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Italian Theoretical Virtual Observatory (ITVO): cosmological simulations in the VO frame

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Abstract. Cosmological simulations' output can be stored in an archive and ingested into a database. Then can be connected to a web interface to allow the end user to explore it. This matches the VO idea of handling the data directly on the server side leaving the user only with the results of the query, or other end products, on his own machine. Besides data searching data centers are then requested to provide services to let the user preview and analyze data and metadata (both generated on-the-fly or pre-computed) with computing performed on the server side and letting only the results to be visualized on the user desktop (or sent to him). Here we present the IA2-ITVO (Italian Center for Astronomical Archives - Italian Theoretical Virtual Observatory) archive web interface mainly focusing on the 'Level 2' post-processing capabilities of the portal and its connection with other VO tools.

Key words. Virtual Observatory (VO) - VO: theoretical data – VO: data previewing

1. Introduction

The huge amount of data from numerical astrophysical simulations (e.g. the data set from the cosmological simulation of (Borgani et al. 2003), stored at IA2 - Italian center for Astronomical Archives - consists of about 1.2 TeraByte) implies that retrieving data sets from archives for further analysis on local machines is not a practical task.

The Virtual Observatory (VO) approach to this problem is to let the user remotely query, analyze and preview data located in relational databases and data archives all over the world and retrieve only the analysis' results.

The International Virtual Observatory Alliance (IVOA, Hanisch & Quinn 2002) work focuses on the development of the standards needed by the community to implement services and tools to generate the VO physical structure.

However, while IVOA documents (http://www.ivoa.net/Documents/) are at a good level of evolution for observational data there is a lack of standards regarding theoretical and simulated data because interest for theory has entered the VO community more recently than other fields and is only now becoming mature. Given this situation, simulated or theoretical

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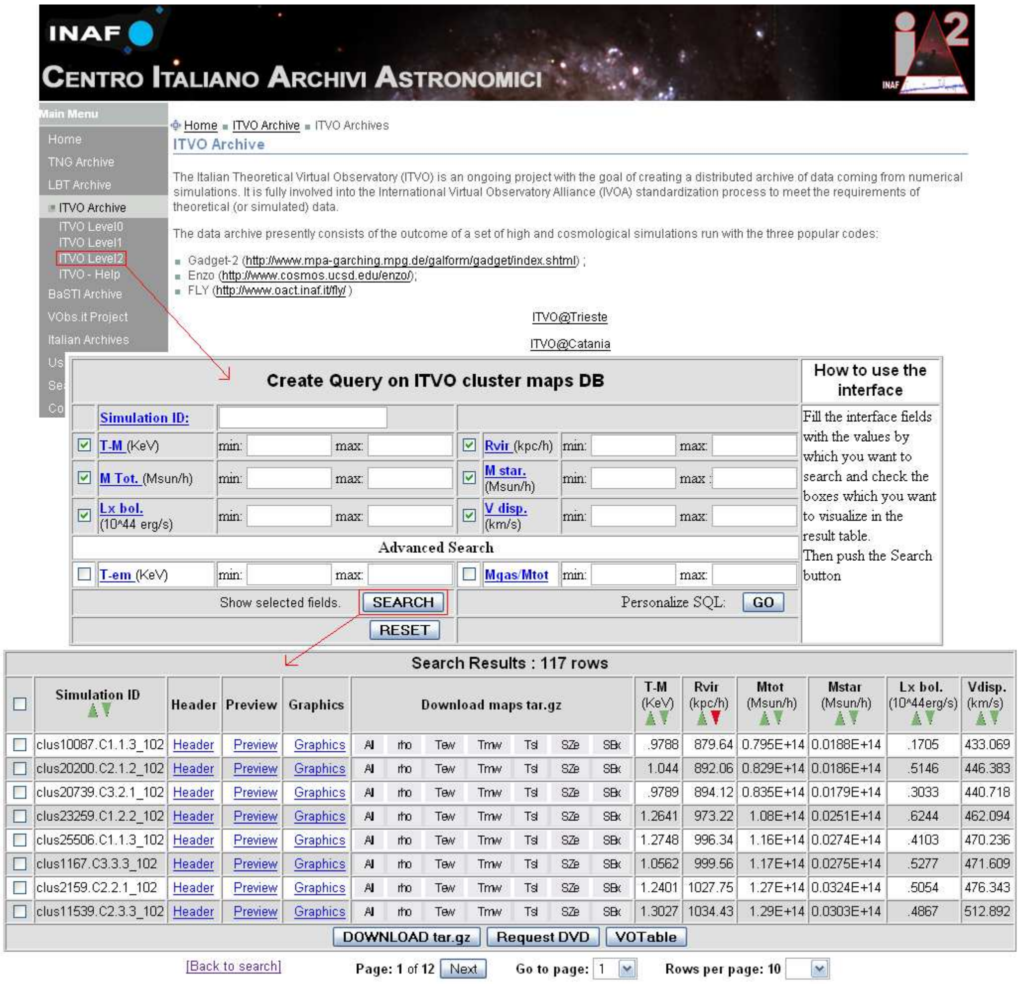


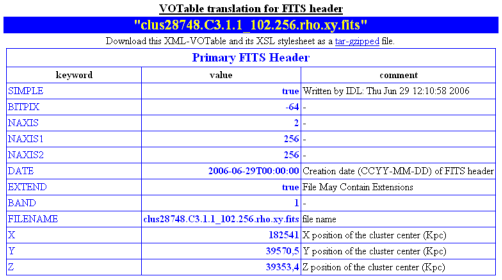
Fig. 1. Top to bottom: the Italian Center for Astronomical Archives - Italian Theoretical Virtual Observatory (IA2-ITVO) web portal, Level 2 query form and sample results output table.

data archives and services have tried, until today, to use observational standards and definitions.

2. The ITVO project

The ITVO (Italian Theoretical Virtual Observatory) project, developed as part of VObs.it (the Italian VO initiative) and mainly participated by INAF (OATs and OACt) and CINECA, maintains a web portal that allows search for cosmological simulations and implements tools to directly preview the data and its related metadata. The data comes from cosmological simulations, mainly generated using the GADGET-2 simulation package [Springel 2005; data in FLY (Antonuccio-Delogu et al. 2003) and ENZO (O'Shea et al. 2004) format are also available].

The related database structure consists of a set of interconnected levels (at present 3): "Level 0", direct simulation output (e.g. snapshots of cosmological simulations); "Level 1", objects (e.g. galaxy clusters) identified within Level 0; "Level 2", post-processed data. The levels idea allows for the creation of other


VOTable translation for FITS header

"clus28748.C3.1.1_102.256.rho.xy.fits"

Download this XML-VOTable and its XSL stylesheet as a tar-gzipped file.

Primary FITS Header

keyword	value	comment
SIMPLE	true	Written by IDL: Thu Jun 29 12:10:58 2006
BITPIX	-64	-
NAXIS	2	-
NAXIS1	256	-
NAXIS2	256	-
DATE	2006-06-29T00:00:00	Creation date (CCYY-MM-DD) of FITS header
EXTEND	true	File May Contain Extensions
BAND	1	-
FILENAME	clus28748.C3.1.1_102.256.rho.xy.fits	file name
X	182541	X position of the cluster center (Kpc)
Y	39570,5	Y position of the cluster center (Kpc)
Z	39353,4	Z position of the cluster center (Kpc)

Fig. 2. Metadata preview using styled XML on the web portal.

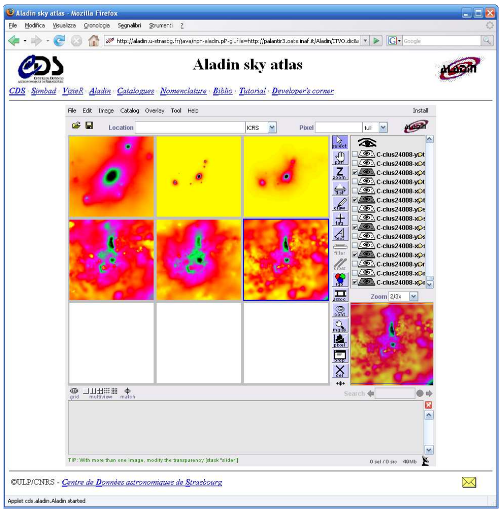


Fig. 3. The projection maps previewed using Aladin applet version.

levels from subsequent post-processing of the data. Levels interconnection allows refinement of data searches. For a more exhaustive description of the archive and database please refer to Manzato et al. (2007, 2008).

In this paper we describe a set of prototype previewing, analysis and exploration tools developed mainly for the Level 2 of the ITVO site located at IA2, Trieste.

3. ITVO portal@Trieste

The ITVO portal in Trieste reflect the database structure. Fig. 1 shows: the IA2 web portal (http://wwwas.oats.inaf.it/IA2/) including the ITVO links listed by Level, the Level 2 interface ready for query input and, at bottom, the

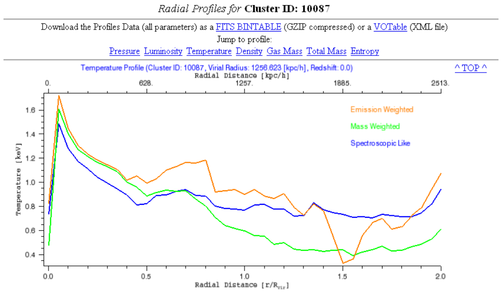


Fig. 4. Profile preview for a single physical quantity as available from the web tool.

result page, available after query submission. Beside data download buttons and the metadata columns, a few other capabilities are available from the results page. In this paper we focus on: metadata visualization (§3.1, Fig. 2); 2-D projection maps of cluster physical quantities (§3.2, Fig. 3); and radial(1-D) profiles of the cluster's physical properties (§3.3, Fig. 4).

3.1. Metadata previewing

Metadata previewing consists of returning, as a VOTable (XML file previewed using XSLT transformation), the headers of the data files (Fig. 2). Metadata are also retrievable from a link on the preview page itself.

3.2. 2-D data previewing

2-D preview of physical quantities consists in 3 projections on the orthogonal planes of the simulated box reference system. At present the FITS files containing the projections' images are pre-computed (and available only for redshift z=0) and the tool loads them directly into the Aladin applet version[1]. Aladin is useful both because it works in the direction of the VO interoperability and because it allows comparison between the simulated data and the observational data searchable from the tool itself. Next step for 2-D data previewing is to generate on-the-fly the 2-D projections (maybe using VisIVOServer developed at Catania).

The FITS files containing the 2-D maps can also be reached from the Aladin standalone version using a dedicated GLU (Fernique

[1] http://aladin.u-strasbg.fr/aladin.gml

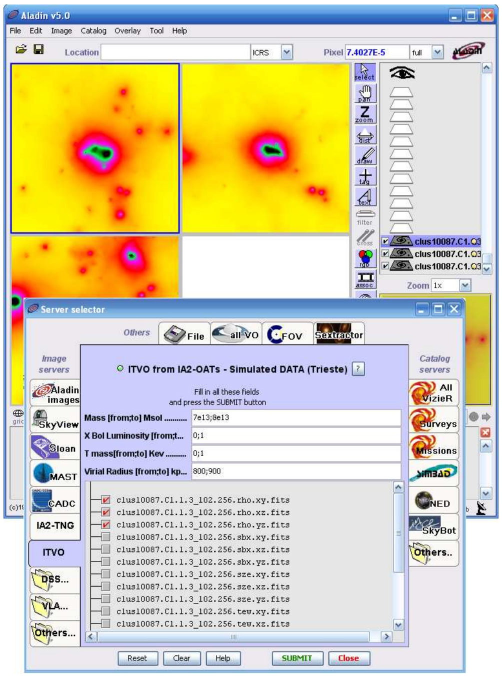


Fig. 5. The projection maps directly available on Aladin standalone using ITVO GLU dictionary.

et al. 1997) dictionary (downloadable from the ITVO web portal) for the ITVO archive (Fig. 5).

3.3. 1-D profile generation

The 1-D preview radial plots of physical quantities of clusters are generated on-the-fly upon user request. The main computation blocks were written by S. Ameglio and G. Murante for the Borgani et al. (2003) simulation and then embedded into the tool available from the ITVO web interface. Profiles data can also be downloaded from the preview page itself allowing further analysis in tools like TOPCAT[2] (Astrogrid, UK).

4. Conclusions

ITVO capabilities need further refinement and upgrade, more direct connection to other VO related tools (maybe using the SAMP protocol), looser connection to simulation types (at present mainly Gadget-2).

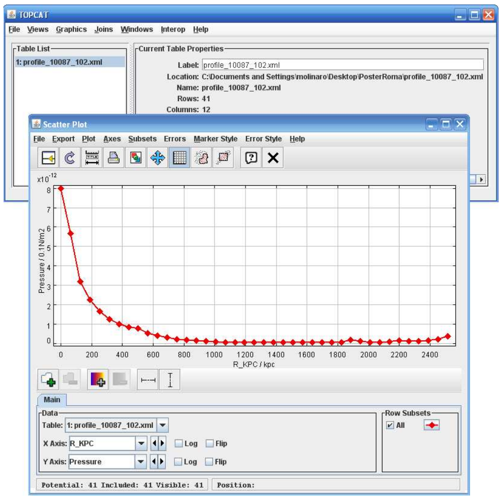


Fig. 6. An example of profiles' data displayed after download with the TOPCAT tool.

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2 `http://www.star.bristol.ac.uk/~mbt/topcat/`