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xx Yunnan models xx
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Contents

1 Outline

In Section 2, we present the description of Yunnan models for evolutionary population synthesis (EPS). In Section 3, we give the algorithms. In Sections 4 and 5, we give the description of the published data. In Section 6, we give the sole effect of binary interactions on the results. Finally, we give some examples of using these data in Section 7.

2 Description of Yunnan models

2.1 Main characteristic

Yunnan models have been built at BPS (binary population synthesis) team of Yunnan observatory. The main characteristic of Yunnan models is the inclusion of various binary interactions. Yunnan models have given the results of stellar populations (SPs) with and without binary interactions at several metallicities (seven for Basel and BLUERED; four for HRES libraries). The age ranges from 0.1 Myr to 15 Gyr.

2.2 Key ingredients

Key ingredients in Yunnan models are: (i) the Cambridge stellar evolutionary tracks (Eggleton, 1971, 1972, 1973); (ii) BaSeL (Lejeune, Cuisinier & Buser, 1997, 1998), HRES (González Delgado et al., 2005) and BLUERED (Bertone et al., 2008) stellar atmosphere models; (iii) various initial distributions of stars; and (iv) various forms of star formation rate (SFR).

The Cambridge stellar evolutionary tracks are obtained by using the rapid single- [based on the stellar evolution tracks by Pols et al. (1998)] and binary-star evolution codes (Hurley, Pols & Tout, 2000; Hurley, Tout & Pols, 2002), and include both single and binary-star evolutionary tracks.

2.3 Initialization of the SP for the standard models

A Monte Carlo method is used to construct a SP of 1×10^6 binary systems (2.5×10^7 is produced for the published data). The initial state of each binary satisfies the following input distributions for the standard models:

- **The initial mass function (IMF) of the primaries,** which gives the relative number of primaries in the mass range $m_1 \rightarrow m_1 + \mathrm{d}m_1$. The initial mass of the primary is chosen from the approximation to the IMF of Miller & Scalo (1979) as given by Eggleton, Fitchett & Tout (1989, hereafter EFT),

$$m_1 = \frac{0.19X}{(1-X)^{0.75} + 0.032(1-X)^{0.25}} \tag{1}$$

  where X is a random variable uniformly distributed in the range [0,1], and m_1 is the primary mass in units of $M_\odot$.
- **The initial secondary-mass distribution**, which is assumed to be correlated with the initial primary-mass distribution in the standard models. So, this depends on the initial primary mass and the initial mass ratio, q, distribution,

which is assumed to be a uniform form (EFT; Mazeh et al., 1992; Goldberg & Mazeh, 1994),

$$n(q) = 1, 0 \le q \le 1, \tag{2}$$

where $q = m_2/m_1$ and m_2 is the secondary mass in units of $M_\odot$.

- The distribution of orbital separations (or periods). This is taken as constant in log a (where a is the separation) for wide binaries and falls off smoothly at close separations:

$$an(a) = \begin{cases} a_{sep}(a/a_0)^p, & a \le a_0, \\ a_{sep}, & a_0 < a < a_1, \end{cases} \tag{3}$$

where $a_{sep} \approx 0.070$, $a_0 = 10R_\odot$, $a_1 = 5.75 \times 10^6 R_\odot$ and $p \approx 1.2$.

- The eccentricity distribution. A uniform form is assumed:

$$e = X, \tag{4}$$

where X is a random variable.

2.4 Inclusion of sdBs

Han et al. (2002, 2003) proposed a binary model for the formation of hot subdwarf B stars (sdBs) in binaries and single hot sdBs (three formation channels), and Han, Podsiadlowski & Lynas-Gray (2007) have presented the ISEDs of SPs with the binary interactions of sdBs. These are combined into Yunnan models for EPS.

We use the all channels of

2.5 Construction of galaxies with different galaxy types

Based on the ISEDs of SPs and various SFRs, we generate the ISEDs of galaxies with different galaxy types, including Burst-, E-, S0-, Sa, Sb, Sc, Sd-, Irr-type galaxies and five classes of galaxies with short e-folding timescales (Composite stellar populations, CSP).

E-type galaxy is constructed by advantage of a delta-form SFR, Irr-type galaxy by a constant-form SFR and the other-type galaxies by exponentially decreasing SFRs with different timescales:

$$\psi(t) = [1 + \varepsilon M_{PG}(t)]\,\tau^{-1}\exp(-t/\tau), \tag{5}$$

where τ is the e-folding timescale, $M_{PG}(t) = [1-\exp(-t/\tau)] - M_{stars} - M_{remnants}$ is the mass of gas that has been processed into stars and then returned to the interstellar medium (ISM) due to stellar evolution at time t, M_{stars} and $M_{remnants}$ are the masses of stars and remnants at t and ε denotes the fraction of $M_{PG}(t)$ that can be recycled into new star formation. The timescales are τ = 0.1, 0.3, 0.5, 0.7, 0.9, 1, 2, 3, 5, 10, 15 and 30 Gyr, respectively, the last six timescales corresponding to E, S0, Sa-Sc and Sd types. During the construction of galaxies with different galaxy types, $\varepsilon = 0$, i.e., the gas could not be recycled into new star formation.

2.6 Nebular continuum, Q(H), $L_{H\alpha}$ and $L_{H\beta}$

We obtain the number of ionizing photons Q(H) by integrating the photons below 912Å, i.e.

$$\mathrm{Q(H)} = \int \frac{\mathrm{F}_\nu}{h\nu}\,\mathrm{d}\nu, \tag{6}$$

where F_ν is the stellar flux in Hz, ν is frequency and h is the Planck constant (= 6.6262×10^{-27} erg s). Moreover, we assume that all the star formation is traced by the ionized gas, and use Case B recombination at electron temperature T_e=10 000K and number density n_e = 100cm^{-3}.

Under the above assumptions, the emission of nebular continuum can be obtained by

$$F_{\mathrm{neb},\lambda} = \Gamma \frac{c}{\lambda^2 \alpha_{\mathrm{B}}} Q(\mathrm{H}), \tag{7}$$

where c is the light velocity and Γ is the emission coefficient for hydrogen and helium (He/H=0.1), which includes free-free and free-bound contributions and the emission coefficient due to the two-photon continuum. The Γ coefficient is wavelength-dependent and is taken from Aller (1984) and Ferland (1980).

The luminosities of Hα and Hβ can be obtained by the following expression:

$$L_{\mathrm{H}\alpha} = Q(\mathrm{H}) \frac{\alpha}{\beta} \frac{j_{\mathrm{B}}}{\alpha_{\mathrm{B}}}, \tag{8}$$

where α_{B} is the recombination coefficient to the excited level in hydrogen, which depends on the electronic temperature, j_{B} and α_{B} are from Ferland (1980) and the ratio α/β is taken from Osterbrock (1989).

3 Algorithms

3.1 ISEDs

The integrated spectral energy distributions (ISEDs) are obtained by

$$F_\lambda(t, Z) = \int_0^t \int_{M_1}^{M_u} \phi(M)\ \Psi(t-\tau)\ f_\lambda(\tau, Z)\ \mathrm{d}M\,\mathrm{d}t, \tag{9}$$

where $f_\lambda(\tau,Z)$ is the spectra of stars with mass M and metallicity Z at a relative age of τ , $\phi(M)$ is the IMF, $\psi(t-\tau)$ is the SFR, M_l and M_u are the lower and upper mass limits of the IMF.

3.2 Lick/IDS indices

The integrated absorption-feature index of the Lick/IDS system is a flux-weighed one. For the ith atomic absorption line, it is expressed in equivalent width (W, in Å),

$$W_i(t, Z) = \frac{\int_0^t \int_{M_1}^{M_u} w_i(\tau, Z)\ f_{i,\mathrm{C}\lambda}(\tau, Z)\ \phi(M)\ \Psi(t-\tau)\,\mathrm{d}M\,\mathrm{d}t}{\int_0^t \int_{M_1}^{M_u} f_{i,\mathrm{C}\lambda}(\tau, Z)\ \phi(M)\ \Psi(t-\tau)\,\mathrm{d}M\,\mathrm{d}t}, \tag{10}$$

where $w_i(\tau,Z)$ is the equivalent width of the ith index of stars with mass M and metallicity Z at a relative age of τ , and $f_{i,\mathrm{C}\lambda}(\tau,Z)$ is the continuum flux at the midpoint of the ith 'feature' passband; and for the ith molecular line, the feature index is expressed in magnitude,

$$C_i(t, Z) = -2.5 \frac{\int_0^t \int_{M_1}^{M_u} 10^{-0.4\,c_i(\tau,Z)}\ f_{i,\mathrm{C}\lambda}(\tau, Z)\,\phi(M)\,\Psi(t-\tau)\,\mathrm{d}M\,\mathrm{d}t}{\int_0^t \int_{M_1}^{M_u} f_{i,\mathrm{C}\lambda}(\tau, Z)\ \phi(M)\ \Psi(t-\tau)\,\mathrm{d}M\,\mathrm{d}t}, \tag{11}$$

where $c_i(\tau,Z)$ is the magnitude of the ith index of stars with mass M and metallicity Z at age τ . The indices include CN_1, CN_2, ..., $H_{\delta F}$ and $H_{\gamma F}$.

3.2.1 FF method:

The $w_i(\tau,Z)$ and $c_i(\tau,Z)$ in Eqs. 10 and 11 can be obtained by the empirical fitting functions (FF) of Worthey et al. (1994) and Trager et al. (1998).

3.2.2 DC method:

The $w_i(\tau,Z)$ and $c_i(\tau,Z)$ in Eqs. 10 and 11 also can be obtained by direct computation (DC) from high-resolution spectra. For the DC method, $w_i(\tau,Z)$ and $c_i(\tau,Z)$ can be obtained from spectra at Lick/IDS resolution or at the original spectral resolution. For the former, the high-resolution spectra are needed to degrade to those at Lick/IDS resolution by applying a Gaussian broadening function,

$$f_{\lambda,\mathrm{Lick}} = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{+\infty} \mathrm{d}\lambda' f_{\lambda,\mathrm{hs}} \exp\left[-\frac{(\lambda-\lambda')^2}{2\sigma^2}\right] \quad (12)$$

where $f_{\lambda,\mathrm{hs}}$ and $f_{\lambda,\mathrm{Lick}}$ are the high-resolution spectra and the broaden spectra at Lick/IDS resolution,

$$\sigma = \frac{\mathrm{FWHM}^2_{\mathrm{Lick}} - \mathrm{FWHM}^2_{\mathrm{hs}}}{2.3548}. \quad (13)$$

Here, $\mathrm{FWHM}^2_{\mathrm{hs}}$ and $\mathrm{FWHM}^2_{\mathrm{Lick}}$ are the FWHM of the high-resolution spectra and spectra at Lick/IDS resolution.

3.3 Magnitudes and filters

The magnitudes are obtained by the following:

$$MAG_i(t,Z) = -2.5 \log \int_0^t \int_{M_l}^{M_u} 10^{-0.4 mag_i(\tau,Z)}\ \phi(M)\ \Psi(t-\tau)\,\mathrm{d}M\,\mathrm{d}t, \quad (14)$$

where $mag_i(\tau,Z)$ is the ith magnitude of stars with mass M and metallicity Z at age τ.

3.3.1 Vega magnitudes

The Vega magnitudes include Johnson-Cousins's *U, B, V, R*, *I* and 2MASS' *J, H* and *K* magnitudes.

3.3.2 AB magnitudes

AB magnitudes include SDSS' *u, g, r, i*, *z*, GALEX's *Fuv*, *Nuv* and HST-WFPC2's *f*122*m*, *f*130*lp*, *f*160*aw*, *f*160*bw*, *f*165*lp*, *f*170*w*, *f*185*w*, *f*218*w*, *f*255*w*, *f*300*w*, *f*336*w*, *f*343*n*, *f*375*n*, *f*380*w*, *f*390*n*, *f*437*n*, *f*439*w*, *f*450*w*, *f*467*m*, *f*469*n*, *f*487*n*, *f*502*n*, *f*555*w*, *f*606*w*, *f*656*n*, *f*658*n*, *f*673*n*, *f*675*w*, *f*702*w*, *f*814*w*, *f*850*lp*, *f*1042*m* magnitudes.

4 Description of data

4.1 All data

Basel_csp_fneb.tar.gz Basel_sp_MLR.tar.gz sdb_csp_quan.tar.gz

Basel_csp_ISED.tar.gz Bluered_sp_idxty.tar.gz sdb_sp_ISED.tar.gz
Basel_csp_quan.tar.gz Bluered_sp_ISED.tar.gz sdb_sp_MAGS.tar.gz
Basel_sp_idxff.tar.gz HRES_sp_ISED.tar.gz sdb_sp-MLR.tar.gz
Basel_sp_ISED.tar.gz sdb_csp_fneb.tar.gz
Basel_sp_MAGS.tar.gz sdb_csp_ISED.tar.gz

4.2 All code

rdidxff_sp.f rdised_fneb.f rdised_sp-hs.f rdmags_sp2.f
rdidxty_sp.f rdised_fneb-sdb.f rdised_sp-sdb.f rdmags_sp2-sdb.f
rdised_csp.f rdised_sp-bl.f rdLha_fneb.f rdmlr_sp.f
rdised_csp-sdb.f rdised_sp-br.f rdLha_fneb-sdb.f rdmlr_sp-sdb.f

4.3 Data for SPs

4.3.1 Stellar mass and magnitudes

We provide the stellar mass and magnitudes (bolometric, GALEX [*Fuv*, *Nuv*], SDSS [*u, g, r, i* and *z*], Johnson-cousins [*U, B, V, R* and *I*], 2MASS [*J, H* and *K*] and HSTWFPC2 [32] magnitudes) at seven metallicities, 90 ages for SPs with and without binary interactions (Basel_sp_MAGS.tar.gz, including 14 files [xxxyy_sp.mags, xxx=metallicity, yy=bb/ss]), and the code of reading these data (rdmags_sp2.f, in Fortran). The data in each file has the following format:

age/yr	m_t	M_{bol}	*Fuv*	*Nuv*	*U*	...
0.10000E+06	1.00000	-1.66541	0.03800	0.27886	0.79083	...
...	...	...	...	...	...	...

The variables have the following meanings:

age:	age in units of yr;
m_t:	stellar mass in units of $M_\odot$;
M_{bol}:	bolometric magnitude;
Mags:	GALEX, SDSS, UBVRI, 2MASS and HST-WFPC2 magnitudes.

4.3.2 Mass-to-light ratios

We provide the ratios of stellar mass to light for various light (bolometric, Johnson-cousins [*U, B, V, R* and *I*], 2MASS [*J, H* and *K*]) at seven metallicities, 90 ages for SPs with and without binary interactions (Basel_sp_MLR.tar.gz, including 14 files [xxxyy_sp.mlr, xxx=metallicity, yy=bb/ss]), and the code of reading these data (rdmlr_sp.f, in Fortran). The data in each file has the following format:

age/yr	M/L_{BOL}	M/L_U	M/L_B	M/L_V	M/L_R	M/L_I	M/L_J	M/L_H	M/L_K
0.10000E+06	0.00267	0.00461	0.01262	0.02871	0.04398	0.06661	0.13231	0.19061	0.20961
...	...	...	...	...	...	...	...	...	...

The variables have the following meanings:

age:	age in units of yr;
M/L:	the ratios of stellar mass to bolometric, *U, B, V, R, I, J, H* and *K* magnitudes in units of the corresponding one of Sun.

4.3.3 ISEDs

We provide the ISEDs at three resolutions (8-20Å, 0.3Å and 0.1Å) for SPs at several metallicities, 90 ages for SPs with and without binary interactions, and the code of reading these data. For the ISEDs at different resolution, the wavelength and metallicity coverages are different.

- **ISED at low resolution:** For the low-resolution ISEDs, the wavelength ranges from 91 to 1600000Å, spectral resolution is 8-20Å and metallicity has seven values and ranges from 0.0001 to 0.03 (Basel_sp_ISED.tar.gz, including 14 files [xxxyy_sp-bl. ised, xxx=metallicity ('m23', 'm18', 'm13','m07','m03','p00','p02'), yy=bb/ss, bl-BaSeL]). The code of reading these data is rdised_sp-bl.f and in Fortran. The flux has been normalized to $F_\lambda/L_\odot/M_\odot$. The data has the following format:

90	*0.1000E+06*	*0.1259E+06*	*0.1585E+06*	*0.1995E+06*	*0.2512E+06*	...
1221	*91.0*	*94.0*	*96.0*	*98.0*	*100.0*	...
0.1228E-08	*0.2945E-08*	*0.5112E-08*	*0.8653E-08*	*0.1432E-07*	...	...
...	...	...	...	...	...	...

  the 1st line: ages (90) in units of yrs;
  the 2nd line: wavelength (1221) in units of Å;
  the 3rd-last lines: physics flux in units of $F_\lambda/L_\odot/M_\odot$.

- **ISED at 0.3Å resolution:** The wavelength ranges from 3000 to 7000Å, and metallicity has four values and ranges from 0.004 to 0.03 (HRES_sp_ISED.tar.gz, including 8 files [xxxyy_sp-hr.ised, xxx=metallicity ('m07','m03','p00','p02'), yy=bb/ss, hr-HRES]). The code of reading these data is rdised_sp-hs.f and in Fortran. The flux has been normalized to $F_\lambda/L_\odot/M_\odot$. The data has the following format:

90	*0.1000E+06*	*0.1259E+06*	*0.1585E+06*	*0.1995E+06*	*0.2512E+06*	...
13323	*3000.2*	*3000.5*	*3000.8*	*3001.1*	*3001.4*	...
0.1694E-01	*0.1695E-01*	*0.1688E-01*	*0.1681E-01*	*0.1677E-01*	...	...
...	...	...	...	...	...	...

  the 1st line: ages (90) in units of yrs;
  the 2nd line: wavelength (13323) in units of Å;
  the 3rd-last lines: physics flux in units of $F_\lambda/L_\odot/M_\odot$.

- **ISED at 0.1Å resolution** The wavelength ranges from 3500 to 7000Å, and metallicity has seven values and ranges from 0.0001 to 0.03 (Bluered_sp_ISED.tar.gz, including 14 files [xxxyy_sp-br.ised, xxx=metallicity ('m23', 'm18', 'm13', 'm07', 'm03', 'p00', 'p02'), yy=bb/ss, bl-BLUERED]). The code of reading these data is rdised_sp-br.f and in Fortran. The flux has been normalized to $F_\lambda/L_\odot/M_\odot$. The data has the following format:

90	*0.1000E+06*	*0.1259E+06*	*0.1585E+06*	*0.1995E+06*	*0.2512E+06*	...
27731	*3500.0*	*3500.1*	*3500.2*	*3500.3*	*3500.4*	...

0.1124E-01	0.1123E-01	0.1121E-01	0.1119E-01	0.1119E-01	...	...
...	...	...	...	...	...	...

the 1st line: ages (90) in units of yrs;
the 2nd line: wavelength (27731) in units of Å;
the 3rd-last lines: physics flux in units of F_λ/L$_\odot$/M$_\odot$.

4.3.4 Lick/IDS indices

- **indices via fitting function method:** We provide the Lick/IDS indices by FF method (W_i and C_i in Eqs. 10 and 11), the pseudo-continuum flux [$F_{i,C\lambda}(t,Z) = \int^t_0 \int^{Mu}_{Ml} f_{i,C\lambda}(\tau,Z)\, \phi(M)\, \psi(t-\tau)\, dM\, dt$, the meaning of $f_{i,C\lambda}(\tau,Z)$ can be seen from Eqs. 10 and 11] and pseudo-continuum wavelength for SPs with and without binary interactions at seven metallicities and 90 ages (Basel_sp_idxff.tar.gz, including 14 files [xxxyy_sp.idxff, xxx=metallicity ('m23', 'm18', 'm13', 'm07', 'm03', 'p00', 'p02'), yy=bb/ss]), and the code of reading these data (rdidxff_sp.f and in Fortran). The data in each file has the following format:

01	02	03	...	27	28	...	52	53	...
Age	CN_1	CN_2	...	$F_{CN1,C\lambda}$	$F_{CN2,C\lambda}$	...	$w_{CN1,C\lambda}$	$w_{CN2,C\lambda}$	...
100000.0	-0.162	-0.093	...	0.852E-02	0.864E-02		4159.625	4159.625	...
...	...	...			...	...	...	...	...

the 1st line:	number;
the 2nd line:	age, indices, $F_{i,C\lambda}$ and $w_{i,C\lambda}$:
age:	ages (90) in units of yrs;
EW_i/C_i:	indices obtained by fitting functions in units of Å or mag, including CN_1, CN_2, Ca4227, G4300, Fe4383, Ca4455, Fe4531, Fe4668, H_β, Fe5015, Mg_1, Mg_1, Mg_b, Fe5270, Fe5335, Fe5406, Fe5709, Fe5782, NaD, TiO1, TiO2, $H_{\delta A}$, $H_{\gamma A}$, $H_{\delta F}$, H_{AF};
$F_{i,C\lambda}$:	integrated pseudo-continuum flux in units of F_λ/L$_\odot$/M$_\odot$;
$w_{i,C\lambda}$:	pseudo-continuum wavelength in units of Å.

- **indices via direct computation method:** We also provide the Lick/IDS indices by DC method, the pseudo-continuum flux and pseudo-continuum wavelength for SPs with and without binary interactions at seven metallicities and 90 ages (Bluered_sp_idxty.tar.gz, including 14 files [xxxyy_sp-br.idxty, xxx=metallicity ('m23', 'm18', 'm13', 'm07', 'm03', 'p00', 'p02'), yy=bb/ss]), and the code of reading these data (rdidxty_sp.f and in Fortran). The data in each file has the following format:

01	02	03	...	27	28	...	52	53	...
Age	CN_1	CN_2	...	$F_{CN1,C\lambda}$	$F_{CN2,C\lambda}$	...	$w_{CN1,C\lambda}$	$w_{CN2,C\lambda}$	...
100000.0	-0.162	-0.093	...	0.852E-02	0.864E-02		4159.625	4159.625	...
...	...	...			...	...	...	...	...

the 1st line:	number;

the 2nd line:	age, indices, $F_{i,C\lambda}$ and $w_{i,C\lambda}$:
age:	ages (90) in units of yrs;
EW_i/C_i:	indices obtained by fitting functions in units of Å or mag, including CN_1, CN_2, Ca4227, G4300, Fe4383, Ca4455, Fe4531, Fe4668, H_β, Fe5015, Mg_1, Mg_1, Mg_b, Fe5270, Fe5335, Fe5406, Fe5709, Fe5782, NaD, TiO1, TiO2, $H_{\delta A}$, $H_{\gamma A}$, $H_{\delta F}$, H_{AF};
$F_{i,C\lambda}$:	integrated pseudo-continuum flux in units of $F_\lambda/L_\odot/M_\odot$;
$w_{i,C\lambda}$:	pseudo-continuum wavelength in units of Å.

4.4 Data for CSP

We provide the low-resolution ISEDs for 13 types of galaxies at seven metallicities and 90 ages on the basis of SP with and without binary interactions (Basel_csp_ISED.tar.gz, including 182 files [xxxyy_csp_zz.ised, xxx=metallicity ('m23', 'm18', 'm13', 'm07', 'm03', 'p00', 'p02'), yy=bb/ss, zz=Burst /S0 /Sa /Sb /Sc /Sd /Irr /p1GBurst /p3GBurst /p5GBurst /p7GBurst /p9GBurst]), and the code of reading these data (rdised_csp.f and in Fortran). The wavelength ranges from 91 to 1600000Å. The data has the following format:

90	*0.1000E+06*	*0.1259E+06*	*0.1585E+06*	*0.1995E+06*	*0.2512E+06*	...
1221	*91.0*	*94.0*	*96.0*	*98.0*	*100.0*	...
0.1228E-08	*0.2945E-08*	*0.5112E-08*	*0.8653E-08*	*0.1432E-07*	...	...
...	...	...	...	...	...	...

the 1st line:	ages (90) in units of yrs;
the 2nd line:	wavelength (1221) in units of Å;
the 3rd -last lines:	physics flux in units of $F_\lambda/L_\odot/M_\odot$.

4.5 Data for nebular continuum

We provide the stellar ($F_{\mathrm{ste},\lambda}$), nebular ($F_{\mathrm{neb},\lambda}$)and total continuum ($F_{\mathrm{tot},\lambda} = F_{\mathrm{ste},\lambda} + F_{\mathrm{neb},\lambda}$) for 13 types of galaxies at seven metallicities on the basis of SP with and without binary interactions (Basel_csp_fneb.tar.gz, including 182 files [xxxyy_csp_zz.fneb, xxx=metallicity ('m23', 'm18', 'm13', 'm07', 'm03', 'p00', 'p02'), yy=bb/ss, zz=Burst /S0 /Sa /Sb /Sc /Sd /Irr /p1GBurst /p3GBurst /p5GBurst /p7GBurst /p9GBurst]), and the code of reading these data (rdised_fneb.f and in Fortran). The wavelength ranges from 91 to 1600000Å. The data has the following format:

90	*0.1000E+06*	*0.1259E+06*	*0.1585E+06*	*0.1995E+06*	*0.2512E+06*	...
1221	*91.0*	*94.0*	*96.0*	*98.0*	*100.0*	...
0.1228E-08	*0.2945E-08*	*0.5112E-08*	*0.8653E-08*	*0.1432E-07*	...	...
0.0000E+00	*0.0000E+00*	*0.0000E+00*	*0.0000E+00*	*0.0000E+00*	...	..
0.1026E-15	*0.2760E-15*	*0.5152E-15*	*0.9353E-15*	*0.1655E-14*	...	...
...	...	...	...	...	...	...

the 1st line:	ages (90) in units of yrs;
the 2nd line:	wavelength (1221) in units of Å;
the 3rd +(k-1) ×3 lines:	stellar continuum (physics flux) in units of $F_\lambda/M_\odot$;
the 4th +(k-1) ×3 lines:	nebular continuum (physics flux) in units of $F_\lambda/M_\odot$;
the 5th +(k-1) ×3 lines:	total continuum (physics flux) in units of $F_\lambda/M_\odot$.

4.6 Data for Q(H), $L_{H\alpha}$ and $L_{H\beta}$

We provide the number of ionizing photons Q(H), the luminosities $L_{H\alpha}$ and $L_{H\beta}$ of for 13 types of galaxies at seven metallicities on the basis of SP with and without binary interactions (Basel_csp_quan.tar.gz, including 182 files [xxxyy_csp_zz.quan, xxx=metallicity ('m23', 'm18', 'm13', 'm07', 'm03', 'p00', 'p02'), yy=bb/ss, zz=Burst /S0 /Sa /Sb /Sc /Sd /Irr /p1GBurst /p3GBurst /p5GBurst /p7GBurst /p9GBurst]), and the code of reading these data (rdLha_fneb.f and in Fortran). The data has the following format:

age/yr	*Nphot*	*L(Ha)*	*L(Hb)*	*L(bol)*
0.10000E+06	*40.35264*	*28.48618*	*28.03025*	*30.37387*
...	...	...	...	...

The variables have the following meanings:

age:	age in units of yr;
Nphot:	the logarithmic number of ionizing photons;
L(Ha):	the logarithmic luminosity of Hα line in units of erg s^{-1};
L(Hb):	the logarithmic luminosity of Hβ line in units of erg s^{-1};
L(bol):	the logarithmic bolometric luminosity in units of erg s^{-1}. (~ L_{FIR})

5 Description of data considering sdBs

We comprising the binary interactions of sdBs into our models, and give the results of SPs, galaxies with different types, nebular emission and luminosities of Hα and Hβ. Because this set of models is only for SPs with binary interactions, the number of files is an half of the above set in Section 4.

5.1 Data for SPs

We provide the low-resolution ISEDs, stellar mass, magnitudes and mass-to-light ratios at several metallicities, 90 ages for SPs with binary interactions of sdBs.

- **stellar mass and magnitudes:** the format is the same as that in Section 4.3.1 (sdb_sp_MAGS.tar.gz, rdmags_sp2-sdb.f) [xxxbb_sp-sdb.mags, xxx=metallicity, 7 files];
- **mass-to-light ratios:** the format is the same as that in Section 4.3.2 (sdb_sp-MLR.tar.gz, rdmlr_sp-sdb.f) [xxxbb_sp-sdb.mlr, xxx=metallicity, 7 files];
- **low-resolution ISEDs:** the format is the same as that of SPs at low resolution in Section 4.3.3 (sdb_sp_ISED.tar.gz, rdised_sp-sdb.f) [xxxbb_sp-sdb.ised, xxx=metallicity, 7 files].

5.2 Data for galaxies with different types

We provide the ISEDs for 13 types of galaxies at seven metallicities on the basis of SP with the binary interactions of sdBs (sdb_csp_ISED.tar.gz, including 91 files [xxxbb_csp_zz-sdb. ised, xxx=metallicity ('m23', 'm18', 'm13', 'm07', 'm03', 'p00', 'p02'), zz=Burst /S0 /Sa /Sb /Sc /Sd /Irr /p1GBurst /p3GBurst /p5GBurst /p7GBurst /p9GBurst]), and the code of reading these data (rdised_csp-sdb.f and in Fortran). The data has the same format as that in Section 4.4.

5.3 Data for nebular continuum, Q(H), $L_{H\alpha}$ and $L_{H\beta}$

We provide the nebular continuum, Q(H), $L_{H\alpha}$ and $L_{H\beta}$ for 13 types of galaxies at seven metallicities on the basis of SP with the binary interactions of sdBs (sdb_csp_fneb.tar.gz & sdb_csp_quan.tar.gz, with each tar file including 91 files [xxxbb_csp_zz-sdb.fneb & xxxbb_csp_zz-sdb.quan, xxx=metallicity ('m23', 'm18', 'm13', 'm07', 'm03', 'p00', 'p02'), zz=Burst /S0 /Sa /Sb /Sc /Sd /Irr /p1GBurst /p3GBurst /p5GBurst /p7GBurst /p9GBurst]), and the code of reading these data (rdised_fneb-sdb.f & rdLha_fneb-sdb.f and in Fortran). The data has the same format as those in Sections 4.5 and 4.6.

6 Sole effect of binary interactions

Ongoing.

7 Example

7.1 On the BC03 models

Ongoing.

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