Appendix A: Theoretical Spectral Access Use Case

Theoretical models are widely used in Astronomy. The physical properties of an object can, for instance, be inferred by comparing its observed spectrum to a grid of theoretical spectra. Theoretical models are usually available in the Internet as collection of data files that can be downloaded (in some case with the help of a web form allowing a previous selection of the files of interest) in different formats like ASCII or FITS.
Building an extra layer on top of these services implementing the SSAP protocol allows for the seamless sharing of theoretical models within the VO community.

This paragraph describes the usage of the FORMAT=METADATA paradigm to access Theoretical Spectra in the context of the Simple Spectrum Access Protocol.

The "Client-Server Parameter" dialogue

The usage of the SSAP to access gridded models of theoretical spectra can be described as a dialogue between the client application and the model server based in three main steps:

1. The client makes a request using the FORMAT=METADATA operation to get the list of available parameters for the model set
2. The client (whether automatically or by human intervention) makes a selection of the desired parameters/ranges for the required models and sends a request for data to the server
3. The server responds with a VOTable containing metadata pertaining to the specified parameter models plus the corresponding "access reference" to the model data.

Note that the request of POS-SIZE, BAND or TIME are not required for this dialogue.

The following example uses a general SSAP service mounted on a generic URL like the following http://modelserver.com/ssap.php

Step by step process

The client (VO application, web interface, etc) sends an http query to the server asking for the contents that the server offers:

http://modelserver.com/ssap.php?format=metadata

The server answers the query by sending a VOTable containing information about the server itself, the list of parameters allowed in the query, their description and, optionally, the accepted values or ranges of values:

```
<description>a general text description of the theoretical model
        offered by the server </description>
 <param name="param1" ucd="..." datatype="float"...>
    <description>a short human-readable text description of the
        meaning of this parameter</description>
  </param>
...
```
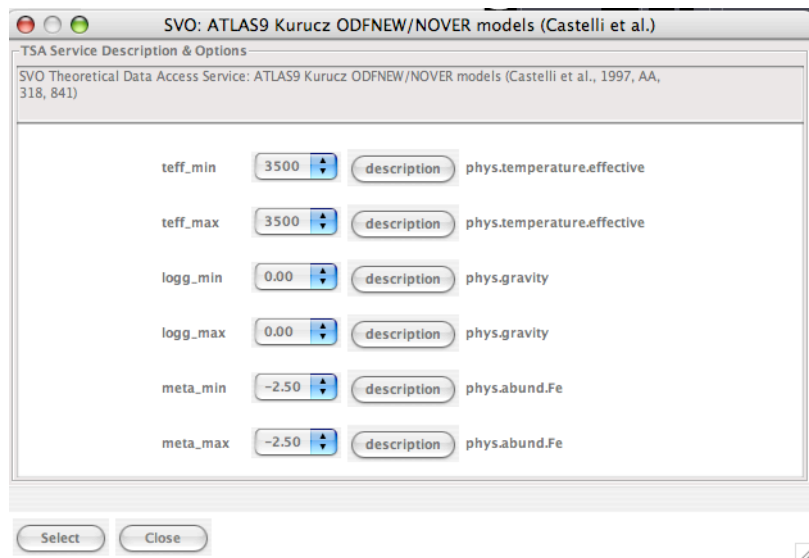
For instance, two parameters like Effective Temperature and Surface Gravity could be described as follows:

```
  <description>Stellar atmosphere model by..., version 1 </description>
  <param    name="teff"    ucd="phys.temperature.effective"    units="K"
datatype="float">
     <description>Effective temperature for the model in K</description>
  </param>
  <param name="logg" ucd="phys.gravity" datatype="float">
    <description>Logarithm of the surface gravity</description>
  </param>
```

The client, reading this VOTable response, knows the parameters –and their ranges- available for the search as well as their names and descriptions and can build a small user interface on-the-fly, like the following one (in this case, for the following parameter ranges: Effective Temperature, Surface Gravity and Metallicity):

When the user makes the selection, the client sends a search query to the server with the constraints on the parameters:

http://modelserver.com/ssap.php?param1=value1&...&paramN=valueN

The server answers the query with a VOTable containing a list with all the particular instances of the model that are available within the specified search criteria. One of the expected fields is the ssa:Access.Reference that allows the model to be retrieved.

Examples of valid VOTable responses for the FORMAT=METADATA operation and for the getData operation are given here for reference:

FORMAT=METADATA request VOTable

```
(NOTE that ellipsis symbol between brackets "[…]" substitutes output of values for brevity)

<VOTABLE version="1.1" xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.1">

<RESOURCE type="meta">
        <DESCRIPTION>
                SVO Theoretical Data Access Service: ATLAS9 Kurucz ODFNEW/NOVER models (Castelli et al.,
                1997, AA, 318, 841)
        </DESCRIPTION>
<INFO name="QUERY_STATUS" value="OK"/>
<PARAM name="INPUT:teff_min" ucd="phys.temperature.effective">
        <DESCRIPTION>
                min value for the effective temperature for the model. Temperatures are given in K
        </DESCRIPTION>
        <VALUES type="actual">
                <OPTION value="3500"/>
                <OPTION value="3750"/>
                <OPTION value="4000"/>
                […]
                <OPTION value="49000"/>
                <OPTION value="50000"/>
        </VALUES>
</PARAM>
<PARAM name="INPUT:teff_max" ucd="phys.temperature.effective">
        <DESCRIPTION>
                max value for the effective temperature for the model. Temperatures are given in K
        </DESCRIPTION>
        <VALUES type="actual">
                <OPTION value="3500"/>
                <OPTION value="3750"/>
                […]
                <OPTION value="48000"/>
                <OPTION value="49000"/>
                <OPTION value="50000"/>
        </VALUES>
</PARAM>
<PARAM name="INPUT:logg_min" ucd="phys.gravity">
        <DESCRIPTION>min value for Log(G) for the model.</DESCRIPTION>
        <VALUES type="actual">
                <OPTION value="0.00"/>
                […]
                <OPTION value="4.50"/>
                <OPTION value="5.00"/>
        </VALUES>
</PARAM>
```

```
<PARAM name="INPUT:logg_max" ucd="phys.gravity">
        <DESCRIPTION>max value for Log(G) for the model.</DESCRIPTION>
        <VALUES type="actual">
                <OPTION value="0.00"/>
                […]
                <OPTION value="4.50"/>
                <OPTION value="5.00"/>
        </VALUES>
</PARAM>
<PARAM name="INPUT:meta_min" ucd="phys.abund.Fe">
        <DESCRIPTION>min value for the Metallicity for the model.</DESCRIPTION>
        <VALUES type="actual">
                <OPTION value="-2.50"/>
                […]
                <OPTION value="0.20"/>
                <OPTION value="0.50"/>
        </VALUES>
</PARAM>
<PARAM name="INPUT:meta_max" ucd="phys.abund.Fe">
<DESCRIPTION>max value for the Metallicity for the model.</DESCRIPTION>
        <VALUES type="actual">
                <OPTION value="-2.50"/>
                <OPTION value="-2.00"/>
                […]
                <OPTION value="0.20"/>
                <OPTION value="0.50"/>
        </VALUES>
</PARAM>


<TABLE>
        <DESCRIPTION>
                ODFNEW /NOVER models. Newly computed ODFs with better opacities and better abundances have
                been used.
        </DESCRIPTION>
<PARAM name="DataModel" utype="ssa:Dataset.DataModel" datatype="char" arraysize="*" value="Spectrum 1.0">
        <DESCRIPTION>Data Model name and version</DESCRIPTION>
</PARAM>
<PARAM name="Publisher" utype="ssa:Curation.Publisher" ucd="meta.organization;meta.curation"
datatype="char" arraysize="*" value="LAEFF/Spanish Virtual Observatory"/>
<PARAM name="PubID" utype="ssa:Curation.PubID" ucd="meta.curation.pubid" datatype="char" arraysize="*"
value="TBD"/>




<PARAM name="Creator" utype="ssa:DataID.Creator" ucd="" datatype="char" arraysize="*"
value="LAEFF/Spanish Virtual Observatory"/>
<PARAM name="Collection" utype="ssa:DataID.Collection" ucd="" datatype="char" arraysize="*" value="Kurucz
models of stellar atmopsheres"/>
<PARAM name="CreationType" utype="ssa:DataID.CreationType" ucd="" datatype="char" arraysize="*"
value="Simulation"/>


<FIELD name="teff" ucd="phys.temperature.effective" unit="K" datatype="int">
        <DESCRIPTION>
                value for the effective temperature for the model. Temperatures are given in K
        </DESCRIPTION>
</FIELD>
<FIELD name="logg" ucd="phys.gravity" unit="log(cm/s2)" datatype="float">
        <DESCRIPTION>value for Log(G) for the model.</DESCRIPTION>
</FIELD>
<FIELD name="meta" ucd="phys.abund.Fe" unit="" datatype="float">
        <DESCRIPTION>value for the Metallicity for the model.</DESCRIPTION>
</FIELD>
<FIELD name="vtur" ucd="VOX:vturb" unit="km/s" datatype="float">
        <DESCRIPTION>Microturbulence velocity</DESCRIPTION>
</FIELD>
<FIELD name="lh" ucd="VOX:lh" unit="" datatype="float">
```

```
        <DESCRIPTION>
                l/Hp where l is the  mixing length of the convective element and Hp is the pressure scale
                height
        </DESCRIPTION>
</FIELD>


<FIELD name="title" ucd="meta.title;meta.dataset" utype="ssa:DataId.Title" datatype="char" arraysize="*">
        <DESCRIPTION>Title.</DESCRIPTION>
</FIELD>
<FIELD name="SpectralAxis" utype="Dataset.SpectralAxis" datatype="char" arraysize="*">
        <DESCRIPTION>
                Flux Axis name.
        </DESCRIPTION>
</FIELD>
<FIELD name="FluxAxis" utype="Dataset.FluxAsix" datatype="char" arraysize="*">
        <DESCRIPTION>
                Spectral Axis name.
        </DESCRIPTION>
</FIELD>
<FIELD name="SpectralSI" utype="Dataset.SpectralSI" datatype="char" arraysize="*">
        <DESCRIPTION>
                SpectralAxis SI.
        </DESCRIPTION>
</FIELD>
<FIELD name="FluxSI" utype="Dataset.FluxSI" datatype="char" arraysize="*">
        <DESCRIPTION>
                Flux Axis SI.
        </DESCRIPTION>
</FIELD>
<FIELD name="UNITS" ucd="VOX:Spectrum_units" datatype="char" arraysize="*">
        <DESCRIPTION>
                Units in each of the axes.
        </DESCRIPTION>
</FIELD>


<FIELD name="SCALEQ" ucd="VOX:Spectrum_scaleq" datatype="char" arraysize="*">
        <DESCRIPTION>
                Scaling factor needed to transform the dimensional equation to the International System of
                Units.
        </DESCRIPTION>
</FIELD>
<FIELD name="DataLength" utype="ssa:Dataset.Length" datatype="char" arraysize="*">
        <DESCRIPTION>Number of points</DESCRIPTION>
</FIELD>
<FIELD name="format" utype="ssa:Access.Format" datatype="char" arraysize="*">
        <DESCRIPTION>Spectrum format</DESCRIPTION>
</FIELD>
<FIELD name="Spectrum" utype="ssa:Access.Reference"  datatype="char" arraysize="*">
        <DESCRIPTION>Link to the spectrum file</DESCRIPTION>
</FIELD>
</TABLE>
</RESOURCE>
</VOTABLE>
```

getData reponse VOTable example

Sample query:

http://svo.laeff.inta.es/projects/svo/theory/db2vo/html/tsap.php?model
=kurucz&teff_min=3500&teff_max=3500&logg_min=0.00&logg_max=0.5&meta_mi
n=-2.5&meta_max=-2.0

```
<VOTABLE version="1.1" xsi:schemaLocation="http://www.ivoa.net/xml/VOTable/v1.1">
<RESOURCE type="results">
<DESCRIPTION>
        SVO Theoretical Data Access Service: ATLAS9 Kurucz ODFNEW/NOVER models (Castelli et al., 1997,
        AA, 318, 841)
```

```xml
        </DESCRIPTION>
<INFO name="QUERY_STATUS" value="OK"/>
<TABLE>
        <DESCRIPTION>dalessio models. Search results.</DESCRIPTION>
<PARAM name="DataModel" utype="ssa:Dataset.DataModel" datatype="char" arraysize="*" value="Spectrum 1.0">
        <DESCRIPTION>Data Model name and version</DESCRIPTION>
</PARAM>

<PARAM name="Publisher" utype="ssa:Curation.Publisher" ucd="meta.organization;meta.curation"
datatype="char" arraysize="*" value="LAEFF/Spanish Virtual Observatory"/>
<PARAM name="PubID" utype="ssa:Curation.PubID" ucd="meta.curation.pubid" datatype="char" arraysize="*"
value="TBD"/>

<PARAM name="Creator" utype="ssa:DataID.Creator" ucd="" datatype="char" arraysize="*"
value="LAEFF/Spanish Virtual Observatory"/>
<PARAM name="Collection" utype="ssa:DataID.Collection" ucd="" datatype="char" arraysize="*" value="Kurucz
models of stellar atmopsheres"/>
<PARAM name="CreationType" utype="ssa:DataID.CreationType" ucd="" datatype="char" arraysize="*"
value="Simulation"/>

<FIELD name="teff" ucd="phys.temperature.effective" unit="K" datatype="int">
        <DESCRIPTION>
                value for the effective temperature for the model. Temperatures are given in K
        </DESCRIPTION>
</FIELD>
<FIELD name="logg" ucd="phys.gravity" unit="log(cm/s2)" datatype="float">
        <DESCRIPTION>value for Log(G) for the model.</DESCRIPTION>
</FIELD>
<FIELD name="meta" ucd="phys.abund.Fe" unit="" datatype="float">
        <DESCRIPTION>value for the Metallicity for the model.</DESCRIPTION>
</FIELD>
<FIELD name="vtur" ucd="VOX:vturb" unit="km/s" datatype="float">
        <DESCRIPTION>Microturbulence velocity</DESCRIPTION>
</FIELD>
<FIELD name="lh" ucd="VOX:lh" unit="" datatype="float">
        <DESCRIPTION>
                l/Hp where l is the  mixing length of the convective element and Hp is the pressure scale
                height
        </DESCRIPTION>
</FIELD>


<FIELD name="title" ucd="meta.title;meta.dataset" utype="ssa:DataId.Title" datatype="char" arraysize="*">
        <DESCRIPTION>Title.</DESCRIPTION>
</FIELD>
<FIELD name="SpectralAxis" utype="Dataset.SpectralAxis" datatype="char" arraysize="*">
        <DESCRIPTION>
                Flux Axis name.
        </DESCRIPTION>
</FIELD>
<FIELD name="FluxAxis" utype="Dataset.FluxAsix" datatype="char" arraysize="*">
        <DESCRIPTION>
                Spectral Axis name.
        </DESCRIPTION>
</FIELD>
<FIELD name="SpectralSI" utype="Dataset.SpectralSI" datatype="char" arraysize="*">
        <DESCRIPTION>
                SpectralAxis SI.
        </DESCRIPTION>
</FIELD>
<FIELD name="FluxSI" utype="Dataset.FluxSI" datatype="char" arraysize="*">
        <DESCRIPTION>
                Flux Axis SI.
        </DESCRIPTION>
</FIELD>
<FIELD name="UNITS" ucd="VOX:Spectrum_units" datatype="char" arraysize="*">
        <DESCRIPTION>
                Units in each of the axes.
        </DESCRIPTION>
</FIELD>
<FIELD name="SCALEQ" ucd="VOX:Spectrum_scaleq" datatype="char" arraysize="*">
        <DESCRIPTION>
```

```
                Scaling factor needed to transform the dimensional equation to the International System of
                Units.
        </DESCRIPTION>
</FIELD>
<FIELD name="DataLength" utype="ssa:Dataset.Length" datatype="char" arraysize="*">
        <DESCRIPTION>Number of points</DESCRIPTION>
</FIELD>
<FIELD name="format" utype="ssa:Access.Format" datatype="char" arraysize="*">
        <DESCRIPTION>Spectrum format</DESCRIPTION>
</FIELD>
<FIELD name="Spectrum" utype="ssa:Access.Reference"  datatype="char" arraysize="*">
        <DESCRIPTION>Link to the spectrum file</DESCRIPTION>
</FIELD>



<DATA>
<TABLEDATA>
<TR>
        <TD>3500</TD>
        <TD>0.00</TD>
        <TD>-2.00</TD>
        <TD>2.0</TD>
        <TD>1.25</TD>
        <TD>
Kurucz ODFNEW /NOVER, teff:3500, logg:0.00, meta:-2.00
</TD>
        <TD>WAVELENGTH</TD>
        <TD>FLUX</TD>
        <TD>L</TD>

        <TD>ANGSTROM ERG/CM2/S/A</TD>
        <TD>1E-10 1E+7</TD>
        <TD>1221</TD>
        <TD>spectrum/votable</TD>
        <TD>
http://svo.laeff.inta.es/projects/svo/theory/db2vo/html/tsap.php?model=Kurucz&id=963
</TD>
</TR>
<TR>
        <TD>3500</TD>
        <TD>0.50</TD>
        <TD>-2.00</TD>
        <TD>2.0</TD>
        <TD>1.25</TD>
        <TD>
Kurucz ODFNEW /NOVER, teff:3500, logg:0.50, meta:-2.00
</TD>
        <TD>WAVELENGTH</TD>
        <TD>FLUX</TD>
        <TD>L</TD>
        <TD>ANGSTROM ERG/CM2/S/A</TD>
        <TD>L ML-1T-3</TD>
        <TD>1E-10 1E+7</TD>
        <TD>1221</TD>
        <TD>spectrum/votable</TD>
        <TD>
http://svo.laeff.inta.es/projects/svo/theory/db2vo/html/tsap.php?model=Kurucz&id=964
</TD>
</TR>
        […]
</TABLEDATA>
</DATA>
</TABLE>
</RESOURCE>
</VOTABLE>
```