

Theory in a Virtual Observatory

“Codes, Tools and Metadata”



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Resources

- <http://www.astro.umd.edu/nemo/tvo> (Theory in a Virtual Observatory – sample theory data + links)
- <http://www.ivoa.net/twiki/bin/view/IVOA/IVOADMSimulationsWP>
IVOA twiki discussion page

Outline of the Talk

- Theory in a VO: obvious and not so-obvious usage:
 - *Observing* simulations (compare them with observations)
 - Comparing models with models (also to check or improve algorithms)
 - Initial conditions (benchmark, compare codes)
 - Saving the code! (cf. [NEMO](#)'s nbody codes, [cloudy](#))
 - Running new simulations? (once we have the GRID!)
 - Big (simulation) data vs. little (ApJ tabular) data ([McDowell](#))
- Some of the current TVO efforts
- Conclusions/Challenges

Note: this would give theory also some new tools they did not have!!

TVO: *observing* simulations

- Great for observers, as they can find matching simulations to their observations (and the other way around!)
- Need a telescope model
 - Note: most modern telescopes have this, except they do not always know about the TVO yet!

TVO: comparing model & model

- Comparing could be done in
 - Model space
 - Observed space (see previous slide)
- Also useful to confirm the correctness of a new code (see next slide)

TVO: initial conditions

- Storing the whole simulation is not needed if
 - You have the code
 - You have the initial conditions
- Can be very hard to generate (sometimes can take another lengthy simulation to create, e.g. Hernquist composite model galaxies for Nbody)
- Useful for benchmarking (see also previous slide)
 - Performance and comparison of different codes on the same data

TVO: saving the code

NEMO: some public codes

- Nbody* (Aarseth) [\[usr\]](#)
- Ptreecode (Dubinski)
- PMCode (Klypkin)
- Gadget (Springel)
- AP3M/hydra (Couchman)
- Galaxy (Sellwood) [\[usr\]](#)
- Treecode (Hernquist) [\[usr\]](#)
- Treecode1 (Barnes) [\[usr\]](#)
- Tree++ (Makino) [\[usr\]](#)
- Vtc (Kawaii) [\[usr\]](#)
- Scfm (Hernquist) [\[usr\]](#)
- Multicode (Barnes) [\[usr\]](#)
- Flowcode (Teuben) [\[usr\]](#)
- Superbox (Richardson)
- YANC (Dehnen) [\[usr\]](#)
- GyrfalcON (Dehnen)

TVO: running simulations

- If you have the code and initial conditions, you can run the code yourself, but:
 - Code can be hard to run for you
 - Making initial conditions is hard
 - Could take a lot of resources (use the GRID)

TVO: simulations vs. tables

- We usually discuss big simulation data in TVO
- What about all the small tabular data we always need? ([McDowell, ADASS 2002](#))
 - Authors produce *small* tables useful for a TVO

Example theory data

- TVO workshops by **DeYoung et al** assembled some sample theory data, see next slide for a snapshot from that website

Toymodel Theory Virtual Observatory

This page is a growing list of links to different type of theory data that various researchers have made available. They do not always strive for scientific completeness (often the best datasets are large surveys), the aim here is width.

Links to other sites that contain links or data

- [AstroWeb](#)'s large list of Data and Archive Centers
- [Web Infrared Tool Shed](#) (if you are Java enabled, you can [jump right into the models](#))
- [NEMO's NBODY archive](#), where you can find a number of examples of Nbody data.
- [Dubinsky's data](#)
- [SkyView](#), a Virtual Telescope.
- [GC3 consortium](#)
- [MPA Numerical Cosmology](#)
- [A grid of chemical evolution models along the Hubble Sequence](#) (example local copy in [mde01](#))
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Benchmarking....

- [11 numerical integrations of a 25-body problem](#) (Lecar, 1968)
- [A Collaborative Experiment in Cluster Evolution](#) (Heggie, 1997), a.k.a. Kyoto-I
- [A Proposed Comparison for Star Cluster Evolution](#) (Heggie, 2001), a.k.a. Kyoto-II

Data....

A few examples existed in our local [N-Body archive](#), some of them have now been converted to this TVO:

- [S93](#): Sellwood (1993)'s "Bar Model for the Galactic Bulge".
- [GCM94](#): (see also [1994MNRAS.271..317G](#)): The fate of central black holes in merging galaxies.
- [PST95](#), (see also [1995ApJ...449..508P](#)), 2D polar-grid (PPM isothermal) hydro in a barred galaxy.
- [DMH96](#), (see also [1996ApJ...462..576D](#)): initial conditions for an M31-Galaxy(M0) encounter.
- [MM00](#), 2000Ap

Piner, Stone & Teuben: 1995

The file [hdf200bg](#) is a binary file in standard [HDF \(version 4\)](#) format. Datasets are 2-dimensional polar-grid, with radial velocity, tangential velocity and density. These data were writing with a fortran subroutine [hdfall](#).

```
% tsd hdf200bg
Found 3 scientific data sets in hdf200bg
1: R-VELOCITY AT TIME=1.00E+00(154,251) km/sec -> [38654 elements of type: 5 (FLOAT32)]
2: PHI-VELOCITY AT TIME=1.00E+00(154,251) km/sec -> [38654 elements of type: 5 (FLOAT32)]
3: DENSITY AT TIME=1.00E+00(154,251) Msolar/pc**2 -> [38654 elements of type: 5 (FLOAT32)]
```

Data Survey (IAU 208, Tokyo 2002)

- Code: 72% develop, 68% use
- Data: 84% posvel table, 14% grid
- Compare: 74% own, 68% other, 70% obs
- Tools: 60% own, 36% sm, 32% idl, 20% nemo/starlab, 20% other

Toymodel TVO:

Current TVO efforts?

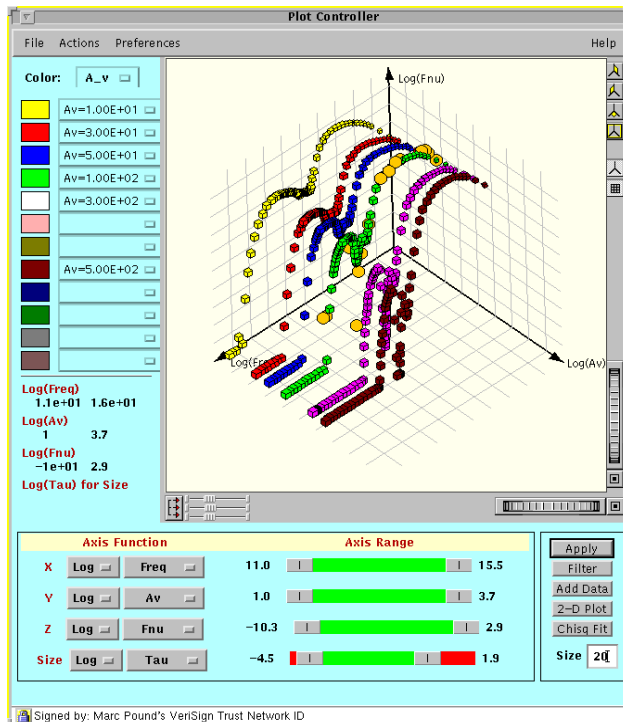
- Most of the current 13 IVOA members have *some* effort going on to do TVO, e.g.:
 - NVO: (GC demo @ AAS; DeYoung/Teuben et al.)
 - Several small workshops in the past 2 years
 - AstroGrid: (VirtU: Frenk et al. proposal)
 - GAVO: (TVO whitepaper: Lemson et al.)
 - AusVO: (ANITA workshop, jan 2003)
 - AVO: (Virgo consortium, White et al.)
- MANY small scale Theory efforts that look much like our TVO will be (see also TVO website)

Web Infrared Tool Shed (WITS)

Mark Wolfire et al. -- UofMD

- PDR Toolbox
- Dust InfraRed Toolbox

Browse 500,000 models!



The web interface shows a browser window with the URL <http://dustem.astro.umd.edu/models.html>. The main content area displays four panels of model results, each with a contour plot and download options:

- Top-left: [C II] 158 μm intensity. [See this image full size](#). Download: [FITS](#) [PostScript: Color B&W](#) [GIF](#)
- Top-right: Surface Temperature. [See this image full size](#). Download: [FITS](#) [PostScript: Color B&W](#) [GIF](#)
- Bottom-left: [O I] 145 μm [O I] 63 μm . [See this image full size](#). Download: [FITS](#) [PostScript: Color B&W](#) [GIF](#)
- Bottom-right: [O I] 63 μm [C II] 158 μm . [See this image full size](#). Download: [FITS](#) [PostScript: Color B&W](#) [GIF](#)

At the bottom, there are links for [PDR Toolbox](#), [PDR Model Details](#), and [PDR Models](#). A footer note states: "Please direct comments, criticisms, corrections and contributions to: found@astro.umd.edu Page last modified: Tuesday, 10 - May - 1999 16:51:16 EDT."

starburst99:

Photoionization Models For Evolving Stellar Populations

- example of a traditional web interface

Simulation Parameters Submitted.

Your simulation is currently running. Upon completion, an e-mail notification will be sent. The results will be located at:

<http://www.stsci.edu/science/starburst99/pickup.html>

The identification number of your job is: 95909

The e-mail address we have on record is: teuben@astro.umd.edu

The location and the identification number will be repeated in your e-mail notification.

Thank you for using Starburst99.

TVO demo (at AAS2004)

- GC observations from HST/CXC
- N-body models from Grape6:
 - Parameters: $IMF(M_0, M_1, \alpha)$, β (initial binary fraction), N
- Web services connecting to starlab/nemo to return a VOTable for Mirage/voplot/....
 - Binaries
 - Mass segregation, density profile
 - CMD (in particular, where do outliers come from)
 - Snapshot / filter

Technical Challenges

- Data formats
 - Grids (**FITS/IMAGE**) vs. Tables (**FITS/BINTABLE**)
 - AMR nested/hierarchical "grids"
 - Starlab's tdyn "tables" (cf. MIRIAD uvio format)
 - Header
- Theory: models / simulations / ..
 - Model parameters:
 - Initial conditions (**the magic...**)
 - Integration parameters (**correctness**)
 - Capabilities (**what did the author intend ot for?**)
- Sociology (NIH) : **!! simple authoring !!**

Time for VO Beer



(speaking is supposed to end here)

the remaining slides are for various backup material