Time Series Data & Sparse Data Cube

CZV Czech Virtual Observatory

Jiří Nádvorník

Faculty of information Technology, Czech Technical University in Prague

Petr Škoda

Astronomical institute, Czech Academy of Sciences Ondřejov

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Outline

1. Why Data Cube for time series?

2. Supported use cases

3. Discovery

Sparse Cube

- *"Sparse data are commonly used for higher-dimensional cubes, and are frequently sparse along one or more axes. For example, a multi-band image has 7 data at only a few given spectral coordinates, (each corresponding to a spectral bandpass). A spectral (or velocity) data cube may contain data for a number of widely spaced spectral bands, each of which may differ in the spectral resolution and number of channels. **A time cube likewise may contain data, either individual points, or time series, arbitrarily spaced along the time axis with time regions where no data was taken**. A multiobject spectral data cube may be sparse in the spatial plane. Event data can be considered a data cube which is sparse in all measurement axes."*(N-Dimensional Cube Model)

Time Series Cube

- Time series "base class"
  - Can describe any time series axes.
  - Is flexible
  - Is extensible (we just define mandatory axes)

Science use Cases for Time Series

- Use cases - (2012-10-20, EnriqueSolano) http://wiki.ivoa.net/twiki/bin/view/IVOA/CSPTimeSeries
- 3 groups of requirements
  - Group A: Combine photometry and light curves of a given object/list of objects in the **same photometric band**
  - Group B: Combine photometry and light curves of a given object/list of objects in **different photometric bands**
  - Group C: Time series **other than light curves**

Combine light curves in same photometric band

- Use Case #1: Supernova classification using the light curve
  - Description: The visual light curves of the different supernova types vary in shape and amplitude, based on the underlying mechanisms of the explosion, the way that visible radiation is produced, and the transparency of the ejected material.
  - Requirements
    - Combine photometry and light curves of a given object **in the same photometric band**
    - Show me a list of data that satisfies
    - Target= SN 2011FE
    - Datatype= Photometry or TimeSeries/lightcurves
    - Axes include time
    - Axes include brightness
    - Information on photometric band (zero point, transmission curve of the filter)

Use case #1 – Datatype= Photometry or TimeSeries/light curves

Use case #1 - Axes include time, Axes include brightness, information on photometric band

Combine light curves of a given object/list of objects in different photometric bands

- Use Case #5: Follow-up characterisation of supernovae (based on Zhang et al. arXiv:1208.6078v1)
  - Description: Light curves at different wavelength provide different information allowing a better understanding of the physical processes related to the supernovae explosion.
  - Requirements
    - Combine photometry and light curves of a given object in the same photometric band. Repeat this for **all the available bands**.
    - Show me a list of data that satisfies
    - Target= SN 2010JL
    - Datatype= Photometry or TimeSeries/lightcurves
    - Axes include time
    - Axes include brightness
    - Information on photometric band (zero point, transmission curve of the filter)

Use case #5 – object/list of objects in different photometric bands

Time series other than light curves

- Use Case #6: Exoplanet studies using radial velocities (based on Lagrange et al. 2012)
  - Description: Using high precision Harps data collected over 8 years since 2003, beta Pic radial velocities have been measured and analyse to put direct constrains on the mass of beta Pic b and to search for additional jovian planets on orbits closer than typically 2 AU.
  - Show me a list of data that satisfies
    - Datatype= TimeSeries/**radial velocity curves**
    - Axes include time
    - Axes include radial velocity

Use Case #6: axes include time, axes include radial velocity

```xml
<GROUP utype="Cube.Char">
    <GROUP utype="NDPoint">
        <GROUP ucd="meta.main;time.epoch;pos.heliocentric" utype="TimeAxis">
            <FIELDref ref="HJD" utype="Coverage.Location.Coord"/>
            <PARAMref ref="apdtggslgndn" utype="Bounds.Limits.StartTime"/>
            <PARAMref ref="apttggslgndn" utype="Bounds.Limits.StopTime"/>
        </GROUP>
        <GROUP ucd="meta.main;phys.veloc;pos.heliocentric" utype="CustomAxis">
            <FIELDref ref="radial_velocity"/>
            <FIELDref ref="radial_velocity_err"/>
        </GROUP>
    </GROUP>
</GROUP>
```
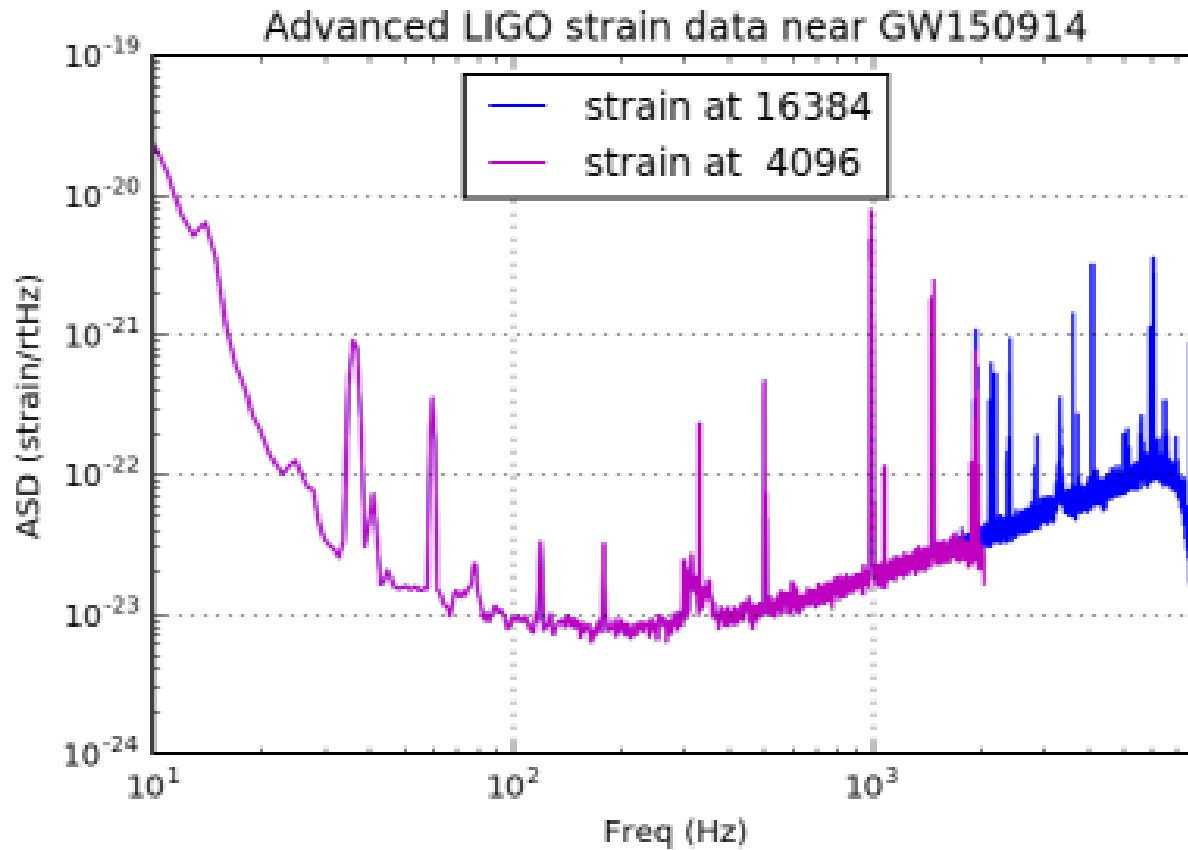
We can have as many as we want, what's in the axis is identified by ucd

Gravitational wave example

Gravitational wave analysis

Advanced LIGO strain data near GW150914

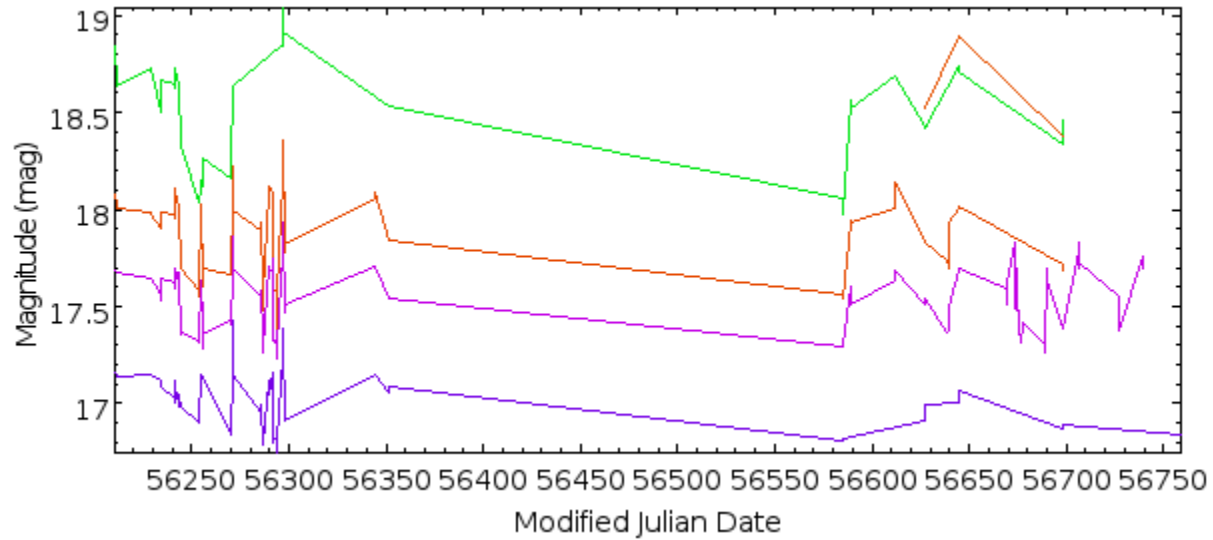# Original data linkage

UBVRI light curve in SPLAT-VO
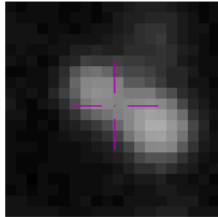
Investigation of points
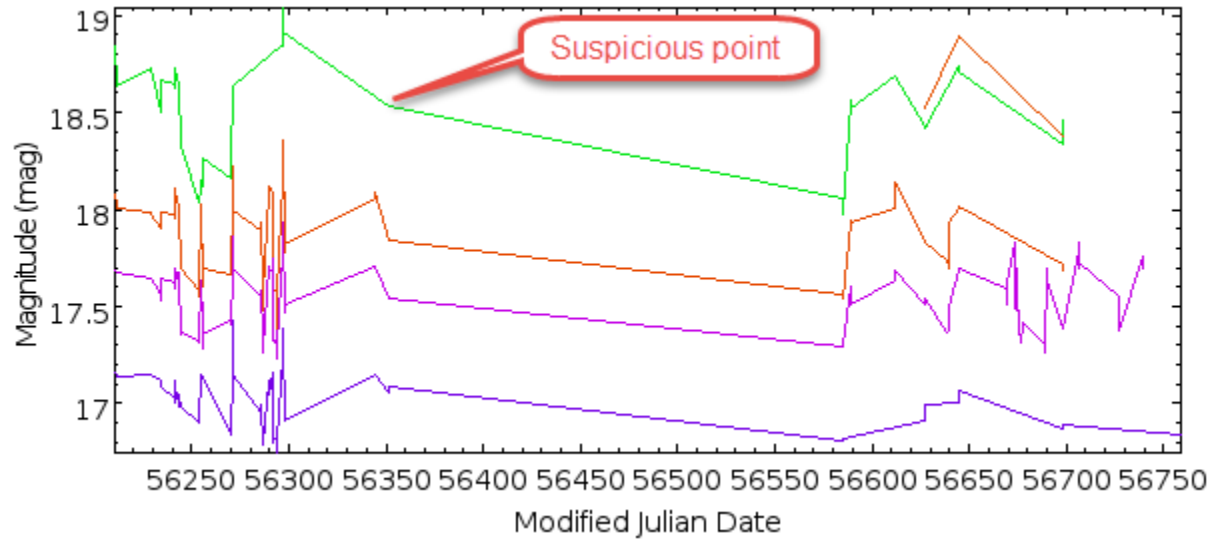
Aladin SIA cutout of original image

Discovery

- Obscore has dataProductType timeseries
- Obscore 1.1 can describe lengths of axes (spectral, time, spatial) and other metadata by default
- Will provide cube with all points, datalink will be used for cutouts

Conclusion

- Dataset.dataProductType=timeseries -> we need at least one TimeAxis in NDPoint

- 0..n number of other axes (SpatialAxis, SpectralAxis, ObservableAxis, CustomAxis)

- Metadata vs. data:
  - PARAM elements – common data for whole timeseries
  - FIELD elements – multiple bands, multiple objects, actual data

- If an axis has one value, we can still describe it in the NDPoint (one bandpass in SpectralAxis)

Questions

- Does Time Series Cube support your usecases?

- Does ObsCore discovery support your usecases?

- Why would you not use this approach?

Next steps

- Subscribe to TDIG list voevent@ivoa.net

- Look for an IVOA note to be announced

- Please supply your use cases to the TDIG mailing list!