CDBS Spectral Atlases of Galaxies and Emission Line Objects

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ABSTRACT

The astronomical catalog section of the CDBS contains on-line spectra of HST standards as well as several stellar atlases, including stellar atmosphere models. The present document explains the content and scope of new spectral atlases of galaxies and galactic emission line objects added to the CDBS astronomical catalog. These new atlases include spectral templates for galaxies of various morphological types and activity classes, and cover the ultraviolet to near-infrared wavelength range, i.e. from 0.12 μm up to about 1 μm. The new spectral templates form a useful database for synthetic photometry purposes and for use with the exposure time calculators of HST instruments.

1. Introduction

The astronomical catalog section of the CDBS provides the absolute spectral energy distribution of the standards used in the absolute calibration of present and future HST instruments. On the other hand, the catalog also provides a database of spectral templates that can be used for a broad range of purposes. These templates, when used with exposure time calculators and/or synthetic photometry tools, allow to compute the required observing time, or expected signal-to-noise ratios, for planned HST observations.

Stars of different spectral type and luminosity class are already well covered by the spectral atlases included in the astronomical catalog. The same is not true for galaxies of different morphological type, for active galaxies, and for galactic emission line objects. A large fraction of HST observations are dealing with galaxies and diffuse galactic objects, and/or use narrow-band filters centered on optical and near-infrared emission lines. There is therefore a need to include spectral templates of galaxies and diffuse emission line objects as part of the on-line CDBS astronomical catalog.

The present report explains the extension and scope of a new set of on-line spectral atlases designed to cover this need.

2. The Bruzual & Charlot Spectral Atlas of Galaxies

This atlas contains spectral energy distributions computed with the Galaxy Isochrone Synthesis Spectral Evolutionary code developed by G. Bruzual and S. Charlot. The latest version of the Bruzual & Charlot atlas (December 1995) contains spectral templates of instantaneous star-forming bursts characterized by different Initial Mass Functions (IMFs) and lower and upper mass limits. Additional composite stellar populations obtained using a constant or an exponentially decreasing star formation rate, are also available. Each instantaneous burst contains 221 spectral energy distributions (SEDs) corresponding to 221 time steps from 0 to 20 Gyr. Each SED has 1206 wavelength points covering the 5 Å to 100 μm wavelength range. The SEDs contain the stellar contribution of a instantaneous burst at a given age but do not include the nebular component, i.e. the emission lines and nebular continuum.

The complete original Bruzual & Charlot atlas (December 1995 version) containing all the *.ised binary files is now on-line (see section 6 for the specific WWW address). The programs needed to decode the binary files and generate a given SED for instantaneous bursts and composite stellar populations, are also available in the same directory. For instructions on how to generate a set of SEDs, read the README file located in the directory. Further details on the range of IMF parameters covered by the models and on how to generate composite stellar population templates can be found in the README file.

The CDBS astronomical catalog also contains an on-line library of 84 Bruzual & Charlot SEDs obtained from the original *.ised binary files using the *galaxevpl* program. Those SEDs correspond to instantaneous and composite bursts of various ages where the star formation is characterized by a Salpeter IMF with various lower and upper mass limits (see Table 1 for details). The files have 1187 wavelength points covering the 100 Å to 100 μm wavelength range. Flux in the files is in units of solar luminosity per angstrom.

The file name convention *bc95_X_YYYY* is used to identify the different SEDs. The root file name is *bc95* for Bruzual & Charlot 1995, *X* is a letter (a, b, c, d, e, f or g) representing a specific burst model, and *YYYY* indicates the age (1.0, 2.5, 5.0, 7.6, 10, 25, 50, 100, 500, 1000, 5000, and 10000 million years) of the burst. For example, the file *bc95_d_50E6.tab* contains the SED of a 50 million years old instantaneous burst characterized by a Salpeter IMF with lower and upper mass limits of 2.5 and 125 solar masses, respectively.

Table 1. On-line CDBS Bruzual & Charlot Galaxy Spectral Templates

Root File Name	IMF	Lower Mass (Solar Mass)	Upper Mass (Solar Mass)	Comments
bc95_a	Salpeter	0.1	125	Instantaneous burst
bc95_b	Salpeter	0.1	65	Instantaneous burst
bc95_c	Salpeter	0.1	30	Instantaneous burst
bc95_d	Salpeter	2.5	125	Instantaneous burst
bc95_e	Salpeter	0.1	125	burst from t= 0 to t= 1Gyr
bc95_f	Salpeter	0.1	125	exp. decreasing SFR with e-folding time of 1 Gyr
bc95_g	Salpeter	0.1	125	constant SFR= 1E-10 Mo/yr

3. The Kinney & Calzetti Spectral Atlas of Galaxies

This atlas contains a set of spectral templates of galaxies covering the ultraviolet to near-infrared spectral range, i.e. from 0.12 μm up to about 1 μm (see Table 2 for the specific wavelength coverages). The ultraviolet spectra have been obtained with the large aperture (10" by 20") and low resolution spectrographs of the IUE satellite. The optical spectra were obtained through a long slit with a 10" width, were a window 20" long was extracted to match the IUE aperture.

The spectral templates cover various galaxy morphological types from ellipticals to late spirals. Starbursts templates for low to high internal extinction, i.e. from E(B-V) < 0.10 to 0.61 < E(B-V) <0.70, are also available. Details on how the templates have been constructed can be found in Kinney et al. (1996) for galaxies of different morphological types, and in Calzetti, Kinney & Storchi-Bergmann (1994) for the starburst galaxies.

The flux of Kinney & Calzetti spectral templates has been normalized to an apparent Johnson visual magnitude of 12.5 (STMAG).

Table 2. On-line Kinney-Calzetti Galaxy Spectral Templates

File Name	Spectral Range (Angstroms)	Comments
elliptical_template	1235-9935	elliptical template
bulge_template	1235-7545	bulge template
s0_template	1235-9940	S0 template
sa_template	1235-9940	Sa template
sb_template	1235-9940	Sb template
sc_template	1235-7660	Sc template
starb1_template	1235-9945	starburst with E(B-V) < 0.10
starb2_template	1235-9945	starburst with 0.11 < E(B-V) < 0.21
starb3_template	1235-9945	starburst with 0.25 < E(B-V) < 0.35
starb4_template	1235-9945	starburst with 0.39 < E(B-V) < 0.50
starb5_template	1235-9945	starburst with 0.51 < E(B-V) < 0.60
starb6_template	1235-9945	starburst with 0.61 < E(B-V) < 0.70

4. The AGN Spectral Atlas

This atlas contains a few spectral templates covering various types of Active Galactic Nucleus (AGN). The origin of the templates is heterogeneous. The LINER and Seyfert 2 templates have been obtained with the large aperture (10" by 20") and low resolution spectrographs of the IUE satellite. The optical spectra were obtained through a long slit with a 10"width, were a window of 20" long was extracted to match the IUE aperture (Calzetti 1995, private comm.). The flux of the LINER and Seyfert 2 templates is normalized to a Johnson visual magnitude of 12.5 (STMAG).

The Seyfert 1 template consists of an UV spectrum obtained with the IUE low resolution spectrographs and of a ground-based optical spectrum (P. Rodriguez, private comm.).

There has been no attempt to mach the IUE and optical apertures in this case. The bright QSO template is a composite spectrum from the Large Bright Quasar Survey of Francis et al. (1991) made available by J.R. Walsh (private comm.). The Seyfert 1 and QSO spectral templates are normalized to a Johnson blue magnitude of 12.5 (STMAG).

Finally, the NGC 1068 template is a composite spectrum. The continuum contains the nebular, stellar, and power-law contributions. The observed fluxes and FWHM of the UV, optical and near-IR emission lines have also been incorporated into the template (J.R. Walsh, private comm; read also the header of the STSDAS table file for full details).

Table 3. On-line AGN Spectral Templates

File Name	Spectral Range (Angstroms)	Comments
liner_template	1235-7550	spectrum of M81
seyfert2_template	1235-9835	composite of several
seyfert1_template	1132-7078	spectrum of NGC 5548
qso_template	800-6000	composite of several
ngc1068_template	1000-11000	model

5. The Galactic Emission Line Object Spectral Atlas

This atlas contains the model spectra of the Orion nebula, and of the planetary nebula NGC 7009. The templates cover the wavelength range from 0.1 μm to 1.1 μm.

The continuum of the Orion's template contains the nebular contribution plus a combination of Kurucz model atmospheres to simulated the stellar contribution. The fluxes of the UV, optical and near-infrared emission lines from different sources are also incorporated into the template (J.R. Walsh, private comm; see also the header of the STSDAS table file for full details).

The continuum of the planetary nebula has a nebular component and a hot stellar component simulated by an 80000K black body. The fluxes of the UV, optical and near-infrared emission lines have also been incorporated into the template (J.R. Walsh, private comm; read also the header of the STSDAS table file for full details).

Table 4. On-line Galactic Emission Line Object Spectral Templates

File Name	Spectral Range (Angstroms)	Comments
orion_template	1000-11000	model
pn_template	1000-11000	model

6. Galaxy Spectral Atlases on the WEB

Information about the new galaxy spectral atlases, and about the rest of the stellar and HST calibration spectral atlases, can be found on the WWW pages of the STScI Observatory Support Group, astronomical catalog section: "*html://www.stsci.edu/ftp/instrument_news/Observatory/astronomical_catalogs.html*".

The complete original Bruzual & Charlot atlas, containing all binary files and decoding programs to generate specific galaxy spectral energy distributions, can be found at "*html://www.stsci.edu/ftp/cdbs/cdbs2/grid/bc95/binary/*". Check the README file there for details on how to generate a given galaxy spectral energy distribution. Several Bruzual & Charlot spectral templates in STSDAS binary table format can be found on-line at "*html://www.stsci.edu/ftp/cdbs/cdbs2/grid/bc95/templates/*".

The html address for the Kinney-Calzetti spectral templates is "*html://www.stsci.edu/ftp/cdbs/cdbs2/grid/kc96/*". The STSDAS binary versions of the spectra contained on the AGN and Galactic Emission Line Object atlases can be found at "*html://www.stsci.edu/ftp/cdbs/cdbs2/grid/agn/*" and "*html://www.stsci.edu/ftp/cdbs/cdbs2/grid/galactic/*", respectively.

All the above files and subdirectories can also be found on-line by moving to the crgrid directory after loading the stsdas package during an IRAF session.

The header of each STSDAS binary file contains information on how the spectrum has been constructed as well as references, when appropriated. If desired, all files in binary STSDAS table format can be converted into ASCII files using the *tdump* task within the tables. ttool package in IRAF.

7. Summary and Future Work

The astronomical catalog section of the CDBS is now supplemented with new spectral atlases of galaxies and emission line objects. The extension and spectral coverage of these atlases form an useful database. Application packages like SYNPHOT and the HST SI's exposure time calculators will benefit from the existence of this database.

Future work should concentrate on the extension of the spectral templates into the near-infrared wavelength range, i.e from 1 μm up to 3 μm. The spectral galaxy atlases should also cover in the future a broader range of galaxies including high redshift quasars and galaxies.

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REFERENCES

Bruzual, G. & Charlot, S. 1993, ApJ 405, 538.

Calzetti, D., Kinney, A.L. & Storchi-Bergmann, T. 1994, ApJ 429, 582.

Francis, P. et al. 1991, ApJ 373, 465.

Kinney, A.L., Calzetti, D., Bohlin, R.C., McQuade, K., Storchi-Bergmann, T. & Schmitt, H.R. 1996, ApJ August issue (also STScI preprint 1037).