MATINS

MAgneto-**T**hermal evolution of **I**solated **N**eutron **S**tars

Name	Default	type	code name	unit	Range/Options	Comments
TIME AND RESOLUTION						
Total time	1d0	double		Myr		
Write checkpoints	-1	integer		timestep		-1=false, otherwise indicate the timestep frequency
Resume from checkpoint	-1	integer		timestep		to activate it, indicate a positive integer
Output times 1D	1.d-4	double		Myr		
Output times 2D and 3D	1.d-3	double		Myr		3D output is in the .vtu format (for Paraview)
Number of the thermal cells in the crust, angular direction	15	integer	nangt	#		must be an odd number
Number of the thermal cells in the radial direction	15	integer	nrt	#		
Number of core shells	50	integer	ncore	#		just for microphysical calculations
MAGNETIC FIELD						
Magnetic field evolution	true	bool		true/false		
Poloidal normalization	1.d0	double	bpol_init	10^{12} G	$\lesssim 10^4$	normalisation wrt the maximum B_r at the surface
Toroidal normalization	1.d1	double	btor_init	10^{12} G	$\lesssim 10^4$	*needs reassessing*
TEMPERATURE						
Temperature evolution	true	bool		true/false		
Envelope model	Gudm	string		-	see Tab. 2	
Initial temperature	8.d1	double		10^8 K	$\gtrsim 40^\dagger$	
STRUCTURE						
EoS	SLy4mu	string		-	see Tab. 3	for just a shell, “simple”
Central pressure	1.36e35	double		erg/cc		sets the total mass. E.g. for the SLy4 EoS: 1.36e35 $\rightarrow$ 1.4$M_\odot$, 7e35 $\rightarrow$ 2 $M_\odot$, 6.5e34 $\rightarrow$ 1$M_\odot$
Crust/envelope pressure	1e28	double		erg/cc		e.g. 1e28$\rightarrow$ 1e10 g/cc; 5e26$\rightarrow$ 1e9 g/cc; 1e25$\rightarrow$1e8 g/cc
fh and eta profiles	realist	string		-	realist†; uniform, Vigan21, Clara22	realist follows from the specified EoS
Use relativistic grid	true	bool		true/false		
Impurity parameter in the crust	1d0	double	Qimp	#		

Name	Default	type	code name	unit	Range/Options	Comments
Impurity parameter in the pasta phase	1d2	double	Qpasta	#		see Pons, Viganò Rea Nature
SUPERFLUIDITY (needs an EoS specified)						
SF n crust	SFB †	string		-	see Tab. 4	0=deactivate
SF n core	TToa †	string		-	see Tab. 4	0=deactivate
SF p core	CCDKp†	string		-	see Tab. 4	0=deactivate
NUMERICAL METHODS FOR MAGNETIC FIELDS						
Time advance method	RK4	string		-	Eul,RK2,RK3,RK4,RK6	
Courant pre-factor in adaptive timestep	0.1d0	double				set=0 to fix timestep to dtb0
Minimum magnetic timestep	1d-8	double	dtb0	Myr		
Scheme for Etor computation	Center†	string		-	Center, Upwind	
COOLING TIMESTEP						
Minimum cooling timestep	1d-7	double	min_dt_cooling	Myr		
Maximum cooling timestep	1d-3	double	max_dt_cooling	Myr		
Timestep/time in cooling advance	double	0.1d0	eps_dt_cooling	Myr		timestep is time*eps_dt_cooling
OUTBURST						
Outburst trigger condition	false	bool		true/false		parameters are specified in a dedicated input file
RADIAL GRID CONTROL						
Use uniform radial grid	true	bool		true/false		
Contrast between the maximum and minimum radial step dr	0.9d0	double	xdr			if above=false
Radius of transition between large and small dr	0.8†	double	xr_transition	radius		if above=false
Size of transition between large and small dr	0.2d0†	double	sigma_transition	radius		if above=false
INITIAL MULTIPOLE WEIGHTS						
ℓ, m decomposition of the initial field, for the poloidal and toroidal components, in units of the normalisation selected above. **nb** pay close attention to the hard-coded radial profile for the different multipoles						

MATINS label	composition	magnetised?	ref.
Iron_PPP15	Fe	yes	Potekhin, Pons & Page (2015)
Accr	light elements	no	Potekhin et al. (2003)
Gudm	Fe	no	Gudmundsson et al. (1983)
Iron_PMG09	Fe	yes	Pons Melatos Geppert (2009)
Iron_PY01	Fe	yes	Potekhin & Yakovlev (2001)
Iron_DV13	Fe	yes	Viganò (2013)
Accr_mag	light elements	yes	Potekhin et al. (2003)

Table 2: Available envelope models.

MATINS label	particle species	dUrca threshold mass $M_\odot$
Sly4	npe	N/A
SLy4mu	npeμ	N/A
SLy2mu	npeμ	N/A
SkMpmu	npeμ	N/A
Skamu	npeμ	1.23
SKbmu	npeμ	N/A
CMF2mu	npeμ	0
CMF6mu	npeμ	1.78
BSk24	npeμ	1.5

Table 3: Available EoSs. Adapted from the CompOSE database (`https://compose.obspm.fr/home`).

type	MATINS label	ref.
$^1S_0$ neutrons	CCDKn	Ho et al. (2015)
	GIPSF	”
	SFB	”
	WAP	”
	An05-d	Andersson 2005
	GC08nf	Gezerlis and Carlson 2008
	Ho12_n	Ho et al. 2012
$^1S_0$ protons	CCDKn	Ho et al. (2015)
	Ho12_n	Ho et al. 2012
	BS	Ho et al. 2012
	An05-d	Andersson 2005
$^3P_2$ neutrons	Ho12-s	Ho et al. (2012)
	Ho12-d	Ho et al. (2012)
	An05-j	Andersson 2005
	An05-k	Andersson 2005
	TToa	Ho et al. 2015

Table 4: Available superfluid gap models with the parametrisation of Kaminker, Yakovlev, Gnedin, Astron. Astroph. 383 (2002) 1076 .