Virtual Observatory:  
an Astronomy’s answer to Big Data

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on behalf of BRAVO
Data in Astronomy

1D, 2D, 3D; intensity/polarization vs. energy, time, position, velocity. Tables, DBs, catalogs, x-ray event lists, radio visibility measurements… various data processing levels, from raw to “science-ready”
A new era in astronomy

- Past: observations of small, carefully selected samples (often with a priori prejudices) of objects in one or a few wavelength bands
A new era in Astronomy

• Now: multi-wavelength data for millions of objects, allowing us to:
  • **discover** significant patterns from the analysis of statistically rich and unbiased databases
  • **understand** complex astrophysical systems via confrontation between data and sophisticated numerical simulation
Survey Science: Big Data in Astronomy

SDSS, DES, J-PAS, LSST, Gaia, SKA…

Exploding Data Rates
The Large Synoptic Survey Telescope (LSST) is a planned wide-field survey that will observe the entire available sky every few nights.

15 TB/night, 7 PB/year, 200 PB total, ~1M transient events/night

(in comparison, SDSS 170 GB/night)
And the scary future... SKA

The Square Kilometre Array is a project to build a radio telescope tens of times more sensitive and hundreds of times faster at mapping the sky than today’s best radio astronomy facilities.

1 exabyte of raw data in a single day; more than the entire daily Internet traffic!!
What do these projects have in common?
Data, data, data!

- Volume
- Complexity
- Interdependency
But with data... should come the software!
Data – Software

DATA
The language in which we register Nature (even if simulated!)

SOFTWARE
The language in which we interpret Nature (even if simulated!)
Data – Software

DATA
The language in which we register Nature (even if simulated!)

SOFTWARE
The language in which we interpret Nature (even if simulated!)

DATA SOURCE A ➔ SOFTWARE A
DATA SOURCE B ➔ SOFTWARE B
DATA SOURCE C ➔ SOFTWARE C
DATA SOURCE D ➔ SOFTWARE C
Data – Software

DATA
The language in which we register Nature (even if simulated!)

SOFTWARE
The language in which we interpret Nature (even if simulated!)

DATA SOURCE A

DATA SOURCE B

DATA SOURCE C

DATA SOURCE D

SOFTWARE A

SOFTWARE B

SOFTWARE C

No!

No!

No!

No!
The language in which we register Nature (even if simulated!)

The language in which we interpret Nature (even if simulated!)

VO-enabled data sources and software tools

DATA
DATA SOURCE A
DATA SOURCE B
DATA SOURCE C
DATA SOURCE D

SOFTWARE
SOFTWARE A
SOFTWARE B
SOFTWARE C

INTEROPERABILITY
The Virtual Observatory (VO) is …

- **the vision** that astronomical datasets and other resources should work as a seamless whole (IVOA)

- a collection of interoperating data archives and software tools which utilize the internet to form an environment in which astronomical research projects can be conducted (Wiki)

- a data discovery, access, and integration **facility** (B. Hanisch)
The Virtual Observatory (VO)

It provides a common language (standards, protocols, data models etc.) for communicating and exchanging data within Astronomy, and indicate where the data is stored!

**Goal**: To enable science! **Transparent and distributed access to data available worldwide**, allowing scientists to discover, access, analyze, and combine nature and lab data from heterogeneous data collections in a user-friendly manner.

_An ambitious goal and no pre-existing model to follow…_
Many projects and data centres worldwide are working towards this goal since 2002.

The IVOA is a standards body created by the VO projects to develop and agree the vital interoperability standards upon which the VO implementations are constructed.

http://www.ivoa.net

17 country members + 2 institutions
VO: bottom-up approach

About 300 refereed papers

30+ VO-enabled applications, from 10+ VO projects

Registry, Protocols, Data Models
VO: bottom up approach

Registry, Protocols and Data Models

Core standards established

Priorities now on multi-dimensional data and time domain astronomy

Science

Tools

Standards
VO: bottom up approach

- Science
- Tools
- Standards

30+ VO-enabled applications, from 10+ VO projects

Many with hundreds of downloads

Web apps used frequently

Many users are unaware that data requests are being handled by VO services
VO: bottom up approach

About 300 refereed papers, several of them with innovative ways

Part of Astronomer’s everyday tool kit

‘VO’ not well cited, but tools are!

Really is just the beginning...
And future surveys, such as J-PAS and Gaia
The VO concept elsewhere

- Space Science
  - Virtual Heliophysics Observatory (HELIO)
  - Virtual Radiation Belt Observatory (ViRBO)
  - Virtual Space Physics Observatory (VSPO)
  - Virtual Magnetospheric Observatory (VMO)
  - Virtual Ionosphere Thermosphere Mesosphere Observatory (VITMO)
  - Virtual Solar-Terrestrial Observatory (VSTO)
  - Virtual Sun/Earth Observatory (VSEO)

- Virtual Solar Observatory
- Planetary Science Virtual Observatory
- Deep Carbon Virtual Observatory

And currently this model is being exported to the National Institute of Standards and Technology (NIST) and to Neurosciences.
BRAVO

- BRazilian Astrophysical Virtual Observatory

- 2006: BRAVO is born as a collaboration between Divisão de Astrofísica and Laboratório de Computação @ INPE

- 2009: BRAVO becomes IVOA partner and associate with INCT-A

- 2015: team 6 integrants and 5 collaborators http://bravo.iag.usp.br

Would you like to join us? Let me know!
Mission

• To **stimulate** and to **encourage** the **projects** of the different local groups, facilitating the necessary coordination and collaboration for the development and deployment of the tools, systems, and organizational structures;

• To **organize workshops and schools** aiming at the dissemination of the VO concepts and the qualification of people capable to use and to work on the development of new VO services and tools;

• To **act as a partner of the IVOA** and as an intermediate between the IVOA and the various Brazilian groups working with VO.
To organize workshops and schools aiming at the dissemination of the VO concepts.
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2012

Workshop de eScience na Astronomia Brasileira

• One day meeting aiming at

• To stimulate the approximation between Astronomy and Computing (CS and Eng.) research communities.

• Open a communication channel between these societies.

• Result: The creation of the Astronomy Track at the Brazilian Computer Society annual meeting!
To organize workshops and schools aiming at the dissemination of the VO concepts

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**DESAFIO BRAVO**

**O QUE É?**
O BRAVO, a Microsoft Research e a AMD te desafiam a desenvolver um sistema para disponibilizar imagens do telescópio SOAR na Wide World Telescope por meio de protocolos do Observatório Virtual.

**QUEM?**
Podem participar graduandos, mestrandos e doutorandos da área de exatas. Pós-doutorandos se estiverem com muita vontade. Preferencialmente em pares!

**QUANDO?**
As inscrições estarão abertas de 11 de junho até 12 de agosto e os trabalhos devem ser entregues até 17 de agosto de 2012. A premiação será feita em Outubro durante o encontro IVOA Interop e os estágios da equipe vencedora serão realizados em 2013.

**PRÊMIO?**
Um mês de estágio na Microsoft Research (Redmond, Estados Unidos) e/ou um mês no Instituto CALTECH (California, Estados Unidos), além de dois notebooks.

**MÃIS INFORMAÇÕES**
www.astro.iag.usp.br/~bravo/desafio/
To organize workshops and schools aiming at the dissemination of the VO concepts

- To develop a minimal SIAP service from scratch and to **demonstrate** that this works **integrated** with Microsoft’s **World Wide Telescope**;

- 21 teams

- **To the winners:** Internship stage at Microsoft Research and/or Caltech and Two AMD notebooks;

- Winner team were 2 undergrad students at UFRJ!
To organize workshops and schools aiming at the dissemination of the VO concepts

- **Aim:** To begin a gradual empowering of the community

- Very good answer from the community. **Over-subscribed!**

- ~35 participants

- **Tutors:** Mark Allen, Mike Fitzgerald, Mathew Graham, Bob Hanisch, Giulia Iafrate, Massimo Ramela
To act as a partner of the IVOA and as an intermediate between the IVOA and the Brazilian groups working with VO
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**VO-DAY**

- The International Virtual Observatory Alliance
  Mark Allen

- The Research Tools of the Virtual Astronomical Observatory
  Robert Hanisch

- What the VO can do for you?
  Massimo Ramela

- An introduction to VO-IRAF
  Mark Fitzpatrick

- The transient sky and the Virtual Observatory
  Mathew Graham

- The VO in the classroom
  Giulia Iafrate
To act as a partner of the IVOA and as an intermediate between the IVOA and the Brazilian groups working with VO

- IVOA centered discussions
- VO-driven presentations.
- Brazilian talks about:
  - J-PAS and S-MAPS
  - DES Brazil
  - South-Pol
  - ... and BRAVO.
We negotiated community access to the IAG/NAT’s Alphacruces cluster, together with the emergent groups.
Quanto tempo de sua pesquisa precisa ser dedicado para tarefas de Tecnologia da Informação para as quais, como astrônomo, você não possui conhecimento ou vocação?

Caso você tenha respostido "muito", e caso seu projeto faça uso de Observatório Virtual, o BRAVO pode ajudá-lo por meio de um novo mecanismo chamado:

http://www.astro.iag.usp.br/~bravo/cdu

Um Caso de Usuário é um projeto simples, curto e facilmente testável, voltado à implementação ou uso de serviços de Observatório Virtual.

Aliás, mesmo que você tenha uma ideia para um projeto de Observatório Virtual nas condições acima, mas não possua o know-how para elaborar um Caso de Usuário completo, o BRAVO poderá auxiliá-lo.

Veja mais em:

• A Database for the SOUTH POL survey
• Photometric Redshifts Portal
• Grid of Synthetic Spectra (3x)
• A-Plus (S-Plus + J-Plus), ~40TB/year

To stimulate and to encourage the projects, facilitating the development and deployment of the tools, systems, and organizational structures
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- First BRAVO’s dedicated servers!
- To host several VO compliant archives and services (catalogues, images and theoretical spectra) **Currently being deployed**
- Software architecture being designed, **advisors:** SVO (Spain), CADC (Canada), NOAO (US), NOVA (Argentine)
BRAVO nowadays

- **Synergy with J-PAS and A-Plus surveys**
  - 3 telescopes, 2 surveys, **17000 square degrees**. A consortium of Spanish and Brazilian institutions, funding agencies and universities. The team of scientists and engineers includes more than 100 people from Brazil, Spain, the U.S.A. and other countries.

- **Archiving and publishing of T80S data** (S-Plus), and negotiating mirror of T80N data (J-Plus)

- Strong support from VO communities abroad, with special thanks to Spanish teams at CEFCA and Spanish VO
We are an alliance of people in Brazil who believes in worldwide, interoperable and distributed access to astronomical data and software.

Would you like to join us? Let us know!

Obrigada!

bravo@iag.usp.br