Interoperable SED Access and Analysis

Project Definition Document

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1 Project Description

The spectral energy distribution (SED) of an object describes how much energy it emits as a function of wavelength or frequency. The SEDtool will be a multi-component access and analysis tool consisting of 2 pre-existing applications - Specview and Sherpa, and a web service to retrieve SEDs from NED.

Specview is the front-end that provides a graphical user interface and manages access to SEDs. Given an object name an inquiry is made to the VAO registry for available services providing SED information (includes the NED SED Service). Upon request from Specview the NED Service will respond with points available for the requested object and then the data is read into Specview. Specview also provides capabilities to edit data (e.g. remove spectral points), display data characteristics stored as metadata and visualize spectral data via plotting capabilities. To analyze a SED the user will select models from a Specview menu and build composite models they want to fit to the data. These models can be added or multiplied together to account for the emission features and for absorption. The user also has access to set parameter value ranges, and select the fitting method and statistic. Specview packages the input and sends the fit to Sherpa via SAMP. Fitting is done in Sherpa and the results are sent back and displayed in Specview.

A one-time task is to download and install the SEDtool. User access will be via the SED portal page and we plan to provide easy installation on a users local machine. We will support Linux and Macintosh platforms and plan to pursue a web-based tool once the year 1 release is delivered.

A library to read and write SEDs is being developed as part of this project. The SEDLib will implement the 1.03 Spectrum Data Model and Specview will utilize the SEDLib to read and write SEDs. The library will also be available to VAO users who are writing SEDs and need an i/o library to output an IVOA compliant file. Documentation and access to download the library will also be provided.

As mentioned above, part of this project is building a SED Access Service that will discover and access data from the NASA/IPAC Extragalactic Database (NED). The database provides a multi-wavelength fusion of data for millions of object outside of the Milky Way galaxy. Services for 3 types of queries will be provided; 1) NED SED Info Discovery, 2) NED SED Info Availability, 3) NED SED Data Retrieval. Access to these services is provided through Specview and more generically through the VAO Portal. The discovery and availability services follow the IVOA Simple Spectral Access Protocol (SSAP) Version 1.04 standard and the data retrieval follows the IVOA Spectral Data Model Version 1.03 standard.

A detailed thread through the tool is presented in the SED Access and Analysis Storyboard. It represents a view of how the VAO user will interact with the SED tool to find and analyze SEDs. The Storyboard covers a typical thread through the application. It does not present an exhaustive list of options available to the user. Some specifics about the look and feel of other development work (i.e. portal) have been included for completeness but may change as details of those projects are further developed.

SED project detailed documents are available on the SEDAccessAnalysis page. Documents including a detailed schedule, derived requirements, project designs, sample data, and meeting notes can be accessed.

2 Project Interdependencies

This project is expected to support the following other projects:

- CANDELS collaboration

This project is expected to depend on the following other projects:

- 1.14 Sherpa-driven SED Fitting
  - This project is a close collaborator and will deliver the Sherpa fitting service to be accessed via Specview.
- 1.15 Specview SED Support
  - This project is a close collaborator and will deliver read, write, edit, and visualization services.

This project is expected to utilize services provided by the following projects:

- 1.1 VAO Portal Infrastructure and Integration
  - It is expected that the Portal will provide a mechanism for leading VAO users to SED capabilities.
- 1.13 DALServer Extension
  - It is expected that the DALServer extension will provide a SED Builder Framework for Users with archives of SED products. (Post Yr1)

This project is expected to depend on the following IVOA standards currently in development.

- IVOA Spectrum Data Model 1.03 (Year1- SEDLib/SED Service Standard)
- IVOA Simple Spectral Access Protocol 1.04 (Year 1 - SED Service Standard)
- IVOA Photometry Data Model (In review)
- IVOA SED Data Model (in review)
- Simple Application Messaging Protocol (SAMP)

Other dependencies (internal):

- SED Library
  - Complete the development of the IVOA compliant SED library & toolkit
- NED/SED Service
  - Provide VO-enable SEDs from NED using IVOA Spectrum/SED Data Model

3 High-level Requirements (Year 1)

Req.#	Sup. Proj.	Requirement statement	Verif. Method
Prj.1	NED	The VAO SED access service shall conform to applicable IVOA guidelines, to the extent that VAO goals and requirements do not conflict.	A
Prj.2	NED	The user will be able to discover SEDs available from NED and be able to download them for analysis.	T, D
Prj.3	NED	The user should be able to easily visualize and analyze SEDs containing between 1 and 500 photometric points and can expect an average number of points to be 5.	T, D
Prj.4	NED	Users should be able to access the SED access, visualization, and analysis capabilities from Linux and Macintosh platforms.	T, D
SED.bui.1	SV	The user can read local spectroscopic and photometric tabular data in VO-compliant (VOtable or FITS described by the IVOA Spectral Data Model) and non-VO compliant formats (CSV, TSV, FITS, XLS) representing IVOA serializations of photometry or spectral data.	T, D
SED.bui.1.1	SV	The user can write a table containing photometric measurements (columns with spectral coordinates and flux measurement) stored in non VO-compliant formats to a VO-compliant format with the appropriate header metadata.	T, D
SED.bui.1.2	SV	The user can write a table containing spectroscopic data stored in non VO-compliant formats (FITS, Native IRAF image format known as OIF, CSV, TSV) to a VO-compliant format with the appropriate header metadata.	T, D
SED.bui.3	SV	The user has access to precomputed SEDs which can come from several sources including Surveys and/or Collections.	T, D
SED.bui.3.2	SV	The user has specific access to pre-computed SEDs from the NED SED Service.	T, D
SED.bui.4	SV	The user has access via IVOA SAMP protocol to interoperate between the SED application and other SAMP-enable applications (e.g. TOPCAT, DS9, Aladin) .	T, D
SED.bui.6	SV	The user can assemble an aggregate SED dataset from separate heterogeneous photometric points and spectral segments. The single elements are required to satisfy 5 criteria specified in Section 2.9	T, D
SED.bui.7	SV	The user can perform point and extended source aperture correction on photometric points. The algorithm utilizes metadata optionally available in photometric SEDs compliant with the IVOA photometry DM.	T, D
SED.bui.7.1	SV	The user can perform a simple aperture correction to the flux of a photometric point following the equation in section 2.1(2) allowing the user to choose the ApFrac? parameter in the range of [0.0, 1.0].	T, D
SED.an.1	Sh	The user can read in a file containing an aggregate SED and convert the units of measure of the SED for both spectral and flux coordinates.	T, D
SED.an.4	Sh	The user can fit SEDs with analytical and tabular functions as source models by identifying the parameter values which give the optimum value of the fit statistic.	T, D
SED.an.4.1	Sh	The user can fit an aggregate SEDs and return the best-fit parameter values and the reduced statistic value.	T, D

SED.an.4.3	Sh	The user has access to spectral models in a library of commonly used functions that are defined either analytically or empirically.	T, D
SED.an.4.4	Sh	The user has access to a modeling language to support algebraic composition of multiple individual models from a standard library. Arithmetic operators are to be supported along with arbitrary functions to be applied to specific model components.	T, D
SED.an.4.5	Sh	The user can specify the range of spectral coordinates to be considered which can be either the whole range or multiple disjoint intervals of spectral coordinates. Intervals are to be provided from a user-defined table or from user interaction.	T, D
SED.an.4.6	Sh	The user can estimate the goodness-of-fit of the model and specify among a small number of reference fit statistics of his choosing. (for example, $\chi2$ statistics and some of the specific statistics derived by the maximum likelihood principle).	T, D
SED.an.4.7	Sh	The user can estimate the confidence levels for the fit parameters at a user-defined standard-deviation.	T, D
SED.viz.1	SV	The user can visualize one or more aggregate or rebinned SEDs.	T, D
SED.viz.1.1	SV	The user can plot the SED as "generic flux" versus spectral coordinates and interactively convert between multiple representations of the SED with a variety of units. (Units listed in Section 2.1)	T, D
SED.viz.1.2	SV	The user can interactively select a spectral region and the re-plotting of the SED in this region.	T, D
SED.viz.1.3	SV	The user can interactively zoom in and out of a SED.	T, D
SED.viz.1.7	SV	The user can interactively inspect metadata (e.g. time of the observation, aperture, photometric system, reference in the literature, name of the PI, parameters of the reduction of the data,...) associated to each single photometric point or spectral segment composing the SED	T, D
SED.viz.1.7.1	SV	The user interaction to access metadata is by hovering the pointer over any data element.	T, D
SED.viz.1.9	SV	The user can plot the modified version of a SED or any section defined in spectral coordinates in a new visualization window.	T, D
SED.viz.1.11	SV	The user can save SED plots in different graphical formats.	T, D
SED.viz.2	SV	The user has access a mechanism to record session operations performed during the work session in order to repeat such analysis and reduction steps in a non-interactive way.	T, D
SED.viz.2.2	SV	The user has access to simple reports of interactive sessions containing only the description of the analysis steps performed during an interactive work session by the user and the references to saved files containing the SED data	T, D

Verification Method Codes: T = Testing, D = Demonstration, I = Inspection, A = Analysis.

The Req# in the table above refer to either 1) Project requirements with id Prj.# -or- the sections in the SED High Level Requirements Document where the Requirement appears. The Support Project column identifies the group responsible for the requirement (**NED**=NED Service, **Lib**=SEDLib, **SV**=Specview, **Sh**=Sherpa, **ALL**=Project-wide**).**

For more details on these and subsequent year requirements for SED Access and Analysis, see the High level requirements document.

4 Roadmap

Information given here may be deprecated during the design phase.

This work is expected to result in the following types of products:

- a SED access library and toolkit

- a NED/SED builder service

- a SED desktop application

- a SED web-based application (Post-Yr1 delivery)

The work for this project is expected to be delivered

- July 29, 2011

Schedule Overview:

- SED Requirements Doc – last update Dec (RD/JCM)

- IVOA Note on Photometry, Spectrum & SED DM – End Nov (JCM)

- SED Science and Software presentations at IVOA – Early Dec (JCM&JDE)

- SED component derived requirements – End Dec (Each team)

  - SED Lib (MCD), NED/SED (RE), Specview (IB), Sherpa (SD)

- Provide sample NED/SED data files (End Jan - team reviewing/few iterations into Feb)

- Designs for SED components – SED Lib, Sherpa, Specview, NED/SED Service (End Jan/Early? Feb)

- Software Development - all sub-teams (Feb/Mar?)

- Use Case Doc – RD/Working (End Feb)

- Photometry, Spectrum, & SED DM Stds with IVOA – JCM-Working (Est. Mar)

- SED Beta1 – Complete end-to-end Yr1 thread (Mid Feb - Apr 1)

  - SED library (New Java Lib using current Spectrum DM standard)

  - SED/NED Service (NED Service using current Spectrum DM standard)

  - SED Service reference framework (for project archives (e.g. CANDELS))

  - Integrate Specview and Sherpa; provide interface to NED/SED Service

  - Internal science evaluation

  - Build regression tests / document science tests

- SED Beta2 (Early May – Early Jun)

  - Component upgrades based on testing feedback

  - Re-test with internal science group

VIRTUAL ASTRONOMICAL OBSERVATORY

- ○ DM standards upgrade if IVOA process complete
- ○ Year 1 requirements not complete in Beta1
- ○ VAO test / team regression tests, science test doc, use case doc as input
- Yr 1 Release (Mid Jun – End Jul)
  - ○ Includes bugfixes/enhancements from testing feedback
  - ○ Integrate into VAO framework – Jira, SVN, Documentation
  - ○ Downloadable on Linux, Mac & Web service are the targets