DTPA
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The Virtual Observatory and Photometric Time Series

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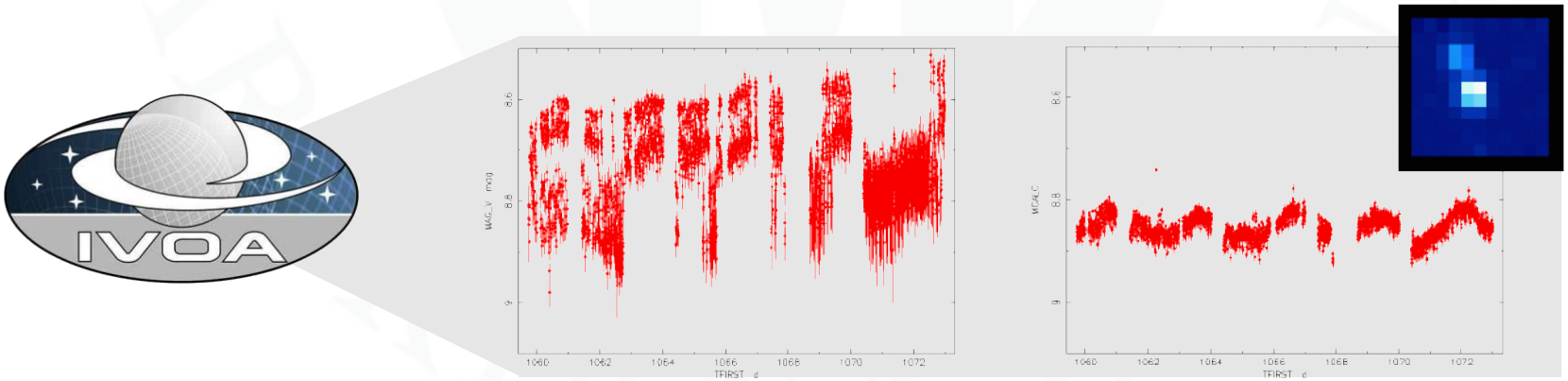


Outline

"Somewhere, something incredible is waiting to be known." (C. Sagan)

1. Introduction
2. **The Virtual Observatory:**
   Crucial step or radical vision?
3. **When images are not enough:**
   Who need photometric time series?
4. **Time series and the VO:**
   Forced marriage... on demand!
5. Conclusions

1. Introduction

"Physics is like sex. Sure, it may give some practical results but it's not why we do it." (R. Feynman)

- **Abilities and ambitions of astronomers have been changing during last decade.**
  (Cui & Zhao 2008)
- **New astronomical fields appeared and these are becoming more and more popular.**
  (Lawrence 2006)
- **The ESO/ST-ECF archive is predicted to increase its size by two orders of magnitude in next 7 years, surpassing ~ 1000 TB.**
  (Padovani 2006)

Photo by Jan Kondziolka

2. The Virtual Observatory

Crucial Step or Radical Vision?

2. The Virtual Observatory

Crucial Step or Radical Vision?

- **There are generally 10 kinds of people:**

  - **Those who understand binary numeral system.**
  - **Those who don't understand it.**
  - **Those who have thought that this joke was in ternary system.**

2. The Virtual Observatory

Crucial Step or Radical Vision?

"The status of the VO in Europe is very good."

Paolo Padovani
Head of ESO VO Department
EURO VO Scientist

"Honestly, I'm convinced that the VO will never work."

Bruno Leibundgut
Head of ESO Office for Science

2. The Virtual Observatory

Crucial Step or Radical Vision?

- **There are generally 10 kinds of scientists:**

  - **Those who think that the VO is the future.**
  - **Those who don't think so.**
  - **Those who have never heard of it.**

2. The Virtual Observatory

Crucial Step or Radical Vision?

- **Explosion of multi-waveband sky surveys and observations has brought many new promising aproaches including multi-wavelength research, multi-archive data mining, time domain analysis, precise cosmology etc.** (Lawrence 2006)

- **Idea of the VO is to achieve the same transparency for astronomical data and information.** (Quinn 2004)

2. The Virtual Observatory

Crucial Step or Radical Vision?

3. When images are not enough...

Who need photometric time series?

Ground-Based Facilities:

- **ASAS** – Photometric all-sky monitoring of approx. 10^7 stars brighter than 14 magnitudes.
- **MACHO** – Light curves in two colours for 8 million stars in the LMC and 10 million stars in the bulge of the Milky Way.

Space Missions:

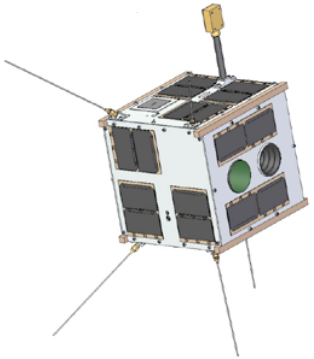
- **INTEGRAL OMC** – Photometry (V-band) from the primary targets of the gamma-ray instruments.
- **COROT** – Light curves for up to 60 000 stars with a sampling rate better than 10 minutes during 5 months.

3. When images are not enough...

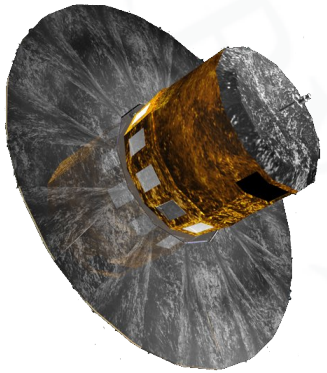
Who need photometric time series?

Incoming Space Missions:

- **Kepler (Feb. 2009) – Light curves for more than 100 000 stars with sampling rate comparable to COROT mission.**



- **BRITE (2009, 2010) – Light curves in two colours for approx. 400 stars brighter than 6.5 mag, during 2-3 years.**



- **GAIA (2011) – Photometry of one billion of stars with about 80 measurements during 5 years for each star.**

4. Time series and the VO

Forced marriage... on demand!

- **What is Photometric Time Serie?**
  - **A sequence of numbers collected, often at regular intervals, over a period of time.**
  - **It is usually time vs. flux.**
  - **Light curve is a good example.**
- **Possible Snags:**
  - **Photometric time series can have irregular intervals.**
  - **They are not always time vs. flux.**
  - **LC is not the only example of a time serie.**
  - **What about phase-folded LCs?**
- **It has to be defined very clearly what kind of time serie is represented by our data.**

4. Time series and the VO

Forced marriage... on demand!

- **EuroVO-DCA WP-6** (Sep. 2007)
  - **An ad-hoc VOTable-based solution was proposed by Konkoly Observatory (Hungarian Academy of Science) in order to make IBVS tabular data VO compliant.**
- **IVOA Spectral Data Model v1.03** (29 Oct. 2007)
  - **The specification able to describe light curves, i.e. it contains UCDs covering some LC attributes.**
  - **However, it is still far from being sufficient for all kinds of photometric archives.**
- **There is no standard to represent time series!**
- **We need to have the VO tools, standards and software ready for the new missions to come, so they can be adapted from the very beginning.**

5. Conclusions

"Inteligence is the ability to adapt to change." (S. Hawking)

- Contemporary VO is just a bunch of standards, mostly without workable implementation.
- There is no usable VO standard for photometric time series.
- We need to develop our own implementation based on existing VO specifications.
- To define a new standard, we should take the IBVS VOTable and the IVOA Spectral Data Model as a good starting point.
- The RTS2 implementation could possibly become a crucial step towards IVOA Photometric Data Model.

References

"First principle is that you must not fool yourself and you are easiest person to fool." (R. Feynman)

- **Cited VO Related Publications:**
  - Quinn, P. J. et al., 2004, Proceedings of the SPE, **5493**, 137
  - Padovani, P., 2006, Chin. J. Astron. Astrophys, 6, **Suppl. 1**, 73
  - Cui, C., Zhao, Y., 2008, Proc. IAUS268, in preparation
  - Lawrence, A., 2008, in: K. A. van der Huchs (eds.) *Highlights of Astronomy*, The Virtual Observatory in action: new science, new technology, and next generation facilities, **vol. 14**, in print