Teramo - Stellar POpulations Tools

This library contains models computed with the Stellar Population Synthesis Code of the SPoT Group developed by Enzo Brocato, Gabriella Raimondo, and Michele Cantiello. The code is described in Brocato et al. (1999, 2000), Raimondo (2002), Cantiello et al. (2003), Cantiello (2004), and Raimondo et al. (2005). Please, refer to those papers for a complete description of the models. Models are available at the *web-site*: *http://www.te.astro.it/SPoT*.

1 Brief Description of models

The models available up to now at the web-site are computed according to the following prescriptions:

- Simple Stellar Populations (SSP): single-age, single-metallicity models. The total mass of each simulation is typically $\mathcal{M} \simeq 5 - 8 \cdot 10^4 \, M_\odot$, unless explicitly stated otherwise. The explored age range is $25 \, Myr \lesssim t \lesssim 14 \, Gyr$.

- Initial Mass Function is from Scalo (1998) in the mass range $0.1 \leq M/M_\odot \leq 10$. The upper mass limit corresponds to the highest mass evolving off the MS in the youngest population we considered. All the more massive stars are expected to be exploded as supernovae, being their quiescent nuclear burning life-time as long as a few million years.

- Stellar Evolution Database: Pietrinferni et al. (2004). All the evolutionary phases, from the Main Sequence (MS) up to the AGB, are covered by models. In particular, the AGB evolution runs up to the onset of the first thermal pulse or to the carbon ignition. We selected the following metallicities $Z = 0.0003, 0.001, 0.004, 0.008, 0.01, 0.02$, and 0.04, computed by adopting a solar–scaled metal distribution with an enrichment law of $\Delta Y/\Delta Z \simeq 1.4$.

- Horizontal Branch morphology is fully reproduced taking into account the effects due to age, metallicity, and the stellar mass spread due to the stochasticity of the mass–loss phenomena along the RGB (Brocato et al., 2000). The RGB mass-loss rate is evaluated according to the Reimers' law (Reimers, 1975): the standard η-value is $\eta_{RGB} = 0.4$; a large grid of different values are also explored (Brocato et al., 2000; Cantiello et al., 2003). Along the HB and the early AGB we assume a Reimer's law with $\eta_{HB} = \eta_{EAGB} = \eta_{RGB}$, while during the end of the AGB phase (thermal pulses AGB, TP–AGB) we assume specific values, see next point.

- Thermal Pulses are simulated using the analytic formulations by Wagenhuber & Groenewegen (1998). We performed an integration of the system of equations obtaining, for each thermal pulse, the luminosity, the core mass, and the duration of the pulse. The stellar temperature is derived by using prescription of Renzini & Voli (1981), coupled with the appropriate slope $d\log(L/L_\odot)/d\log(T_e)$ for the evolutionary tracks we are using. Three different mass–loss rates are included: B1 and B2 mass-loss rates of Bloecker (1995), and BH mass-loss rate of Baud & Habing (1983).

- Integrated Colors Indices and Surface Brightness Fluctuations (SBF) amplitudes: for each set of SSP parameters (t, Z, mass-loss rates, etc ...) are computed over 5000 *independently* generated simulations.

IMPORTANT NOTES:

1. The SSP Models provide:

   (a) Synthetic Color-Magnitude Diagram (SCMD);
   (b) Integrated Colors Indices;
   (c) Surface Brightness Fluctuations (SBF) amplitudes.

2. We adopt two procedures to populate the SCMD. Stars with $M \geq M_r$ are generated randomly, while stars with $M < M_r$ are binned in mass intervals properly chosen. Models in the age range $25 \, Myr \leq t \leq 5 \, Gyr$ have $M_r = 1 M_\odot$, while models for ages $t \geq 5 \, Gyr$ have $M_r = 0.7 - 0.8 M_\odot$. The corresponding CMD files are identified by the file-extension *.cmd ($M \geq M_r$), and *.lcmd ($M < M_r$), respectively. The number of stars with masses in each mass-bin is indicated in the last column of the CMD files (f): $f = 1$ random star; $f > 1$ binned masses. Please, note that the *.cmd files should be considered as an example of the CMD expected for the SSP of the given age and chemical composition.

3. The methods used to derive SBF are extensively explained in Raimondo (2002); Cantiello et al. (2003); Cantiello (2004); Raimondo et al. (2005). Basically, we adopt two procedures to compute SBF amplitudes. The *standard* procedure (*std*-procedure, see e.g. Cantiello et al., 2003) is based on the analysis of population's integrated magnitudes, and computed over 5000 simulations for each model. SBF values from this procedure are recommended for stellar systems with a high number of stars, and spatially–unresolved stellar systems (galaxies). For spatially-resolved systems (e.g. star clusters), we also developed a procedure which is based on the SCMD of single populations (*RS*-procedure, Raimondo et al., 2005). In this case, we provide the mean SBF values averaged over 5000 independent simulations, and the related SBF statistical uncertainties. The *RS*–procedure is recommended for under-sampled and spatially-resolved populations.

4. We provide models computed assuming three different atmosphere models: BaSeL3.1 (Westera et al., 2002), BaSeL2.2 (Lejeune et al., 1997, 1998), and Bessell et al. (1998). We suggest to use BaSeL3.1 models.

2   Description of the on-line material

In the web-site there are two different ways of downloading files:

1. **Quick Download**: This option allows you to retrieve the files containing Integrated Color Indices and SBF amplitudes for SSP of all the chemical compositions and ages available. In details:

    (a) the ssp_BaSeL31_B1.mean.color file lists the integrated color indices averaged over 5000 simulations, the mean values and the standard deviation are reported for each.

    (b) the ssp_BaSeL31_B1.std.sbf lists the SBF magnitudes from the *std-procedure* (see Raimondo et al., 2005).

2. **Download the specific quantities for single model**:

    The models' files included in the library are available in compressed archive files (gzipped tar files) named ZxxYyy.tar.gz, where Z refers to metallicity and Y to helium content in stellar models:

Z34Y245.tar.gz	=	models for	Z=0.0004	Y=0.245
Z13Y246.tar.gz	=	models for	Z=0.001	Y=0.246
Z43Y251.tar.gz	=	models for	Z=0.004	Y=0.251
Z83Y256.tar.gz	=	models for	Z=0.008	Y=0.256
Z12Y259.tar.gz	=	models for	Z=0.01	Y=0.259
Z22Y273.tar.gz	=	models for	Z=0.02	Y=0.273
Z42Y300.tar.gz	=	models for	Z=0.04	Y=0.300

    Each *.tar file contains sub-directories marked by the ages and mass-loss rate prescriptions adopted in the models: es. XX_tp_YY:

XX	=	Age (Myr)
tp	=	Thermal Pulses included
YY	=	B1: mass-loss rate by Bloecker (1995) (see Raimondo et al., 2005)
		B2[1]: mass-loss rate by Bloecker (1995) (see Raimondo et al., 2005)
		BH[1]: mass rate by Baud & Habing (1983)

[1]The first release of the SPoT web-site comprises only the B1 models. Please, check the web-site soon to find the models for B2 and BH prescriptions.

Each sub-directory XX_tp_YY contains the files:

ssp_BaSeL31.cmd	ssp_BaSeL22.wfpc2.cmd	ssp_BaSeL22.nic.cmd
ssp_BaSeL31.color	ssp_BaSeL22.wfpc2.color	ssp_BaSeL22.nic.color
ssp_BaSeL31.lcmd	ssp_BaSeL22.wfpc2.lcmd	ssp_BaSeL22.nic.lcmd
ssp_BaSeL31.sbf	ssp_BaSeL22.wfpc2.sbf	ssp_BaSeL22.nic.sbf
ssp_BCP.wfpc2.cmd	ssp_BCP.nic.cmd	ssp.properties
ssp_BCP.wfpc2.color	ssp_BCP.nic.color	
ssp_BCP.wfpc2.lcmd	ssp_BCP.nic.lcmd	
ssp_BCP.wfpc2.sbf	ssp_BCP.nic.sbf	

In details, the files *ssp_Transf.xx* are named according to the following table:

ssp	=	simple stellar population		=	single-burst models
Transf	=	color-temperatures tables:	BaSeL31	=	BaSeL3.1: Westera et al. (2002)
			BaSeL22	=	BaSeL2.2: Lejeune et al. (1997, 1998)[2]
			BCP	=	Bessell et al. (1998)[2]
xx	=	information available	cmd	=	Synthetic Color Magnitude Diagram for masses generated randomly
			lcmd	=	Synthetic Color Magnitude Diagram for binned masses
			sbf	=	Surface Brightness Fluctuations
			color	=	Integrated Color Indices
			properties	=	Useful properties of the models

[2]Transformations tables from Origlia & Leitherer (2000).

The files named ssp_*.*cmd list:

    ssp_BaSeL31.*cmd:
Col. 1:	Mass	=	Star mass
Col. 2:	LogL	=	Logarithm of the bolometric luminosity (solar units)
Col. 3:	LogTe	=	Logarithm of the effective temperature
Col. 4:	Log g	=	Logarithm of the gravity
Col. 5:	MV	=	Absolute V magnitude
Col. 6-16:		=	Color indices in standard *UBVRIJHK* system
Col. 17:	f	=	number of stars in each mass-bin
			($f = 1$ star randomly generated; $f > 1$ binned-mass)

    ssp_*.nic.*cmd:
Col. 1:	Mass	=	Star mass
Col. 2:	LogL	=	Logarithm of the bolometric luminosity (solar units)
Col. 3:	LogTe	=	Logarithm of the effective temperature
Col. 4:	MV	=	Absolute V magnitude
Col. 5-10:		=	Color indices in the Johnson-HST/NICMOS system
Col. 11:	f	=	number of stars in each mass-bin
			($f = 1$ star randomly generated; $f > 1$ binned-mass)

    ssp_*.wfpc2.*cmd:
Col. 1:	Mass	=	Star mass
Col. 2:	LogL	=	Logarithm of the bolometric luminosity (solar units)
Col. 3:	LogTe	=	Logarithm of the effective temperature
Col. 4:	MV	=	Absolute V magnitude
Col. 5-9:		=	Color indices in the Johnson-HST/WFPC2 system
Col. 10:	f	=	number of stars in each mass-bin
			($f = 1$ star randomly generated; $f > 1$ binned-mass)

The files named ssp_*.color contain the integrated color indices for the 5000 simulations computed with the age and chemical composition. The files list:

    ssp_BaSeL31.color:
Col. 1:	MV	=	Absolute Integrated V magnitude
Col. 2-8:		=	Integrated color indices in *UBVRIJHK* standard filters

    ssp_*.nic.color:
Col. 1:	MV	=	Absolute integrated V magnitude
Col. 2-7:		=	Johnson-HST/NICMOS integrated colors

    ssp_*.wfpc2.color:
Col. 1:	MV	=	Absolute integrated V magnitude
Col. 2-6:		=	Johnson-HST/WFPC2 integrated colors

The file named **ssp.properties** lists few properties of the models. In details, the file lists:

    ssp_*.properties:
Col. 1:	Nmod	=	Simulation Number
Col. 2:	Age	=	Age (in Gyr)
Col. 3:	Total mass	=	Total Stellar Mass of the simulation ($M_\odot$)
Col. 4:	Mto	=	Mass of the Turn Off star
Col. 5:	Nhb	=	Number of HB and AGB stars (for ages larger than 5 Gyr only)
Col. 6:	$\langle$Mhb$\rangle$	=	Average HB mass (for ages larger than 5 Gyr only)
Col. 7:	Mtip	=	Mass of the brightest star in the simulation
Col. 8:	Ltip	=	Luminosity of the brightest star in the simulation

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