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Implementing SimpleTimeSeries and Spectral Data Models in the OMC Archive.

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Abstract

Time Domain is, together Multi-Dimensional Data, one of the IVOA Science Priority Areas. Nevertheless, there is a current lack in the IVOA of any standardized way to represent an astronomical time series. SimpleTimeSeries[1] (STS) is an XML format designed for exchanging time series data that has been proposed as a working solution in the interim as an alternative to the Spectral Data Model v2.0[2].

This Note describes the implementation of both data models in an operational archive like OMC[3]. It mainly focuses on the identification of the missing information to properly represent the light curves available in the OMC archive.

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1   http://www.ivoa.net/documents/Notes/SimpleTimeSeries/20140513/NOTE-SimpleTimeSeries-1.0-20140513.html

2   http://www.ivoa.net/documents/SpectralDM/20150528/PR-SpectralDM-2.0-20150528.pdf

3   https://sdc.cab.inta-csic.es/omc/index.jsp

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Status of This Document

This is an IVOA Note expressing suggestions from and opinions of the authors. It is intended to share best practices, possible approaches, or other perspectives on interoperability with the Virtual Observatory. It should not be referenced or otherwise interpreted as a standard specification.

The first release of this document was 2015 June 15.

A list of current IVOA Recommendations and other technical documents *can be found at* http://www.ivoa.net/Documents/ .

Acknowledgements

Conformance related definitions

The **Virtual Observatory (VO)** is a general term for a collection of federated resources that can be used to conduct astronomical research, education, and outreach. The **International Virtual Observatory Alliance (IVOA)** is a global collaboration of separately funded projects to develop standards and infrastructure that enable VO applications.

Contents

1.- Introduction

Time Series encompass every field in Astronomy, from Solar System to Cosmology. Ground-based archives like CRTS[4], SuperWASP[5] or ASAS[6] (to name a few) provide access to millions of light curves. These resources are complemented with observations made from space with instruments like CoRoT[7] or Kepler[8] reaching a photometric accuracy and time sampling never got before. Also, other missions like WISE[9] are opening new research fields providing variability information of thousand of objects in wavelength ranges other than the optical. The importance of Time Domain Astronomy has been recognized by the IVOA which included it as a science priority[10].

The Optical Monitoring Camera (OMC[11]) observes the optical emission from the prime targets of the gamma-ray instruments on-board the ESA mission INTEGRAL. OMC has also the capability to monitor serendipitously a large number of optically variable sources within its field of view. The OMC Archive[12] is hosted at Centro de Astrobiología (INTA-CSIC) and is managed in the framework of the Spanish Virtual Observatory project. At present it provides magnitude-calibrated (V Johnson) light curves for more than 540 000 sources.

OMC data are currently published in the Virtual Observatory using SSAP[13] and Spectrum v1.03 as access protocol and data model, respectively. In this document we summarise the results obtained after mapping OMC data with the SimpleTimeSeries and the Spectral Data Model v2.0, with particular emphasis on the identification of limitations and caveats.

2.- Describing OMC data with SimpleTimeSeries and Spectral Data Model

The OMC VO service returns information assembled in *groups.* In what follows we will match the OMC parameters/fields for each group with the corresponding *utypes* in the two data models.

2.1 Curation

Curation metadata describes who curates the dataset and how it is published to the VO. In the current SSAP service, OMC provides the following parameters:

---

4   http://crts.caltech.edu/
5   http://www.superwasp.org/
6   http://www.astrouw.edu.pl/asas/
7   http://missions-scientifiques.cnes.fr/COROT/Fr/
8   http://kepler.nasa.gov/
9   http://www.nasa.gov/mission_pages/WISE/main/index.html
10   http://wiki.ivoa.net/twiki/bin/view/IVOA/IvoaSciencePriorities
11   https://sdc.cab.inta-csic.es/omc/help/documentation.jsp
12   https://sdc.cab.inta-csic.es/omc/index.jsp
13   http://sdc.cab.inta-csic.es/omc/jsp/ssap.jsp?

```
▼<GROUP utype="ssa:Curation">
   <PARAM name="publisher" datatype="char" arraysize="*" ucd="" utype="ssa:Curation.Publisher"
   value="LAEFF-CAB"/>
   <PARAM name="publisherId" datatype="char" arraysize="*" ucd="meta.ref.url;meta.curation"
   utype="ssa:Curation.PublisherDID" value="http://laeff.cab.inta-csic.es"/>
  </GROUP>
```

Parameter	STS	Spectral DM v2.0
Publisher	---	Curation.Publisher
PublisherId	---	Curation.Publisher.Id

2.2 DataID

The Data Identification (DataID) stores the dataset identifiers and its membership within larger collections. The current OMC service provides the following parameters:

```
▼<GROUP utype="ssa:DataID">
   <FIELDref ref="Title"/>
   <PARAM name="Collection" datatype="char" arraysize="*" ucd="meta.id"
   utype="ssa:DataID.Collection" value="LAEFF-OMC"/>
   <PARAM name="Instrument" datatype="char" arraysize="*" utype="ssa:DataID.Instrument"
   ucd="meta.id;instr" value="OMC-INTEGRAL"/>
   <PARAM name="InstrumentBandpass" datatype="char" arraysize="*" utype="ssa:DataID.Bandpass"
   ucd="instr.bandpass" value="VJohnson"/>
  </GROUP>
```

Parameter	STS	Spectral DM v2.0
Title	STS.Title	DataID.Title
Collection	---	DataID.Collection
Instrument	---	ObsConfig.Instrument.Name
InstrumentBandpass	---	ObsConfig.Bandpass.Name

2.3 Characterisation

Characterisation includes the metadata necessary to describe the physical parameter space of observed or simulated astronomical datasets. The OMC SSAP services makes use of the following parameters:

```
▼<GROUP utype="ssa:Char">
   <FIELDref ref="CoverageSpatial"/>
   <FIELDref ref="startTime"/>
   <FIELDref ref="stopTime"/>
  ▼<PARAM name="PhotometricAperture" datatype="float" arraysize="1"
   utype="ssa:Char.SpatialAxis.Coverage.Bounds.Extent" ucd="instr.fov" unit="deg"
   value="1.45866666e-2">
    ▼<DESCRIPTION>
       The photometric aperture is formed by a box of 3x3 pixels of 17.504 arcsec each.
     </DESCRIPTION>
   </PARAM>
   <PARAM name="MidpointBand" datatype="float" arraysize="1"
   utype="ssa:Char.SpectralAxis.Coverage.Location.Value" ucd="instr.bandpass" unit="m" value="550E-
   9"/>
  </GROUP>
```

Parameter	STS	Spectral DM v2.0
CoverageSpatial	STS.SpaceTimeSys. PositionDefaults.Val	Char.SpatialAxis. Coverage.Location.Value
PhotometricAperture	---	Char.SpatialAxis. Coverage.Bounds.Extent
StartTime	---	Char.TimeAxis.Coverage. Bounds.Start
stopTime	---	Char.TimeAxis.Coverage. Bounds.Stop
MidpointBand	---	Char.SpectralAxis. Coverage.Location.Value

2.4 CoordSys

CoordSys gives information about the coordinate systems implemented in the service.

```
▼<GROUP ID="CoordSys" name="CoordSys" utype="ssa:CoordSys">
   <DESCRIPTION>Coordinate System Metadata.</DESCRIPTION>
  ▼<PARAM ID="SpaceFrameName" name="SpaceFrameName" utype="ssa:CoordSys.SpaceFrame.Name"
   value="ICRS" datatype="char" arraysize="*">
     <DESCRIPTION>Spatial coordinate frame.</DESCRIPTION>
   </PARAM>
  ▼<PARAM ID="SpaceFrameEquinox" name="SpaceFrameEquinox" utype="ssa:CoordSys.SpaceFrame.Equinox"
   value="2000.0" datatype="double">
     <DESCRIPTION>Equinox.</DESCRIPTION>
   </PARAM>
  </GROUP>
```

Parameter	STS	Spectral DM v2.0
SpaceFrameName	STS.SpaceTimeSys. SpaceFrame. SpaceRefFrame	CoordSys.SpaceFrame. Name
SpaceFrameEquinox	---	CoordSys.SpaceFrame. Equinox

2.5 Target

"Target" allows to specify the target of the observation, which maybe an astronomical source or some other type of source (e.g. calibration, diffuse background).

```
▼<GROUP utype="ssa:Target">
    <FIELDref ref="target"/>
  </GROUP>
```

Parameter	STS	Spectral DM v2.0
Target	---	Target.Name

2.6 Dataset

Dataset contains the high-level metadata necessary to describe any type of astronomical data.

```
▼<GROUP utype="ssa:Dataset">
    <PARAM name="DatasetType" datatype="char" arraysize="*" ID="datasetType"
    utype="ssa:Dataset.Type" value="TimeSeries"/>
    <FIELDref ref="nsamples"/>
    <PARAM name="DataModel" datatype="char" arraysize="*" utype="ssa:Dataset.DataModel"
    value="Spectrum-1.03"/>
  </GROUP>
```

Parameter	STS	Spectral DM v2.0
DatasetType	---	Dataset.Type
NumberOfSamples	---	Dataset.Length
DataModel	---	Dataset.DataModel.Name

3.- Conclusions

We have seen that the SimpleTimeSeries data model is not detailed enough to properly describe even simple services like OMC. On the contrary, the Spectral Data Model is adequate to be used in services returning monochromatic light curves.

The SimpleTimeSeries data model was proposed as an interim solution to provide the community with a mechanism to represent time series in an standard way until the IVOA Data Model Working Group finishes the definition of the Spectral Data Model v2.0. Given that, to our knowledge, no data centre has implemented SimpleTimeSeries and that Spectral Data Model v2.0 is already at the level of *"Proposed Recommendation",* we suggest to use the latter for, at least, the simple cases. The suitability of the Spectral Data Model for more complex cases (e.g. radial velocity curves, services providing simultaneous light curves in different bands) will require a further analysis.

Appendix.- OMC Light Curve as VOTable that follows Spectral DM v1.03

```
<?xml version="1.0" encoding="UTF-8"?>
<VOTABLE xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="xmlns:http://www.ivoa.net/xml/VOTable/VOTable-1.1.xsd"
version="1.1">
<RESOURCE utype="sed:TimeSeries" type="results">
<DESCRIPTION>OMC Light Curve.</DESCRIPTION>
<TABLE utype="sed:Spectrum">
<FIELD ID="Time" name="Time" datatype="double" ucd="time"
utype="spec:Spectrum.Data.TimeAxis.Value" unit="d"/>
<FIELD ID="Mag" name="Mag" datatype="float" ucd="phot.mag"
utype="spec:Spectrum.Data.FluxAxis.Value" unit="mag"/>
<FIELD ID="MagErr" name="MagErr" datatype="float" ucd="phot.flux;stat.error"
utype="spec:Spectrum.Data.FluxAxis.Accuracy.StatError" unit="mag"/>
<FIELD ID="Problems" name="Problems" datatype="int" ucd="phot.flux;meta.code.qual"
utype="spec:Spectrum.Data.FluxAxis.Quality"/>
<FIELD ID="Exposure" name="Exposure" datatype="double" ucd="time.expo"
utype="spec:Spectrum.Coverage.Extent.Time" unit="s">
<DESCRIPTION>Exposure time</DESCRIPTION>
</FIELD>
<PARAM datatype="char" name="Model" utype="spec:Spectrum.DataModel" value="Spectrum-
1.03" arraysize="*"/>
<PARAM datatype="char" name="Type" utype="spec:Spectrum.Type" value="LightCurve"
arraysize="*"/>
<GROUP name="Curation" utype="spec:Curation">
<PARAM datatype="char" name="Publisher" ucd="meta.curation"
utype="spec:Spectrum.Curation.Publisher" value="LAEFF-CAB" arraysize="*"/>
<PARAM datatype="char" name="PublisherID" ucd="meta.ref.url;meta.curation"
utype="spec:Spectrum.Curation.PublisherID" value="http://laeff.cab.inta-csic.es" arraysize="*"/>
<PARAM datatype="char" name="email" ucd="meta.ref.url;meta.email"
utype="spec:Spectrum.Curation.ContactEmail" value="raul@cab.inta-csic.es" arraysize="*"/>
</GROUP>
<GROUP ID="CoordSys" name="CoordSys" utype="spec:CoordSys">
<DESCRIPTION>Coordinate System Metadata.</DESCRIPTION>
<PARAM ID="SpaceFrameName" datatype="char" name="SpaceFrameName"
utype="spec:Spectrum.CoordSys.SpaceFrame.Name" value="ICRS" arraysize="*">
<DESCRIPTION>Spatial coordinate frame.</DESCRIPTION>
</PARAM>
<PARAM ID="SpaceFrameEquinox" datatype="double" name="SpaceFrameEquinox"
utype="spec:Spectrum.CoordSys.SpaceFrame.Equinox" value="2000.0">
<DESCRIPTION>Equinox.</DESCRIPTION>
</PARAM>
<PARAM ID="TimeFrameRefPos" datatype="char" name="TimeFrameRefPos"
utype="spec:Spectrum.CoordSys.TimeFrame.RefPos" value="BARYCENTER" arraysize="*">
<DESCRIPTION>Times of photon arrival are at this location.</DESCRIPTION>
</PARAM>
</GROUP>
<GROUP name="SpatialAxis" utype="spec:Char.SpatialAxis">
<PARAM unit="deg" datatype="double" name="SkyPos" ucd="pos.eq"
utype="spec:Spectrum.Char.SpatialAxis.Coverage.Location.Value" value="288.25833333
33.41333333" arraysize="2">
<DESCRIPTION>Right Ascension and Declination</DESCRIPTION>
</PARAM>
<PARAM unit="deg" datatype="float" name="PhotometricAperture" ucd="instr.fov"
utype="spec:Spectrum.Char.SpatialAxis.Coverage.Bounds.Extent" value="1.45866666e-2"
arraysize="1">
<DESCRIPTION>The photometric aperture is formed by a box of 3x3 pixels
```

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of 17.504 arcsec each.</DESCRIPTION>
</PARAM>
</GROUP>
<GROUP name="SpectralAxis" utype="spec:Char.SpectralAxis">
<PARAM unit="m" datatype="float" name="Instbandpass" ucd="instr.bandpass"
utype="spec:Spectrum.Char.SpectralAxis.Coverage.Location.Value" value="550E-9"/>
</GROUP>
<GROUP name="FluxAxis" utype="spec:Char.FluxAxis">
<PARAM datatype="char" name="Calibration" ucd="meta.code.qual"
utype="spec:Spectrum.Char.FluxAxis.Calibration" value="CALIBRATED" arraysize="*"/>
<PARAM datatype="char" name="FluxAxisUcd" utype="spec:Spectrum.Char.FluxAxis.ucd"
value="phot.mag" arraysize="*"/>
<PARAM datatype="char" name="FluxAxisUnit" utype="spec:Spectrum.Char.FluxAxis.unit"
value="mag" arraysize="*"/>
</GROUP>
<GROUP name="TimeAxis" utype="spec:Char.TimeAxis">
<PARAM unit="d" datatype="double" name="TimeStart" ucd="time.expo.start"
utype="spec:Spectrum.Char.TimeAxis.Coverage.Bounds.Start" value="2165.435852284692">
<DESCRIPTION>Start time.</DESCRIPTION>
</PARAM>
<PARAM unit="d" datatype="double" name="TimeEnd" ucd="time.expo.end"
utype="spec:Spectrum.Char.TimeAxis.Coverage.Bounds.End" value="2165.521552574793">
<DESCRIPTION>Stop time.</DESCRIPTION>
</PARAM>
</GROUP>
<GROUP utype="spec:DataID">
<PARAM datatype="char" name="Title" ucd="meta.title;meta.dataset"
utype="spec:Spectrum.DataID.Title" value="OMC Light Curve. Target: AAVSO1909+33
" arraysize="*"/>
<PARAM datatype="char" name="Instrument" ucd="meta.id;instr"
utype="spec:Spectrum.DataID.Instrument" value="INTEGRAL/OMC" arraysize="*"/>
<PARAM datatype="char" name="Creator" utype="spec:Spectrum.DataID.Creator"
value="INTA/LAEFF" arraysize="*"/>
</GROUP>
<GROUP utype="spec:Target">
<PARAM datatype="char" name="Object" ucd="meta.id;src"
utype="spec:Spectrum.Target.Name" value="AAVSO1909+33   " arraysize="*">
<DESCRIPTION>Target name of the observed star.</DESCRIPTION>
</PARAM>
</GROUP>
<GROUP utype="spec:Data">
<FIELDref ref="Time"/>
<FIELDref ref="Mag"/>
<FIELDref ref="MagErr"/>
<FIELDref ref="Problems"/>
<FIELDref ref="Exposure"/>
</GROUP>
<DATA>
<TABLEDATA>
<TR><TD>53709.43350946384</TD><TD>15.378248</TD><TD>0.70244735</TD><TD>4</TD><TD>300.00020599365234</TD></TR>
<TR><TD>53709.43982579221</TD><TD>15.483881</TD><TD>1.0318134</TD><TD>17</TD><TD>450.0003089904785</TD></TR>
<TR><TD>53709.45296913659</TD><TD>15.163495</TD><TD>0.5638181</TD><TD>5</TD><TD>300.00020599365234</TD></TR>
</TABLEDATA>
</DATA>
</TABLE>
</RESOURCE>
</VOTABLE>