that.
545	`h1hm10`	1.d-1	mass fraction of ^{1}H burnt to write out the `#hm10` dump. KEPLER set `h1ini (q 101)` to the initial value found at the end of the first time step at the center and computes the burnt hydrogen mass fraction relative to that.

3 Changed Parameters (by value)

P	name	default	description
87	idzonef	1	value changed to flags: 1: do dezoning; 2: write edits; 4: exit on failure
69	pbound	0.0D0	the boundary pressure from the accretion phantom zone is no longer added here. I goes now into pboundac (q 96).
137	bethemt	0.0D0	Disabled and removed. We now use the weak rates from Langanke & Martínez (2000) replaced by nadapb for adaptive BURN network adjustment.
204	abunminx	-1.E-5	Negaive abundance backup now checked for all isotopes in APPROX independent of their abundance. Now only the absolute value of abunminx is considered, i.e., backups are made if and isotope mass fraction is less than −ABS(abunminx).
211	accrate	0.0E0	**New:** Negative accretion rate now reads in time-dependent accretion rate data from file PROBNAME.acc. The file contains a comment line with version information, then a line with the number of entries (I6), then the data in two columns: time in seconds and accretion rate in grams per second. FORMAT: (2E13.6). The resulting rate is multiplied by −accrate to allow scaling without having to change the file.
271	vloss	1.d99	zones exceeding vloss are cut off the surface, keeping tbound (p 68) and pbound (p 69). **New:** the APPROX and BURN isotope masses are added to the "wind" arrays.
313	fmaxmcig	1.d0	reset fmax0 (p 150) to fmax0cig (p 313) at #cign (tn(1) > tempcig (p 311)) **New:** unless fmax0cig (p 313) is 0. or less.
314	fmax0cig	1.d0	reset fmaxm (p 195) to fmax0cig (p 314) at #cign (tn(1) > tempcig (p 311)) **New:** unless fmaxmcig (p 314) is 0. or less.

4 New Edit ('Q') Parameters

Q	name	description
78	`eninr`	initial rotational energy (erg)
79	`enr`	current rotational energy (erg)
80	`anglint`	initial angular momentum (erg·sec)
81	`anglt`	current angular momentum (erg·sec)
82	`xmlossr`	current mass loss rate (g/sec)
83	`zfak`	computed metallicity multiplier on mass loss rate
84	`enn`	total neutrino energy lost from the star (erg)
85	`enpist`	total energy input by the piston (erg)
86	`enpistd`	energy input rate by the piston (erg/sec)
87	`capeff`	opacity at effective radius (cm^2/g)
88	`xmlost`	mass lost in the "wind" (g)
89	`radconv`	radius (cm) outside of which no convection is allowed. This value is determined using optconv (p 408).
90	`zninvl`	number of BURN matrix inversions in last cycle.
91	`ngbkup`	number of negative abundance backups in SDOT for APPROX network
92	`mncbkup`	number mass non-conservation backups in SDOT for APPROX network
93	`nacbkup`	number of excess abundance change backups in SDOT for APPROX network
94	`isebkup`	number if ISE non-convergence backups in SDOT
95	`enhd`	rate of change of thermal ("heat") energy content = $\int_0^M c_{\mathrm{V}}(T(m,t))\,(T(m,t)-T(m,t-\Delta t))\,\mathrm{d}m\,/\,\Delta t$.
96	`pboundac`	boundary pressure due to accretion; this is not added to pbound any longer
97	`velnegm`	This quantity is for fallback test only. Stores the maximum mass coordinate for which negative velocities occurred instead matter moving outward 1000 km/s or faster. This edit quantity can be reset using `resetvnm`.
98	`fbrate`	Fallback accretion rate.
99	`fallback`	Total fallback mass.
100	`ncycr`	Cycle of problem generation or last restart.

101	`h1init`	Initial central hydrogen mass fraction. This is set to the central value at the end of the time step if the present value of `h1init` is less then `-0.5`.
102	`enrd`	Change of rotational energy during last (?) step.
103	`ilastpl`	"Time-of-day" seconds of last plot. Used *internally* to limit plot outputs in interactive mode.
104	`itimeg`	time/date when problem was generated
105	`itimed`	time/date when dump was generated
106	`entloss`	total energy removed from problems by cutsurf
107	`eniloss`	internal energy removed from problems by cutsurf
108	`enkloss`	kinetic energy removed from problems by cutsurf
109	`enploss`	potential energy removed from problems by cutsurf
110	`enrloss`	rotational energy removed from problems by cutsurf
111	`angloss`	total angular momentum removed from problems by cutsurf
112	`anglwnd`	total angular momentum lost due to wind
113	`angit`	total momentum of inertia of the star;

$$\int_0^M \frac{2}{3} r^2 \,\mathrm{d}m \approx \frac{2}{5} \sum_{j=1}^{jm} \frac{r_j^5 - r_{j-1}^5}{r_j^3 - r_{j-1}^3} \Delta m_j = \ldots$$

$$\ldots = \frac{2}{5} \sum_{j=1}^{jm} \frac{r_j^4 + r_j^3 r_{j-1}^1 + r_j^2 r_{j-1}^2 + r_j^1 r_{j-1}^3 + r_{j-1}^4}{r_j^2 + r_j r_{j-1} + r_{j-1}^2} \Delta m_j$$

114	`wimpcrsi`	WIMP spin-*indepenedent* capture rate in 1/s
115	`wimpcrsd`	WIMP spin-*depenedent* capture rate in 1/s
116	`wimparad`	WIMP annihilation radius scale in cm
117	`wimpateq`	WIMP capture & annihilation equilibrium time scale in s
118	`wimparat`	WIMP annihilation rate in s (two WIMPs annihilate in one annihilation "event")
119	`wimpalum`	total WIMP annihilation luminosity as computed by WIMP subroutine in erg/s
120	`eprodw`	WIMP energy deposition rate in star in erg/s
121	`eprow`	total energy deposited in star by WIMP annihilation in erg
122	`eprodwx`	WIMP annihilation luminosity *outside* star in erg/s
123	`eprowx`	total energy prodoced by wimps OUTSIDE star by WIMP annihilation in erg
124	`xmacc`	total amount of mass accreted in g

125	`dmacc`	mass accreted in last time step in g
126	`jloss`	mass losing zone
127	`jacc`	accretion zone
128	`delmass`	mass lost in last time step in g
129	`xmdec`	total mass removed from bottom
130	`decmass`	total mass removed from bottom and not added to substrate
131	`dmdec`	mass removed in last time step
132	`xmacrate`	accretion rate
133	`he4init`	initial ^{4}He
134	`zinit`	initial metallicity
135	`xladv`	current advection luminosity

5 New Terminal Commands

`fin`
`end`
`exit`
`stop`
`bye`
`quit`
`halt`
Because I am tired of having to remember all the different commands for program termination for the different programs all these commands do the same: just terminating.

`pulsedit` [*FILENAME*]
write out a pulsation edit file needed by Isabelle Baraffe's and Jeremiah Murphey's code. This file contains several thermodynamical quantities and hard-to-compute derivatives. If no filename *FILENAME* is given the generic name *PROBNAME-CYCLENUMBER* is used.

`pulsednr` [*FILENAME*]
write out a pulsation edit file needed by Jeremiah Murphey's code. This file contains several thermodynamical quantities and hard-to-compute derivatives. If no filename *FILENAME* is given the generic name *PROBNAME=CYCLENUMBER* is used.

`closewin`
closes the graphics window.

`kapedit` *GRID TLOW THI NTEMP DLOW DHI NDENS EPS*
makes a kappa edit to the screen. *GRID* is the cell number the composition for evaluation of the opacities is taken from, *TLOW* the lower bound temperature, *THI* the upper bound temperature, *NTEMP* the number of temperature grid points, *DLOW* the lower bound temperature, *DHI* the upper bound temperature, *NDENS* the number of density grid points, and *EPS* the relative change in temperature and density, respectively, used for numerical derivatives. The output is a list of temperature, density, opacity, analytical derivative of the opacity for temperature and density, respectively, numerical derivative of opacity for temperature and density, respectively, and, finally, the deviations between the numerical and analytical determinations of the derivatives.

`solidrot`
brings the star to solid body rotation.

`setspin` *VALUE* [`mult` — `div`]
If the optional keyword `mult` is present, multiply the rotation rate the factor *VALUE*, if the optional keyword `div` is present, divide the rotation rate the factor *VALUE*. Otherwise set the **total** angular momentum to *VALUE*, keeping the relative distribution of the angular momentum profile. To enforce rigid rotation afterwards, use the `solidrot` command.

`mode`
echos whether KEPLER is in interactive mode or not. This is used for an IDL interface I wrote.

`datapath` [*PATH*]
sets the "data path" (variable "datapath") where KEPLER looks for data files if they cannot be found in the local directory. If *PATH* is omitted the current value of "datapath" is displayed. If *PATH* is set to *CLEAR* the variable "datapath" is erased. If the environment variable "KEPLER_DATA" is set, KEPLER will also look in the path specified in the variable for data file if they cannot be found in the local directory or the directory specified in "datapath" (if set). This allows for a machine-dependent setting of the data path and is probably the better way in most cases when general/global files are to be used. However, the "datapath" allows to give the location of specialized files (maybe as relative path). In both cases, "datapath" and "KEPLER_DATA" the character "∼" (tilde) is replaced by the value of the system variable "HOME", allowing for machine-independent specification of paths.

`wind`
`windb`
write the wind / windb data to the screen.

`core` [*COREXLIM* [*COREFELM*]]
writes the different core sizes to the screen. The values given are the shell number (j), interior mass (zm), radius (rn), exterior binding energy (ybind), and total entropy at the core boundary (stot). These values are displayed for the center of the star, the ye-jump (ye drops below 0.49), the boundary of the approx network, the O shell (maximum in energy generation by O burning), the iron core (defined by the mass fraction of heavy elements with mass number > 46 exceeding $1/2$), the Si core (Si mass frac-

tion >*COREFELM* and Si mass fraction bigger than O mass fraction), the Ne/Mg/O core (C mass fraction first drops below *COREXLIM* and iron is more abundant than *COREFELM*), the C/O core (He mass fraction first drops below *COREXLIM* and iron is more abundant than *COREFELM*), and the helium core (H mass fraction first drops below *COREXLIM* and iron is more abundant than *COREFELM*).

`copycomp` *JGRID*
copy the composition of shell *JGRID* into the internal array `XNWCOMP`.

`prncomp`
print the internal composition array `XNWCOMP`.

`setcomp` *IFIRST ABUN1 ABUN2 ...*
set the values of the internal composition array `XNWCOMP` are to *ABUN1*, *ABUN2 ...*, starting with index *IFIRST*. See original documentation for the index/isotope relation.

`newnetb` *FILENAME*
generate new BURN network from file *FILENAME*. Currently only the `net`, `netw`, `p`, and `c` cards are supported. The new network(s) has to include *all* isotopes of the previous network(s)! This command can also be used in aliases and link files.

`pf` | `yd` | `y` | `YD` | `Y` | `pfe` | `ye` | `YE` [`approx` | `burn` | `wind` | *NSTART* [*NEND*]]
makes abundance plots according to the command chosen:

`pf`	production factor of all stable isotopes relative to solar
`Y`	mass of all isotopes (in solar masses)
`YD`	decayed mass of all stable isotopes (in solar masses)
`y`	mass fraction of all isotopes
`yd`	mass fraction of all stable isotopes
`pfe`	elemental decayed production factor relative to solar
`YE`	decayed mass of all elements (in solar masses)
`ye`	decayed mass fraction of all elements

If `approx` is given everything in the APPROX network plus the wind is summed up. If `burn` is given everything that is processed by the BURN network, i.e., that has a mass coordinate at the base of the zone bigger than `bmasslow` (`p 419`), plus the wind is summed up. If `wind` is given only the wind is summed up. *NSTART* and *NEND* indicate the lower and upper zone number limit for summing abundance. If *NEND* is not given, it is assumed

equal to *NSTART*; if it is bigger than `jm` (`q 2`) the wind data is plotted. Negative values of *NSTART* and/or *NEND* indicate zones counted from the surface (i.e., 0 corresponds to the surface zone, -1 to the zone below the surface zone and so forth). If (and only if) *NSTART* and/or *NEND* are bigger than `jm` (`q 2`; e.g., 99999) the wind is added. So, to see everything in star above a given shell number but excluding the wind, 0 (zero) should be chosen as upper boundary!

`killburn`
turns off and removes the burn co-processing. `inburn` and `imaxb` are set to zero.

`burnamax`
prints the maximum abundances reached in the BURN network (only if `irecb` (p 418) is set to 1).

`burnaplt`
plots the maximum abundances reached in the BURN network.

`burnaclr`
reset the recording of maximum abundances of BURN network.

`arange` [*NSTART NEND*]
set the mass number range for BURN isotope plots. The edit parameters `minapro` and `maxapro` are set to the values given. If no values are specified they are set to their default values (-1000).

`k`
`kill`
immediately terminates KEPLER without the usual "shutdown logging".

`rateb` *TEMPERATURE DENSITY*
edit the BURN reaction rates (here: the `sig` array) for temperature *TEMPERATURE* and density *DENSITY*.

`ratenub` *R9 TIME*
edit the BURN neutrino reaction rates (here: the `signun` and `signuc` arrays, and some special reaction rates) for radius *R9* at time *TIME* after bounce. If *TIME* is omitted, 0 is assumed.

`weightb` *TEMPERATURE*

edit the BURN statistical weights (here: the `g` and `w` arrays) for temperature *TEMPERATURE*.

`flowb` *ZONE TEMPERATURE DENSITY TIMESTEP* [*RADIUS*] [*FILENAME* | `matrix`]
edit the BURN flows, abundances, partition functions, and reaction rates of zone *ZONE* for temperature *TEMPERATURE* (in K), density *DENSITY* (in $\mathrm{g\,cm^{-3}}$), and time step *TIMESTEP*. For neutrino exposure the radius *RADIUS* (in cm) is used or 10^{99} cm if omitted. The output is written to the file *FILENAME* or the screen if omitted. The filename "`-`" is used to indicate the current log file as output destination. If the flag "`matrix`" is given, a diagnostic of the non-zero matrix elements is printed to the screen. If *TEMPERATURE* or *DENSITY* are set to "`-`" the current values of zone *ZONE* are used. If *TIMESTEP* is set to "`-`" the new time-step "`dtnew (p 1)`" is used.

`alliso`
generates a BURN network that contains *all* isotopes from the `bdat` file (plus `p`, `n`, and ^{4}He). Useful for debugging purposes. For real simulations use the adaptive network instead.

`edep` [*STARTZONE* [*ENDZONE*]] *DELTA_E*
add *DELTA_E* to zones *STARTZONE* – *ENDZONE*. Same code as the `det` command except that the composition remains unchanged. Same treatment of zone numbers as with the `z` command.

`eostab2` *ZONE TLOW THI NTEMP DLOW DHI NRHO*
write out EOS table Type II for zone *ZONE* with *NTEMP* steps in temperature between *TLOW* and *THI DTEMP* steps in density between *DLOW DHI*. Similar to the `eostab2` command, but T, ρ, P, P_T, P_ρ, e, e_T, e_ρ, κ, and S are tabulated.

`mixcycle` [*0* | *1*]
perform mixing/diffusion operation using current coefficients and new time step (`dtnew`) if `mixcycl` (`p 433`) = 0. If the optional parameter is not set or not zero then the diffusion coefficients are zeroed to prevent additional mixing when the run is continued.

`burn` *DATAFILE*
do BURN processing of zone 1 according to history in *DATAFILE*. (not yet implemented)

`bstat`
output some BURN statistics

`![#]`
`!` re-executes the last command. If the number # is specified (no space between the `!` and the number) the command issued that many times earlier is re-executed. Currently # must be less than 100, since the history is limited to 100. The history is not saved to restart dumps.

`!!`
lists the last commands, last command last, and their number in the list to be used with the `!` command. The rest of the input line is ignored.

`pulsar` [*PSRMB*]
prints out estimated pulsar rotation rate. Optionally, the pulsar baryonic mass (*PSRMB*; in solar masses) can be specified. *(may need more documentation)*

`mapburn`
maps BURN abundaces to APPROX in all APPROX zones.

`compsurf` [*ZONE* — `show` | `clear` | *ABUN ion* | *IDXSTART ABUN1 ... ABUNN*]
`compsurb` [*ZONE* — `show` | `clear` | *ABUN ion* | *IDXSTART ABUN1 ... ABUNN*]
set APPROX (`compsurf`) and BURN (`compsurb`) accretion abundances.
Without parameter the abundance vector is copied from the outermost zone.
Here, `compsurf` copies only the APPROX abundances whereas `compsurb` copies only the BURN abundances. IF *ZONE* is specified, zone *ZONE* is used instead if the outermost zone.
If `show` is specified, the abundance vector is printed to the screen.
If `clear` is specified, the abundance vector is initialized to zero.
If abundance *ABUN* and *ion* the abundance of that isotope is set in the abundance vector is set to the specified value.
A series of n subsequent isotopes starting at index *IDXSTART* in the abundance vector can be set to the values *ABUN1 ... ABUNN*.
Note that by default the abundances of the outermost zone are copied in the surface composition vectors on problem generation so that, if this is desired, no additional `compsurf` *or* `compsurb` *command is required.*

`resetvnm`

resets the edit quantity velnegm to `0.0D0`.

`adzone` *ZONE*
manulally adzone zones *ZONE–ZONE+1* to zones *ZONE–ZONE+2*

`dezone` *ZONE* [`-`]
manulally dezone zones *ZONE–ZONE+2* to zones *ZONE–ZONE+1*. If "`-`" is given, ignore gradient constraints on rejecting dezoning.

`cutbin`
manually truncate binary output files to current cycle.

`x`
write out dump file then end KEPLER.

`setcycle` *CYCLE*
change cycle number to *CYCLE*. This changes edid quantity `ncyc`. The edit quantities `ncycb` and `ncycr` are also reset. For example, this leads to truncation of the binary log files like `*.wnd`, `*.cnv`, etc.

`newbin`
delete all output files (`*.cnv`, etc.) and reset all convection plot and wind parameters and version numbers to current default values.

`mapsurfb`
map `compsurfb` array to `compsurf` array.

`m` *VARIABLE* [*VARIABLE* [...]]
same as `mon` command except that mongo si quit immediately after making the plot.

`resetacc`
reset accretion q-parameter (`xmacc` (`q 124`)) to `0.D0`.

`resetdec`
reset decretion q-parameters (`xmdec` (`q 129`) and `decmass` (`q 130`) to `0.D0`.

`cpzone` *ZONE_FROM ZONE_TO_LOW ZONE_TO_HIGH* [*MODE*]
copy composition from zone reset *ZONE_FROM* to zone range specified by *ZONE_TO_LOW ZONE_TO_HIGH*. The optional parameter *MODE* specifies the adjustment of thermodynamics on the copied zone. Currently all

modes by default keep zone density. If *MODE* is skipped, the zone temperatures is not changed. The following values for temperature extrapolation are implemented:

(none) keep temperature

`ct` copy temperature

`ita` ideal gas temperature extrapolation adiabatic ($\gamma = 5/3$)

`rta` relativistic gas temperature extrapolation adiabatic ($\gamma = 4/3$)

`ltg` local gradient temperature extrapolation

`tpn` temperature exponent to fit pn(`ZONE_TO_LOW`)

`h` adjust temperature to get same pressure and density

`cnviso` *ISO_FROM ISO_TO FRACTION ZONE_START ZONE_END*
convert fraction *FRACTION* of BURN isotope *ISO_FROM* to BURN isotope *ISO_TO* in zones *ZONE_START* to *ZONE_END*. NOTE: At this time, this is all that happens; APPROX is not updates, neither is thermodynamics, abar, zbar, etc., so you may want to use it only with small mass fractions.

6 Changed Terminal Commands

`p` *NAME* | *NUMBER* [*VALUE* [`add` | `+` | `mul` | `*` | `div` | `/` | `sub` | `-`]]
`p` *NUMBER1* − *NUMBER2*
`p` *NUMBER1* `..` *NUMBER2*
`p` [*]*STRING*[*]
Display or change parameters. The second and third form print the values of a range of parameters (*NUMBER1* may be smaller or larger than *NUMBER2*). The third form prints all parameter that contain textslSTRING at the beginning (*STRING**), end (**STRING*)

`q` *NAME* | *NUMBER*
`q` *NUMBER1* [− | `..`] *NUMBER2*
Display edit parameters. The second form prints the values of a range of parameters (*NUMBER1* may be smaller or larger than *NUMBER2*).

`z`
`zed`
`v`
`vf`
`ved`
`vfed`
The treatment of grid-point numbers has been improved: Grid number 0 counts for the surface, and negative grid numbers are taken to be the corresponding negated grid point counted from the surface of the star. If two numbers are given, they are ordered by size automatically after, after negative grid-point numbers have been reinterpreted – so don't worry to give the upper bound grid-point number first.

`z`
`zed`
Instaed of integer grid numbers now floats are accepted as well an interpreted as the interior mass coordinate in units of solar masses.

`cutsurf` *NSURF* [+ | -]
Now also adds the mass of the isotopes of the zones "cut off" to the arrays "wind" and "windb". Same for the corresponding link command `cutsurf`.
If *NSURF* is negative, the zones -*NSURF* and above are removed.
The optional argument "-" keeps `tbound` (p 68) and `pbound` (p 69) unchanged.
The optional argument "+" keeps just `tbound` (p 68) unchanged.

`editiso`
is now prepared to work with arbitrary networks. It reads the solar abundances from the data file *solabu.dat* and the decay data / branch ratios from *decay.dat*. The yields and production factors are now given including the wind and additionally yields and production factors are given for the wind by itself. The data formats of the files *decay.dat* and *solabu.dat* are given at the beginning of the existing sample files.

`chngcomp` *JMIN JMAX* [*IFIRST ABUN1 ABUN2* ...]
changes the zonal composion of given range. If *JMIN* or *JMAX* are integer values (containing no ".") they are interpreted as zone numbers. If they are float values, they are interpreted as mass coordinates (in solar masses).
If *IFIRST*, *ABUN1*, *ABUN2* ... are given, the values of the internal composition array `XNWCOMP` are set to *ABUN1*, *ABUN2* ..., starting with index *IFIRST*. See original documentation for the index/isotope relation.
See also addon documentation for `copycomp`, `prncomp`, and `setcomp`.

`test` *TESTVAR J T D*
is now enhanced to allow the *TESTVAR* `d` to print the degeneracy parameter η and its derivatives. *J*, *T*, and *D* are the zone from which the composition is taken, the desired temperature and density, respecrively.

`mlim`
if only one argument is given, the maximum value is set to this and the minimum value to `summ0`. Then the plot is redone.

`sumi`[`g`|`sun`] [*JMIN JMAX*] [*ISOTOPE*]
`sumi`[`g`|`sun`] [*ISOTOPE*] [*JMIN JMAX*]
`sumb`[`g`|`sun`] [*JMIN JMAX*] [*ISOTOPE*]
`sumb`[`g`|`sun`] [*ISOTOPE*] [*JMIN JMAX*]
sums up and prints the total mass of a isotope *ISOTOPE* from zone *JMIN* to zone *JMAX*. `sumi` sums up isotopes in the APPROX network, `sumb` sums up isotopes in the BURN network. *ISOTOPE* must not contain a leading "`iso`" or "`ion`". If *ISOTOPE* is not given, all isotopes with masses greater than `abunlim` (`p 128`) or `abunlimb` (`p 272`), respectively, are printed. If *JMIN* and *JMAX* are not given, `1` and `jm` (`q 2`) are assumed. If *JMIN* or *JMAX* is less than one, the (unsigned) zone number is counted from the surface, i.e., `0` (zero) corresponds to the surface zone. If *JMIN* or *JMAX* is greater than `jm` (`q 2`) the wind is included. Note that *JMIN* and *JMAX* are sorted internally for the bigger and the smaller values, so that they are accepted in arbitrary order. The `sumb` and `sumi` forms return mass fractions, the `sumbg`

and `sumig` return absolute masses in grams, and the `sumbsun` and `sumisun` forms return absolute masses in solar masses.

`mix` *NZMIN NZMAX DELMASS* [*FLAG*]
mix zone by zone from zone *NZMIN* up to zone *NZMAX* over a mass "window" of *DELMASS*. Now also mixes BURN isotopes. If an additional forth parameter is given, `pbound (p 68)` and `tbound (p 69)` are not changed.

`addsurf` [*MSURF* | *NSURF MSURF TEMPSURF RHOSURF VELSURF*
If *no* parameter is given, the mass of the current "phantom zone" `xmacrete (p 212)` will be added as a new zone to the problem and `xmacrete (p 212)` will be set to zero.
If *one* parameter is given a mass of this zone will be accreted and `xmacrete (p 212)` will be reduced by this amount or set to zero if the result is negative.
If *five* parameters are given, *NMAX* zones with total mass of *MSURF*, temperature *TEMPSURF*, density *RHOSURF* and velocity *VLESURF* will be accreted.

`compsurf` see *new terminal commands*

7 Changed Generator Commands

The generator card `g` has been enhanced in order to allow for the addition of rotation on generation of the problem. The new format is

`g` *ZONE EXTMASS NETW TEMP RHO* [*OMEGA* [*VEL*]]

where *ZONE* is the zone number (starting at 0), *EXTMASS* is the exterior mass coordinate in g, *NETW* the network number, *TEMP* the temperature in K, and *RHO* the density in g/cm^3. The argument *OMEGA* is optional and a default value of 0 is supplied if *OMEGA* is given for none of the cards. However, if only some are missing, they are interpolated. *I.e.*, to generate an initial model with constant gradient in the rotational velocity (or a rigidly rotating model), only for the innermost and the outermost zone values for *OMEGA* have to be supplied. The radial velocity is set by the optional argument *VEL*.

`cutsurf`
see terminal commands.

8 New Generator Commands

`linkfile` *FILENAME*
Generate a stellar model from file *FILENAME*. When this command is used, no further generator cards are allowed nor needed. **Here should go a description of the file format...**

`rigidl` *VALUE*
This card allows to give the star the angular momentum *VALUE* (erg·sec) at startup and distribute it such that the star is rigidly rotating.

bounce JCUT TMIN RMIN RMAX ALPHA [`cut`] [`scut`] [`accel`]
This card generates a piston that moves inward from the outer boundary radius of zone *JCUT* to the radius *RMIN* in a time *TMIN*. The radius as a function of time is fit by a parabola with the initial slope being the velocity at the outer boundary of zone *JCUT*. After *TMIN* the piston moves outwards with the (negated) free fall velocity from a point at radius *RMAX* in a gravitational field that is *ALPHA* times that of the mass enclosed by the outer boundary of zone JCUT. When the maximum position of the piston is reached, the movement of the piston is stopped.
If the optional keyword `cut` is given, the innermost *JCUT* zones are cut away (see `cut` command). If *JCUT* is a floating point number, it is interpreted as the Y_e value where to locate the piston. If the keyword `scut` is set, it is interpreted as the entropy value where to locate the piston. If the keyword `accel` is set then *TMIN* is interpreted as the acceleration for the piston infall. The time of bounce than becomes variable. If the piston is generated successfully, `tshock (p 343)` is set accordingly. This is particularly useful if `accel` is used

`newnetb` *FILENAME*
see terminal commands.

`radlim` *VALUE*
minmum zone thickness relative to radius coordinate. If a zone is thinner, radius and density are adjusted. Default is 1.E-3. Set to zero to keep density unchanged.

`rescalem` *SCALE* [`msun`] [`mult` | `div`]
scale the mass coordinate by *SCALE*. If `msun` is given the scaling factor is multiplied by $M_\odot$/g. If `div` is given, the mass coordinate is divided by the scale factor, otherwise it is multiplied by the scale factor. The flag `mult` has

no effect but must not be given together with `div`. This command allows to adopt a generator file with a given mass grid to a different mass.

`killpist` reset/terminate piston.

`mapburn`
see terminal commands.

`zonemass` [[`g`] | `msun`]
generator card give zone mass not mass coordinate. *Obviously need to specify all zones.* As a backup, for now, the mass of the previous zone will be copied. However, in this case you still need to specify the mass of zone 1. NOTE: *"zone 0" mass is ignored. But you may need to give this for velocity and angular velocity interpolation.* If the mass unit (`g` or `msun`) is omitted, `g` is the default.

9 New BURN Generator Cards

`gg` *NETW COMP*
Sets *all* zones to BURN network number *NETW* and BURN composition *COMP*. Otherwise similar to the `g` command. The important difference is that now the same generator can be used independent of the number of zone in the problem generator file!

`netw` *NETW EL* {*ASTART AEND*}
Adds the isotopes *ASTART* – *AEND* of element *EL* to BURN network *NETW*. Several ranges *ASTART* – *AEND* can be given in the same line. Otherwies similar to the `net` command.

10 New plots and plotting commands

New plot types are number are (p 113 ipixtype):

`7` shows the angular velocity (ω), specific angular momentum (j) and total diffusion coefficient for mixing of chemical species.

`8` shows the angular velocity (ω), specific angular momentum (j) contributions of the different rotationally induced mixing coefficients and the total diffusion coefficient for mixing of chemical species.

`9` shows the production factor/yield for the different isotopes from the BURN co-processing network. Refer to parameters **p 396** to **p 403** for details of the plot adjustment.

New multiplicities of plots supported are (p 113 ipixtype):

`3`
- To get three plots of equal size, placed vertically below each other use the format `ABC00`, where `A`, `B`, and `C` are the numbers of the individual plots.
- To get three plots, the first of which is larger and the other two are smaller, use the format `ABC`, where `A`, `B`, and `C` are the numbers of the individual plots.

`4` To get fours plots of equal size, placed in the corners of the window, use the format `ABCD`, where `A`, `B`, `C`, and `D` are the numbers of the individual plots.

This is now determined in subroutine `setplottype`.

New types and handling of y-axis (p 132 irtype):

`1` log radius (cm)

`2` interior mass fraction

`3` interior mass (solar masses)

`4` radius (cm)

`5` moment of inertia coordinate ($M_\odot\ R_\odot^2$)

`6` zone number

`7` log interior mass ($M_\odot$) using `jp0` and `jp1`

`8` interior mass ($M_\odot$) using `jp0` and `jp1`

`9` log exterior mass ($M_\odot$) using `jp0` and `jp1`

`10` exterior mass ($M_\odot$) using `jp0` and `jp1`

`11` log column density (g cm^{-2}) using `jp0` and `jp1`

`12` column density (g cm^{-2}) using `jp0` and `jp1`

`13` pressure (erg cm^{-3}) using `jp0` and `jp1`

`14` log pressure (erg cm^{-3}) using `jp0` and `jp1`

`15` (non-relativistic) gravitational potential (cm^2 s^{-2}) using `jp0` and `jp1`

`16` log (non-relativistic) gravitational potential (cm^2 s^{-2}) using `jp0` and `jp1`

`17` normalized (non-relativistic) gravitational potential (c^2) using `jp0` and `jp1`

`18` log normalized (non-relativistic) gravitational potential (c^2) using `jp0` and `jp1`

`19` gravitational redshift using `jp0` and `jp1`

`20` log gravitational redshift using `jp0` and `jp1`

`21` enclosed volume (cm^3) using `jp0` and `jp1`

`22` log enclosed volume (cm^3) using `jp0` and `jp1`

`23` enclosed volume ($R_\odot^3$) using `jp0` and `jp1`

`24` log enclosed volume ($R_\odot^3$) using `jp0` and `jp1`

Notes:
For y-axis types `2` and `3` the diffusion coefficients in plot types `7` and `8` are shown in mass units, as it is most useful for investigating mixing of chemical species, for y-axis types `1` and `4` they are radius mass units, and for y-axis type `5` they are given in moment of inertia coordinates, as it is most useful if transport of angular momentum is considered.
For flot types `9 - 12` the surface of the star is to the left.

11 New Edit Quantities

name	description
angj	specific angular momentum (erg·sec)
angi	specific moment of inertia (cm^2)
angw	angular velocity (1/s)
angv	rotational velocity (cm/s)
ange	specific rotational energy (erg/g)
angp	rotational period (s)
angvk	Keplerian rotational velocity (cm/s)
gamed	Eddington Gamma
angwc	critical angular velocity (1/s)
angwwc	angular velocity / critical velocity
angvvc	rotational velocity / critical velocity
angwk	Keplerian angular velocity (1/s)
angek	specific Keplerian energy (erg/g)
angwwk	angular velocity / Keplerian velocity
angvvk	rotational velocity / Keplerian velocity
angeek	rotational energy / Keplerian energy
stotd	old specific entropy (erg/g/K)
eg	specific gravitational energy generation rate (erg/g/s)
gamma1	adiabatic exponent Γ_1
gamma2	adiabatic exponent Γ_2
gamma3	adiabatic exponent Γ_3
enbtn	$(\partial$ en / ∂ tn $)_{dn}$ (erg/g/K)
enbdn	$(\partial$ en / ∂ dn $)_{tn}$ (erg cm^3 g^{-2})
pnbtn	$(\partial$ pn / ∂ tn $)_{dn}$ (dyn/K)
pnbdn	$(\partial$ pn / ∂ dn $)_{tn}$ (dyn cm^3/g)
angri	Richardson number
angdg	total rotational diffusion coefficient (cm^2/s)
angd0	diffusion coefficient for convective processes (cm^2/s)
angd1	diffusion coefficient for dynamical shear instability (cm^2/s)
angd2	diffusion coefficient for Solberg-Høiland instability (cm^2/s)
angd3	diffusion coefficient for secular shear instability (cm^2/s)

`angd4`	diffusion coefficient for Eddington-Sweet circulation (cm^2/s)
`angd5`	diffusion coefficient for Goldreich-Schubert-Fricke instability (cm^2/s)
`mu`	mean molecular weight (g/mol)
`tau`	optical depth
`zm`	interior mass coordinate (g)
`xbind`	binding energy of zone (erg)
`ybind`	exterior binding energy (erg)
`zbind`	interior binding energy (erg)
`uesc`	local escape velocity w/r layers below (cm/sec)
`magvcc`	arsinh(mag. VC criterion*1.17) according to Henk Spruit (ask him for details)
`snt`	∂ sn / ∂ T (erg/g/s/K)
`snd`	∂ sn / ∂ ρ (erg $cm^3/g^2/s$)
`sneut`	sneut (erg/g/s)
`sneutbt`	∂ sneut / ∂ T (erg/g/s/K)
`sneutbd`	∂ sneut / ∂ ρ (erg $cm^3/g^2/s$)
`snuc`	snuc (erg/g/s)
`snucbt`	∂ snuc / ∂ T (erg/g/s/K)
`snucbd`	∂ snuc / ∂ ρ (erg $cm^3/g^2/s$)
`snuw`	snuw (erg/g/s)
`snuwbt`	∂ snuw / ∂ T (erg/g/s/K)
`snuwbd`	∂ snuw / ∂ ρ (erg $cm^3/g^2/s$)
`snubps`	snubps (erg/g/s)
`snubpsbt`	∂ snubps / ∂ T (erg/g/s/K)
`snubpsbd`	∂ snubps / ∂ ρ (erg $cm^3/g^2/s$)
`snlt`	∂ ln sn / ∂ ln T
`snld`	∂ ln sn /∂ ln ρ
`sneutlt`	∂ ln sneut / ∂ ln T
`sneutld`	∂ ln sneut /∂ ln ρ
`snuclt`	∂ ln snuc / ∂ ln T
`snucld`	∂ ln snuc / ∂ ln ρ
`snuwlt`	∂ ln snuw / ∂ ln T
`snuwld`	∂ ln snuw / ∂ ln ρ

`snubpslt`	∂ ln snubps / ∂ ln T
`snubpsld`	∂ ln snubps / ∂ ln ρ
`xmag...`	magnetic quantities (Spruit 2002)

12 New Variables

which are saved to the restart dump file:

name	description
`angj`	array(0:jmz) specific angular momentum (erg·sec)
`angdg`	array(0:jmz) total rotationally induced diffusion coefficients (cm^2/sec)
`angd`	array(0:jmz,1:nangmd) rotational diffusion coefficients separated for processes (cm^2/sec) 1: dynamical shear instability 2: Solberg-Høiland instability 3: secular shear instability 4: Eddington-Sweet circulation 5: Goldreich-Schubert-Fricke instability
`datapath`	CHARACTER*(80) contains a search path for data files
`wind`	array(nitz) stores the APPROX abundances removed from the star
`windb`	array(nitzb) stores the BURN abundances removed from the star
`burnamax`	array(nburn) stores the maximum abundances reached in the BURN network
`burnmmax`	array(nburn) stores the mass coordiantes where the maximum abundances in the BURN network were reached
`ibcmax`	array(nburn) stores the cycle numbers of when the maximum abundances in the BURN network were reached

13 New auto-linked aliases

`hdep`
execued when central hydrogen drops below 1 %.

`hedep`
execued when central helium drops below 1 %.

`&`
executed after each cycle.

`hburn`
executed half way through hydrogen burning.

`heburn`
executed half way through helium burning

14 All New: Environment Variables

KEPLER_DATA
sets the "data path" (see also: variable "datapath") where KEPLER looks for data files if they cannot be found in the local directory.
If the environment variable "KEPLER_DATA" is set, KEPLER will look in the path specified in the variable for data files if they cannot be found in the local directory or the directory specified in "datapath" (if set). This allows for a machine-dependent setting of the data path and is probably the best way in most cases when general/global files are to be used. The character "∼" (tilde) is replaced by the value of the system variable "HOME", better utilizing the machine-independent specification of paths.

KEPLER_MAIL
KEPLER_USER
If both variables are set, KEPLER will send an email to the address specified in KEPLER_USER using the mail program specified in KEPLER_MAIL when it terminates. Useful when several instances of KEPLER are run simultaneously.

15 MONGO Environment Variables

`FONTDAT`
where to find `fonts.dat`

`FONTNEW`
where to find `fonts.vis`

`HELPFILE`
where to find `help.dat`

`MONGOPS`
where to find MONGO postscript files.

Sample code for tcsh

```
setenv FONTDAT $HOME/kepler/mongo_dp64/fonts.dat
setenv FONTNEW $HOME/kepler/mongo_dp64/fonts.vis
setenv HELPFILE $HOME/kepler/mongo_dp64/help.dat
setenv MONGOPS $HOME/kepler/mongo_dp64/postscript/
```

16 Changed OS/Startup Commands

`z?`
now in addition to `z` also `z1`–`z9` will star up dumps with that ending.

`k`
will not load BURN data and kill burning, similar to the `killburn` command.

`#*`
will star from labeled dump with same base name.

`*g, *z, *#*`
will separate out base name for run automatically.