Parameters of the Just-Jahreiß model of the Milky Way disk[1]

(python package `jjmodel`[2])

Contents

1. General information

There are two parameter files to be prepared for the Just-Jahreiß (JJ) model:

1. **`parameters`**. This file contains most of the model parameters and must be filled for every run. Parameters are organized in rows.

2. **`sfrd_peaks_parameters`**. Contains parameters which describe the special thin-disk populations (extra peaks on the star formation rate, SFR, and kinematics of these stars). These parameters need to be specified only when these special model features are activated (parameter `pkey`, see Sect. 2.5.1). In this file, parameters are organized in columns (and the number of rows corresponds to the number of additional peaks added to the thin-disk SFR).

List of acronyms and paper aliases:

AMR	age-metallicity relation	Paper I	Just and Jahreiß (2010)
AVR	age-velocity dispersion relation	Paper II	Just et al. (2011)
DM	dark matter	Paper III	Rybizki and Just (2015)
IMF	initial mass function	Paper IV	Sysoliatina and Just (2021)
MAP	mono-age population		
MD	metallicity distribution		
MW	Milky Way		
SF	star formation		
SFR	star formation rate		
SA	stellar assembly		

[1]Document updated on 24th June, 2021. With questions, comments, suggestions, or bug reports, please contact Kseniia Sysoliatina via Sysoliatina@uni-heidelberg.de or sskevja@gmail.com.

[2]https://github.com/askenja/jjmodel

2. File parameters

2.1. Run settings

run_mode : Running mode (int, Dimensionless[see description])

There are two options how to use the `jjmodel` package: when `run_mode` = 0, only the Solar neighbourhood is modeled (and not all of the parameters listed in this manual must be given, see Sect. 4 for details); when `run_mode` = 1, in addition to the Solar radius, the Milky Way (MW) disk is modeled in a range of Galactocentric distances.

nprocess : Number of independent processes (int, Dimensionless[see description])

The `jjmodel` package supports multiprocessing. It is used in two cases: (1) when the Poisson-Boltzmann Eq. is iteratively solved at each Galactocentric distance R (each R-bin of the MW disk is processed independently from other bins), and (2) during the generation of the so-called stellar assemblies (populations of the same metallicities, ages, and masses, SA) at a given radius. In the first case, the maximum reasonable value of `nprocess` is (`Rmax` − `Rmin`)/`dR` (see Sect. 2.3). But as far as we know, setting a somewhat higher value does not lead to any significant slowing of calculation, so this is not forbidden. In the second case, the larger `nprocess` is, the better, because the SA number can be large ($10^3 - 10^5$, depending on the MW component and mass resolution of isochrones). In practice, however, the number of independent processes is limited by the number of available CPU cores (and the code will not allow setting `nprocess` larger than the number CPUs).

out_dir : Name-particle of the output directory (string)

The default name of the output directory is constructed according to the formula:
`default_name` = 'Rsun' + `Rsun` if `run_mode` = 0, or `default_name` = `Rmin` + 'R' + `Rmax` + '_dR' + `dR` otherwise.
The full directory name is then constructed as `default_name` + '_' + `out_dir`. Thus, with the help of this parameter user can customize the output directory name which later helps for better distinguishing between the different model realizations.

out_mode : Saving mode (int, Dimensionless[see description])

Prescribes how the output is saved when the output directory already exists. If `out_mode` = 0, all existing files in the folder will be removed before saving the new ones. If `out_mode` = 1, the files will be overwritten. This second option is useful when a user is sure that the change in parameters will have an impact only on some of the output quantities (e.g. potential, scale heights, density profiles), but cannot affect others (e.g. computationally expensive SA tables, such that it is not necessary to re-calculate them). However, if the parameter impact is understood wrongly, this will result in a mixture of two different model realizations in one folder, therefore, use this option cautiously. If uncertain, set `out_mode` = 0 or create a unique folder name for each run with `out_dir` parameter.

2.2. Solar coordinates and velocity

Rsun : Solar Galactocentric distance (float, Distance[kpc])

Galactocentric distance of the Sun. For the most recent and precise value, see e.g. Gravity Collaboration et al. (2019). Does not influence the local potential-density pair. When a range of Galactocentric distances is modeled, `Rsun` plays a role of scaling parameter in the radial density laws of the MW components, and therefore, impacts potential and density at other R. When the JJ model is compared to some data in terms of (Galactocentric) distance-dependent quantities (e.g. stellar positions or velocities in Galactic coordinates), be sure that the value of `Rsun` is the same when these quantities are calculated from the observational data and when the model predictions are produced.

zsun : Solar distance from the Galactic plane (float, Distance[pc])

Distance of the Sun from the Galactic plane (positive, as the Sun is located "above" the plane). In the literature, this value varies in the range of 0 – 20 pc, depending on the method. In the JJ model, we usually assume `zsun` value of $\sim$20 pc (e.g. see Bovy, 2017). Does not influence potential-density pairs at any R, but may become important when the model predictions are compared to the data in the local volume, especially close to the Galactic plane. In this case, be sure that the value of `zsun` is the same when the compared quantities are calculated from the observational data and the model.

Vsun : Solar peculiar velocity component (float, Velocity[km s^{-1}])

The tangential component of the Solar peculiar velocity. The value of 12.24 km s^{-1} from Schönrich et al. (2010) is used most often, but also significantly larger and smaller values are reported in the literature (e.g. Sysoliatina et al., 2018). Does not influence the local potential-density pair, but implicitly affects the scaling parameter of the radial profile of the dark matter (DM) halo, and thus, impacts the vertical potential and density laws at other R (specifically, it is used to calculate the local circular speed: $v_c(R_\odot) = v_\odot - V_\odot$, where the Solar tangential speed $v_\odot$ is consistent with the assumed Solar Galactocentric distance `Rsun` and the measured proper motion of SgrA* from Reid and Brunthaler, 2005; the scaling parameter of the DM cored isothermal sphere, a_h, is then adapted to reproduce $v_c(R_\odot)$).

2.3. Rz-grid and radial profiles of the Milky Way components

Rmin : Minimal Galactocentric distance (float, Distance[kpc])

Center of the innermost radial bin. The JJ model is not applicable for the central MW region with bulge and bar, so the model must not be applied to distances smaller than 4 kpc. This implies $\texttt{Rmin} - \texttt{dR}/2 \geq 4$ kpc, where `dR` is the bin width.

Rmax : Maximal Galactocentric distance (float, Distance[kpc])

Center of the outermost radial bin. As the disk warp is not included in the JJ model, we recommend using $\texttt{Rmax} \lesssim 15$ kpc.

dR : Resolution in Galactocentric distance (float, Distance[kpc])

Width of the radial bins.

zmax : Maximum height (float, Distance[pc])

Maximum distance from the Galactic plane up to which the vertical gravitational potential and density profiles are reconstructed at each radius. The standard value is 2000 pc.

dz : Resolution in height (float, Distance[pc])

Step for the vertical z-grid. Should not be too large ($\gtrsim 10$ pc), especially when near-plane regions have to be investigated, as it defines how accurately the shape of the vertical gravitational potential can be reconstructed. On the other side, setting very small values can significantly slow down the calculation. Optimal values lay in the range of 1 – 5 pc.

Rd : Thin-disk radial scale length (float, Distance[kpc])

Exponential scale length of the overall thin-disk radial density profile. See Bland-Hawthorn and Gerhard (2016) for the overview of determination of R_d.

Rt : Thick-disk radial scale length (float, Distance[kpc])

Exponential scale length of the overall thick-disk radial density profile (see Bland-Hawthorn and Gerhard, 2016).

Rg1 : Radial scale length of molecular gas (float, Distance[kpc])

The exponential scale length of the radial profile of molecular gas. Surface density profile of molecular gas peaks at $\sim$4 kpc and declines at larger radii with a short scale length of $\sim$2 – 3 kpc (Kramer and Randall, 2016) which we adopt for our modeling.

Rg2 : Radial scale length of atomic gas (float, Distance[kpc])

The exponential scale length of the radial profile of atomic gas. According to Kramer and Randall (2016), the HI surface density remains roughly constant in the wide distance range of R $\approx$ 4 – 14 kpc and then declines with a scale length of $\sim$4.5 kpc. Similarly, Kalberla and Dedes (2008) describe HI radial distribution as approximately constant in the inner disk with and declining exponentially in the outer disk (with a scale length of 3.75 kpc for 12.5 kpc $< R <$ 30 kpc). When the global JJ model is built for 4 kpc $< R \lesssim$ 14 kpc, we often put `Rg2 = 10` kpc to describe the atomic gas as a component with a slow decline of surface density with radius which is broadly consistent with the mentioned observational results.

Rg10 : Radius of the H_2 inner hole (float, Distance[kpc])

The radius of an inner hole in the molecular gas disk. According to observations (see Kramer and Randall, 2016 for an overview), the H_2 gas density peaks at $\sim$4 kpc and quickly decreases at smaller R, therefore, this parameter may be important for modeling the innermost radial bins. Also, it is necessary to account for the inner hole in gas distribution to get a correct enclosed gas mass for the prediction of the MW rotation curve.

Rg20 : Radius of the HI inner hole (float, Distance[kpc])

The radius of an inner hole in the atomic gas disk. See Kramer and Randall (2016) for an overview of measured HI gas distribution across the disk. In comparison to molecular has, atomic hydrogen density peaks at somewhat larger radius, $\sim$6 kpc instead of $\sim$4 kpc, and the density decrease at smaller R is not so quick as for H_2. With the current model parameters, `Rg2` and `Rg20`, this graduate change in the gas density in the inner disk cannot be reproduced, so it is possible that at $R \approx 5 - 6$ kpc the assumed HI surface density will be under- or overestimated, depending on whether the inner hole is added or not. Parameter `Rg20` is mainly needed for predicting a correct enclosed mass of the atomic gas needed for the calculation of the MW rotation curve.

Rf : Radius where the thin disk begins to flare (float, Distance[kpc])

The Galactocentric distance where the thin disk begins to flare. As it is common to assume a constant disk thickness, disk flaring can be switched off by simply setting this value larger than the outermost radial bin, `Rf` $>$ `Rmax`.

Rdf : Thin-disk flaring scale length (float, Distance[kpc])

Describes flaring of the thin disk – the exponential scale length of the thin-disk thickness radial profile. Motivated by Kalberla et al. (2014) where authors report a common flaring of stars and HI gas across the MW disk and propose a simple exponential law describing the change of the gaseous and stellar disk thickness. Note that Kalberla et al. (2014) assume a common flaring law for the atomic gas and stars. The radial profile of the HI gas scale height is the JJ model input (data from Nakanishi and Sofue, 2016). If the flaring is allowed in the model, a preliminary check for consistency between the assumed `Rdf` and the input HI scale height profile may be needed.

a_in : Power index of the inner halo profile (float, Dimensionless[see description])

The power index of the radial density profile of the inner halo. Does not influence the model predictions for the Solar neighbourhood, but impacts the potential-density pair at other radii (though very weakly as the halo contribution is very small). Also, enters the expression for the MW rotation curve. Note that if the model predictions for halo need to be extrapolated to z $>$ `zmax`, (e.g. to get star counts integrated over the line of sight perpendicular to the Galactic plane). Then also power index of the outer halo `a_out` and break radius `r_br` should be assumed, but this we leave to a user.

Mb : Mass of the bulge (float, Mass[$M_\odot$])

Mass of the MW bulge. This parameter is used only in the calculation of the MW rotation curve, where the bulge is included simply as a point mass.

2.4. Local surface densities

sigmad : Thin-disk surface density (float, Surface density[$M_\odot$ pc^{-2}])

The total surface density of the thin-disk stars in the Solar neighbourhood (if there are additional peaks at the thin-disk SFR, `sigmad` is still the total surface density – the surface densities of these peaks' populations are included into it, see parameter `sigmap` in Sect. 3).

sigmat : Thick-disk surface density (float, Surface density[$M_\odot$ pc^{-2}])

Local surface density of the thick-disk stars.

sigmag1 : Molecular gas surface density (float, Surface density[$M_\odot$ pc^{-2}])

Local surface density of the molecular gas.

sigmag2 : Atomic gas surface density (float, Surface density[$\mathrm{M_\odot\ pc^{-2}}$])

Local surface density of the atomic gas.

sigmadh : DM halo surface density (float, Surface density[$\mathrm{M_\odot\ pc^{-2}}$])

Local surface density of the DM (note that only up to `zmax`).

sigmash : Stellar halo surface density (float, Surface density[$\mathrm{M_\odot\ pc^{-2}}$])

Local surface density of the halo stars.

2.5. Star formation rate

2.5.1. Thin disk

td1 : Galactic time of the beginning of the thin-disk formation (float, Time[Gyr])

The standard thin-disk SFR of the JJ model (smooth function with a single peak $\sim$10 Gyr ago) is given by Eq.(10) in Paper IV. By default, `td1` $= 0$ Gyr, i.e., there is no time delay between the beginning of the formation of the thick and thin disk (see Beraldo e Silva et al., 2021 for the discussion of the co-evolution of both disks). Though allowing a sequential formation of the two disks is in principle possible within the JJ model, (`td1` > 0 Gyr), this functionality is not implemented yet. So for now `td1` $= 0$ Gyr is the only available option.

td2 : SFR parameter (float, Time[Gyr])

The thin-disk SFR parameter. An increase of `td2` results in a slower increase of SFR at old ages, a shift of the peak to younger ages, and a slower SFR decline after the peak (Eq.(10) in Paper IV). The default value is `td2` $= 7.8$ Gyr.

dzeta : SFR power index (float, Dimensionless[see description])

The thin-disk SFR parameter. An increase of parameter `dzeta` has the same effect as an increase of `td2`: SFR grows slower at old ages, peaks later (peak shifts to younger ages), and declines slower after the peak (Eq.(10) in Paper IV).

eta : SFR power index (float, Dimensionless[see description])

The thin-disk SFR parameter. An increase of parameter `eta` has the opposite effect with respect to an increase of `td2` or `dzeta`: SFR grows faster at old ages, peaks earlier (peaks shifts to older ages), and declines faster after the peak (Eq.(10) in Paper IV).

pkey : SFR shape + kinematics mode (int, Dimensionless[see description])

This parameter can take three values: 0, 1, or 2. Option `pkey` $= 0$ corresponds to the thin-disk SFR given by Eq.(10) in Paper IV. If `pkey` $= 1$, the thin-disk SFR is allowed to have an *arbitrary* number of Gaussian peaks on top of the underlying continuum, which is described by a generalized Eq. (12) from Paper IV, where two additional peaks were introduced. Also, in this case the stellar populations associated with the star formation (SF) excess in the peaks have special vertical kinematics. Namely, their W-velocity dispersion σ_W is different from σ_W prescribed for the thin-disk populations of the same age by the age-velocity dispersion relation (AVR). When `pkey` $= 2$, extra peaks can be added to the SFR, but all thin-disk stars follow AVR. Parameters describing the peak shapes (`pkey` $= 1, 2$) and kinematics (`pkey` $= 1$) must be specified in the second parameter file `sfrd_peaks_parameters` (Sect. 3).

k_td2 : Power index of the radial law of the thin-disk SFR parameter `td2` (float, Dimensionless[see description])

To introduce a variation of the thin-disk SFR with Galactocentric distance R, parameters `td2`, `dzeta`, and `eta` are assumed to have power-law radial profiles, i.e., $\sim \mathtt{td2} \cdot (R/\mathtt{Rsun})^{\mathtt{k\_td2}}$. An example of a combination of these SFR parameters' radial slopes which allows to mimic the inside-out disk growth is (`td2`, `dzeta`, `eta`) = $(1.5\ \mathrm{Gyr}, 0.18, -0.1)$.

k_dzeta : Power index of the radial law of the thin-disk SFR parameter `dzeta` (float, Dimensionless[see description])

See parameter `k_td2`.

k_eta : Power index of the radial law of the thin-disk SFR parameter `eta` (float, Dimensionless[see description])

See parameter `k_td2`.

2.5.2. Thick disk

tt1 : Thick-disk SFR parameter (float, Time[Gyr])

Thick-disk SFR is given by Eqs. (7) and (8) in Paper IV, and is a combined power-exponential function. Parameter `tt1` is related to a starting value of SF at t = 0 Gyr. The default value is `tt1` $= 0.1$ Gyr. The thick-disk SFR shape is assumed to be the same at all Galactocentric distances, so parameters `tt1`, `tt2`, `gamma`, `beta` are the same at all radii.

tt2 : Galactic time when the thick-disk formation ceases (float, Time[Gyr])

Galactic time, when the formation of the tick disk stopped (Eqs. (7) and (8) in Paper IV). The thick disk has formed quickly, so `tt2` cannot be very large, our default value is 4 Gyr (but in fact, the SF drops to almost zero even earlier due to the exponential decline).

gamma : Thick-disk SFR exponential index (float, Dimensionless[see description])

Controls the steepness of the SFR increase at the oldest ages (Eqs. (7) and (8) in Paper IV). The default value is `gamma` $= 2$.

beta : Thick-disk SFR exponential index (float, Inverse time[Gyr^{-1}])

Controls the declining part of the thick-disk SFR (Eqs. (7) and (8) in Paper IV). The default value is `beta` $= 3.5$ Gyr^{-1}.

2.6. Initial mass function

imfkey : Thick-disk SFR exponential index (float, Dimensionless[see description])

When `imfkey` = 0, the initial mass function (IMF) is a four-slope broken power law, and its shape is described by parameters (`a0`, `a1`, `a2`, `a3`, `m0`, `m1`, `m2`). Another option is `imfkey` = 1, which corresponds to a custom IMF shape, which has to be specified by a user by introducing custom IMF parameters (in this parameter file, or directly in a script). Note that the class `IMF` from `jjmodel.funcs` already has pre-defined Kroupa93 and Chabrier03 IMF.

a0 : IMF slope (float, Dimensionless[see description])

The IMF slope for masses $m <$ `m0`.

a1 : IMF slope (float, Dimensionless[see description])

The IMF slope for masses `m0` $\leq m <$ `m1`.

a2 : IMF slope (float, Dimensionless[see description])

The IMF slope for masses `m1` $\leq m <$ `m2`.

a3 : IMF slope (float, Dimensionless[see description])

The IMF slope for masses $m \geq$ `m2`.

m0 : IMF break point mass (float, Mass[$\mathrm{M}_\odot$])

The break point between the IMF slopes `a0` and `a1`.

m1 : IMF break point mass (float, Mass[$M_\odot$])

The break point between the IMF slopes `a1` and `a2`.

m2 : IMF break point mass (float, Mass[$M_\odot$])

The break point between the IMF slopes `a2` and `a3`.

2.7. Age-metallicity relation and metallicity distributions

2.7.1. Thin disk

FeHd0 : Initial thin-disk metallicity (float, Metallicity[dex])

`FeHd0` is metallicity of the oldest thin-disk subpopulation at the Solar radius `Rsun`, this is one of four parameters of the thin-disk age-metallicity relation (AMR) which is given by Eqs. (21) and (22) in Paper IV. In the AMR, metallicity is assumed to monotonously increase with Galactic time at all radii. Many observations imply that the local value `FeHd0` belongs to the range of $(-0.8, -0.6)$ dex.

FeHdp : Present-day thin-disk metallicity (float, Metallicity[dex])

Metallicity of the youngest thin-disk subpopulation at the Solar radius `Rsun`, the thin-disk AMR parameter. The value of `FeHdp` belongs to the range of $(0.1, 0.3)$ dex.

rd : Thin-disk AMR power index (float, Dimensionless[see description])

The parameter controlling the thin-disk AMR shape. An increase of `rd` results in a slower increase of metallicity with Galactic time.

q : Thin-disk AMR parameter (float, Dimensionless[see description])

The parameter controlling the thin-disk AMR shape. An increase of this parameter has an opposite effect with respect to an increase of `rd`: AMR then has a faster chemical enrichment at old ages.

k_FeHd0 : Power index of the radial law of `FeHd0` (float, Dimensionless[see description])

By analogy to the thin-disk SFR, to introduce a variation of the thin-disk AMR with Galactocentric distance R, parameters `FeHd0`, `FeHdp`, `rd`, and `q` are assumed to vary with R according to power laws, i.e., $\sim \texttt{FeHd0} \cdot (R/\texttt{Rsun})^{\texttt{k\_FeHd0}}$. An example of such combination of the AMR parameters' radial slopes which corresponds to a faster enrichment in the inner disk is (`FeHd0`, `FeHdp`, `rd`, `q`) = $(-0.025, -0.0875, 0.005, -0.03)$.

k_FeHdp : Power index of the radial law of `FeHdp` (float, Dimensionless[see description])

See parameter `k_FeHd0`.

k_rd : Power index of the radial law of `rd` (float, Dimensionless[see description])

See parameter `k_FeHd0`.

k_q : Power index of the radial law of `q` (float, Dimensionless[see description])

See parameter `k_FeHd0`.

dFeHdt : Dispersion of the disk MAP MDs (float, Metallicity[dex])

If `dFeHdt` = 0, there is a unique correspondence between age and metallicity in the model, which is prescribed by the thin-disk and thick-disk AMR functions. However, we know from observations that the AMR has a significant scatter in metallicity, i.e., a range of different metallicities can correspond to the same age (radial migration effect). If `dFeHdt` > 0, this scatter is modeled by assuming for each mono-age (sub)population (MAP) a Gaussian metallicity distribution (MD) with a mean value prescribed for that age by the AMR and dFeHdt being its dispersion. This is applied to both the thin and thick disk.

n_FeHdt : Number of subpopulations for sampling the disk MAP MDs (int, Dimensionless[see description])

The number of subpopulations used to sample disk MAP MDs (see parameter dFeHdt). n_FeHdt = 1 corresponds to no scatter in AMR. Obviously, if the scatter is added (dFeHdt > 0), then n_FeHdt must be > 1 to sample the assumed MAP MDs. n_FeHdt has to be an uneven number (to sample the MD mean value). Do not use too large values ($\gtrsim 9$ or so), as the overall SA number increases approximately proportionally to n_FeHdt, i.e., the calculation of different quantities will take ∼n_FeHdt times longer. E.g., use n_FeHdt = 7 to sample the mean MD value $\langle[\mathrm{Fe/H}]\rangle = \mathrm{AMR}(t)$ and values $\pm 1\sigma,\ \pm 2\sigma,\ \pm 3\sigma$ from it, where $\sigma =$ dFeHdt.

2.7.2. Thick disk

FeHt0 : Initial thick-disk metallicity (float, Metallicity[dex])

FeHt0 is metallicity of the oldest thick-disk subpopulation at the Solar radius Rsun, this is one of four parameters of the thick-disk AMR which is given by Eqs. (21) and (22) in Paper IV. Belongs to the range of $(-1, -0.8)$ (same at all R, no variation of the thick-disk AMR with radius is assumed).

FeHtp : Present-day thick-disk metallicity (float, Metallicity[dex])

Metallicity of the youngest thick-disk subpopulation at the Solar radius Rsun, same at all radii.

rt : Thick-disk AMR power index (float, Dimensionless[see description])

The thick-disk AMR parameter controlling the AMR shape, same at all radii. An increase of rt results in a slower increase of metallicity with Galactic time.

t0 : Thick-disk AMR scaling parameter (float, Dimensionless[see description])

The thick-disk AMR parameter controlling the AMR shape, same at all radii. An increase of this parameter has an opposite effect with respect to an increase of rt: AMR then prescribes a faster chemical enrichment at old ages.

2.7.3. Halo

FeHsh : Mean metallicity of the stellar halo MD (float, Metallicity[dex])

The stellar halo is represented in the JJ model by a single-age subpopulation with a Gaussian MD. FeHsh is the mean value of this distribution.

dFeHsh : Metallicity dispersion of the stellar halo MD (float, Metallicity[dex])

The metallicity dispersion of the stellar halo MD.

n_FeHsh : Number of the stellar halo MAPs (int, Dimensionless[see description])

The number of subpopulations used to sample the halo MD (analog of n_FeHdt parameter for the disk). An uneven number (to sample the MD mean value). E.g., use n_FeHsh = 7 to sample $\langle[\mathrm{Fe/H}]_{\mathrm{sh}}\rangle =$ FeHsh and $\pm 1\sigma,\ \pm 2\sigma,\ \pm 3\sigma$ values from it, where $\sigma =$ dFeHsh.

2.8. W-velocity dispersions

alpha : AVR power index (float, Dimensionless[see description])

The thin-disk AVR power index (AVR analytic form is given by Eq.(13) in Paper IV). Assumed to be constant at all radii.

sige : AVR scaling parameter (float, Velocity[km s^{-1}])

The thin-disk AVR scaling parameter at `Rsun`, corresponds to the W-velocity dispersion of the oldest thin-disk subpopulation. A variation of `sige` with radius (and thus, a variation of the AVR shape) is determined within the code using the prescribed disk thickness (see parameters `Rf` and `Rdf`) as a “boundary condition”.

`sigt` : Thick-disk W-velocity dispersion (float, Velocity[km s^{-1}])

The W-velocity dispersion of the thick disk. No variation with age or radius is assumed.

`sigdh` : DM halo W-velocity dispersion (float, Velocity[km s^{-1}])

W-velocity dispersion of the DM halo (same at all radii).

`sigsh` : Stellar halo W-velocity dispersion (float, Velocity[km s^{-1}])

W-velocity dispersion of the stellar halo (same at all radii).

3. File `sfrd_peaks_parameters`

`sigmap` : Amplitude-related parameter of the i-th peak (float, Surface density [$M_\odot$ pc^{-2}])

The parameter related to the amplitude of the thin-disk SFR peak at `Rsun`. For the exact expression linking this parameter to the real amplitude of the peak see Sect. 3.1 in Paper IV. Note that the surface density of the peak does not add to the thin-disk surface density `sigmad`, but is included in it.

`taup` : Mean age of the i-th peak (float, Age[Gyr])

The mean age of the thin-disk SFR peak, same at all radii. Formally, can be also negative which corresponds to the future.

`dtau` : Age dispersion of the i-th peak (float, Age[Gyr])

The age dispersion of the thin-disk SFR peak, same at all radii.

`Rp` : Mean radius of the i-th peak (float, Distance[kpc])

The mean Galactocentric distance of the thin-disk SFR peak (Gaussian distribution across R is assumed).

`dRp` : Radial dispersion of the i-th peak (float, Distance[kpc])

The radial dispersion of the thin-disk SFR peak, defines which interval of Galactocentric distances is affected by the presence of the special populations associated with this extra SF event.

`sigp` : W-velocity dispersion of the i-th peak’s populations (float, Velocity[km s^{-1}])

The W-velocity dispersion of the thin-disk stellar populations associated with the SFR peak (same for all ages of these special populations). Must be specified only when `pkey` = 1 (see parameter `pkey`).

4. Summary table of the JJ model parameters

Table 1: Summary of the JJ model parameters. Colours indicate whether a parameter is related to the Solar neighbourhood model (red) or to the extension of the local model to other radii (green). Parameters that must be specified regardless of the running mode (local or global model) are also highlighted with red. Parameters are classified as (a) constrained independently from the JJ model, (b) uncalibrated, (c) calibrated against Gaia DR2 in Paper IV, (d) calibrated against APOGEE RC in Paper IV, (e) boolean (switch on and off different JJ model features), and (f) technical (do not influence the JJ model predictions or influence their quality). In case of the technical and boolean parameters, as well as parameters which values are not yet constrained, an example of possible values is given in the column "Value". For the rest of parameters the best values are given (determined in the framework of the JJ model or independently from it).
References: [1] Gravity Collaboration et al. (2019), [2] Bennett and Bovy (2019), [3] Schönrich et al. (2010), [4] Bland-Hawthorn and Gerhard (2016), [5] Kramer and Randall (2016), [6] Kalberla and Dedes (2008), [7] Kalberla et al. (2014), [8] Nakanishi and Sofue (2016), [9] Paper IV, [10] Paper I, [11] McKee et al. (2015) [12] Paper II, [13] Paper III, [14] Rybizki (2018), [15] Conroy et al. (2019).

Parameter	Units	Value	Name in ref.	Comment
		Run settings		
`run_mode`	-	$1^{(f)}$	-	Can be 0 or 1
`nprocess`	-	$4^{(f)}$	-	[1, number of available CPUs)
`out_dir`	-	'model1' $^{(f)}$	-	Example of a name
`out_mode`	-	$1^{(f)}$	-	Can be 0 or 1
		Solar coordinates and velocity		
`Rsun`	kpc	$8.178 \pm 0.013_{\rm stat} \pm 0.022_{\rm sys}\ ^{(a)}$	$\mathrm{R}_\odot$	Value from [1], we often use 8.2 kpc
`zsun`	pc	$20.8 \pm 0.3\ ^{(a)}$	$\mathrm{z}_\odot$	Value from [2], we often use 20 pc
`Vsun`	km s^{-1}	$12.24 \pm 0.47\ ^{(a)}$	$\mathrm{V}_\odot$	Value from [3]
		Rz-grid and radial profiles of the MW components		
`Rmin`	kpc	$4.0^{(f)}$	$R_{\rm min}$	Must be $\geq$ 4 kpc
`Rmax`	kpc	$14.0^{(f)}$	$R_{\rm max}$	Should be $\lesssim$ 15 kpc
`dR`	kpc	$0.5^{(f)}$	dR	Recommended $\leq$ 1 kpc
`zmax`	pc	$2000^{(f)}$	$z_{\rm max}$	Values > 2000 pc were never tested
`dz`	pc	$2^{(f)}$	dz	Recommended range is (0.5,10) pc
`Rd`	kpc	$2.5^{(a)}$	$R_{\rm d}$	See literature overview in [4]
`Rt`	kpc	$2.0^{(a)}$	$R_{\rm t}$	See literature overview in [4]
`Rg1`	kpc	$3.0^{(a)}$	$R_{\rm H_2}$	See literature overview in [5]
`Rg2`	kpc	$10.0^{(a)}$	$R_{\rm HI}$	See [6] and literature overview in [5]
`Rg10`	kpc	$4.0^{(a)}$	$R_{\rm in,H_2}$	See literature overview in [4]
`Rg20`	kpc	$4.0^{(a)}$	$R_{\rm in,HI}$	See literature overview in [4]
`Rf`	kpc	$7^{(a)}$	-	Set < `Rmax` to include disk flaring
`Rdf`	kpc	$9.22^{(a)}$	-	See [7], but compare to the model input from [8]
`a_in`	dim	$-2.5^{(a)}$	α_{in}	Taken from [4]
`Mb`	$\mathrm{M}_\odot$	$0.8\ 10^{10}$	$M_{\rm b}$	
		Local surface densities		
`sigmad`	$\mathrm{M}_\odot$ pc^{-2}	$29.4^{+2.7}_{-2.7}\ ^{(c)}$	$\Sigma_{\rm d}$	Updated in [9], consistent with [10]
`sigmat`	$\mathrm{M}_\odot$ pc^{-2}	$4.9^{+1.4}_{-1.3}\ ^{(c)}$	$\Sigma_{\rm t}$	Updated in [9], consistent with [10]
`sigmag1`	$\mathrm{M}_\odot$ pc^{-2}	$1.7^{(a)}$	$\Sigma_{\rm H_2}$	Adopted from [11]
`sigmag2`	$\mathrm{M}_\odot$ pc^{-2}	$10.86^{(a)}$	$\Sigma_{\rm HI}$	Adopted from [11]
`sigmadh`	$\mathrm{M}_\odot$ pc^{-2}	$51.6^{+9.3}_{-9.3}\ ^{(c)}$	$\Sigma_{\rm dh}$	Updated in [9], broadly consistent with [10]
`sigmash`	$\mathrm{M}_\odot$ pc^{-2}	$0.49^{+0.14}_{-1.14}\ ^{(c)}$	$\Sigma_{\rm sh}$	
		Star formation rate		

Thin disk				
td1	Gyr	$0.0^{(b)}$	$t_{\rm d1}$	Eq.(10) in [9], currently fixed
td2	Gyr	$7.8^{(b)}$	$t_{\rm d2}$	Eq.(10) in [9], consistent with model A in [10,12]
dzeta	dim	$0.83^{+0.09}_{-0.09}$ $^{(c)}$	ζ	Eq.(10) in [9]
eta	dim	$5.6^{+0.1}_{-0.1}$ $^{(c)}$	η	Eq.(10) in [9]
k_td2	dim	$1.5^{(b)}$	$k_{t_{\rm d2}}$	**Will be link to Eq. in Paper V**
k_dzeta	dim	$0.18^{(b)}$	k_ζ	**Will be link to Eq. in Paper V**
k_eta	dim	$-0.1^{(b)}$	k_η	**Will be link to Eq. in Paper V**
pkey	-	$1^{(e)}$	-	Can be 0, 1, or 2; 1 is the preferred mode at $R_\odot$ [9]
sigmap	$M_\odot$ pc^{-2}	$[3.5^{+2.4}_{-1.8}, 1.3^{+1.3}_{-0.8}]$ $^{(c)}$	$\Sigma_{\rm p1}$, $\Sigma_{\rm p2}$	Eq.(12) in [9], **Will be link to Eq. in Paper V**
taup	Gyr	$[3.0^{+0.8}_{-0.9}, 0.5^{+0.5}_{-0.5}]$ $^{(c)}$	$\tau_{\rm p1}$, $\tau_{\rm p2}$	Eq.(12) in [9], **Will be link to Eq. in Paper V**
dtaup	Gyr	$[0.7^{+0.15}_{-0.14}, 0.25^{+0.05}_{-0.05}]$ $^{(c)}$	$d\tau_{\rm p1}$, $d\tau_{\rm p2}$	Eq.(12) in [9], **Will be link to Eq. in Paper V**
Rp	kpc	$[7.5, 10.3]^{(b)}$	$R_{\rm p1}$, $R_{\rm p2}$	**Will be link to Eq. in Paper V**
dRp	kpc	$[1.0, 0.5]^{(b)}$	$dR_{\rm p1}$, $dR_{\rm p2}$	**Will be link to Eq. in Paper V**
Thick disk				
tt1	Gyr	$0.1^{(b)}$	$t_{\rm t1}$	Eq.(8) in [9]
tt2	Gyr	$4.0^{(b)}$	$t_{\rm t2}$	Eq.(8) in [9]
gamma	dim	$3.5^{(b)}$	γ	Eq.(8) in [9]
beta	Gyr^{-1}	$2.0^{(b)}$	β	Eq.(8) in [9]
		Initial mass function		
imfkey	-	$0^{(f)}$	-	Can be 0 or 1
a0	dim	$1.31^{+0.28}_{-0.28}$ $^{(c)}$	α_0	Updated in [9], consistent with [13]
a1	dim	$1.5^{+0.23}_{-0.24}$ $^{(c)}$	α_1	Updated in [9], consistent with [13]
a2	dim	$2.88^{+0.26}_{-0.23}$ $^{(c)}$	α_2	Updated in [9], broadly consistent with [13]
a3	dim	$2.28^{(b)}$	α_3	Adopted from [14]
m0	$M_\odot$	$0.49^{+0.15}_{-0.15}$ $^{(c)}$	m_0	Poorly constrained, see [9]
m1	$M_\odot$	$1.43^{+0.14}_{-0.14}$ $^{(c)}$	m_1	Updated in [9], consistent with [13]
m2	$M_\odot$	$6^{(b)}$	m_2	Adopted from [14]
		Age-metallicity relation and metallicity distributions		
Thin disk				
FeHd0	dex	$-0.7^{(d)}$	$[\rm Fe/H]_0$	Eqs.(21) and (22) in [9]
FeHdp	dex	$0.29^{(d)}$	$[\rm Fe/H]_p$	Eqs.(21) and (22) in [9]
rd	dim	$0.34^{(d)}$	$r_{\rm d}$	Eqs.(21) and (22) in [9]
qd	dim	$-0.72^{(d)}$	q	Eqs.(21) and (22) in [9]
k_FeHd0	dim	$-0.025^{(b)}$	$k_{[\rm Fe/H]_0}$	**Will be link to Eq. in Paper V**
k_FeHdp	dim	$-0.0875^{(b)}$	$k_{[\rm Fe/H]_p}$	**Will be link to Eq. in Paper V**
k_rd	dim	$0.005^{(b)}$	$k_{r_{\rm d}}$	**Will be link to Eq. in Paper V**
k_qd	dim	$-0.03^{(b)}$	$k_{\rm q}$	**Will be link to Eq. in Paper V**
dFeHdt	dex	$0.1^{(a)}$	$\sigma_{[\rm Fe/H]_{dt}}$	Value from 0 to $\sim$0.2 – 0.25 dex
n_FeHdt	-	$7^{(f)}$	-	Uneven value >1, values $\gtrsim 11$ are not recommended
Thin disk				
FeHt0	dex	$-0.94^{(d)}$	$[\rm Fe/H]_0$	Eqs.(21) and (22) in [9]
FeHtp	dex	$-0.04^{(d)}$	$[\rm Fe/H]_p$	Eqs.(21) and (22) in [9]
rt	dim	$0.77^{(d)}$	$r_{\rm t}$	Eqs.(21) and (22) in [9]
t0	Gyr	$0.97^{(d)}$	t_0	Eqs.(21) and (22) in [9]
Halo				
FeHsh	dex	$-1.5^{(a)}$	$[\rm Fe/H]_{sh}$	**Some RAVE paper? Still searching for it** -1.2 in [15]
dFeHsh	dex	$0.4^{(a)}$	$\sigma_{[\rm Fe/H]_{sh}}$	**Some RAVE paper** or [15]

`n_FeHsh`	-	$7^{\,(f)}$	-	Uneven value > 1, no need to set $\gtrsim 15$
		W-velocity dispersions		
`alpha`	dim	$0.409^{+0.046\,(c)}_{-0.045}$	α	Eq.(13) in [9]
`sige`	km s^{-1}	$25.1^{+1.8\,(c)}_{-1.7}$	$\sigma_{\rm e}$	Eq.(13) in [9]
`sigp`	km s^{-1}	$[26.3^{+4.4}_{-4.0}, 12.6^{+3.0\,(c)}_{-2.9}]$	$\sigma_{\rm p1}, \sigma_{\rm p2}$	
`sigt`	km s^{-1}	$43.3^{+3.7\,(c)}_{-3.8}$	$\sigma_{\rm t}$	Determined in [9], consistent with [12]
`sigdh`	km s^{-1}	$140^{\,(b)}$	$\sigma_{\rm dh}$	Assumed in [10]
`sigsh`	km s^{-1}	$100^{\,(b)}$	$\sigma_{\rm sh}$	Assumed in [10]

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