Theoretical VO (for nearby galaxies but not only!)

- general context
- HORIZON project

Why publish simulations/models in the VO ?

- Until now the various VO efforts have confined themselves to observational data products and services. More recently, considerable interest has been shown in including products of theoretical research.
- This push comes especially from groups involved in *large-scale computer simulations* who want to publish their results in a VO compatible form.

Why publish simulations/models in the VO ?

- To allow independent checks of conclusions based on theoretical results.
- To allow further analysis by third parties based on the published data.
- To allow comparisons with similar results/methodologies or with the corresponding data by observers/theoreticians.
- To make theoretical results more easily accessible and understandable for observers.
- Journals may allow/require links to actual data products and/or software used in published work.

Why does theory need a special attention in the VO?

One of the main goals of the TVO is to enable *federation* of theoretical with observational archives.

- Position based query protocols irrelevant for TVO
- Federation based on similarity, not identity
- New observables
- Exact vs observable quantities
- Models
- pre-creating artificial observations from simulations

International status

- GAVO has in its charter the establishment of simulation services using the Grid paradigm. GAVO is furthermore closely cooperating with the MPA group to publish the results of their various simulations.
- The US (N)VO made a theory demo at the AAS meeting in January 2004 (Peter Teuben).
- A British proposal for funding a “Virtual Universe” project has been partially approved. (e-science)
- IVOA working group on Theoretical VO created (white paper published)

What kinds of theory data products can be published ?

Data products that have been proposed for theory/observation interface in IVOA WG on TVO:

- synthetic observations of X-Ray clusters (Springel, Tormen) vs. XMM/Chandra observations (Böhringer, Schuecker et al.)
- color-magnitude diagrams of globular clusters observed (Zurek et al.) vs. simulated (Zurek et al., Hut et al.)
- galaxy catalogues from semi-analytical work (Kauffmann et al., Frenk et al) vs. observations (for example SDSS)
- galaxy merger simulations (Steinmetz) vs. observations (?)
- Planck CMB simulations with non-trivial topologies (Banday)
- Ly-α forest simulated (Nusser et al) vs. observed ones (Nusser/Sheth)

Non-observational products:

- particle lists
- halo catalogues
- halo merger histories

How can one describe simulations ?

Classification by subject of simulations

- CMB
- Large-scale structure
  - analysis: gravitational lensing, Lyman alpha cloud spectra, pencil beams, semi-analytical galaxy formation, gravitational clustering, clusters
- galaxy clusters
- galaxy formation
- galaxy mergers
- globular cluster
- molecular clouds
- stellar evolution tracks
- supernovae
- accretion disks
- gravitational waves from merging black holes
- planetary systems
- spectra
- jets

Others classifications

- classified by type of evolution equations:
  - gravity
  - (magneto-)hydrodynamics
  - effective physics (semi-analytical, stellar evolution)
  - “transfer equations” (for example CMBFAST)
- classified by implementation choice
  - particle based
    - PP
    - tree based
  - grid based
    - fixed
    - adaptive
  - mixed
    - PPPM
    - AP3M
    - TreePM
    - AMR
- Classification by kind of data product:
  - particle list
  - grid

Orbit-based methods
(e.g. Schwarzschild method)

What kind of services should be offered?

- Query services
  - example might be to return all particles from a cosmological N-body simulation within a given sized volume randomly positioned in space at a given redshift.
- Analysis services
  - Virtual (or synthetic) telescope. Service that “observes” simulation results to produce “images” that can be directly compared to observations (cf. Guiderdoni this meeting). Also (simpler) optical subsets from semi-analytical galaxy catalogues.
  - *Comparators* for comparing the results of these synthetic telescopes to the actual observations.
  - Statistics calculators such as n-point functions, morphology indicators (cf. Bertin this meeting).
  - Halo finders.
  - Visualization services
- Simulators
  - N-body codes for galaxy mergers (Steinmetz). Connected with GRID techno
  - Semi-analytical galaxy formation algorithms on halo-merger trees (Kauffmann)
  - N-body codes linked to stellar evolution codes for globular cluster simulations (Teuben, NVO demo at AAS 2004).

Efforts already in progress or planned (white paper IVOA TVO working group)

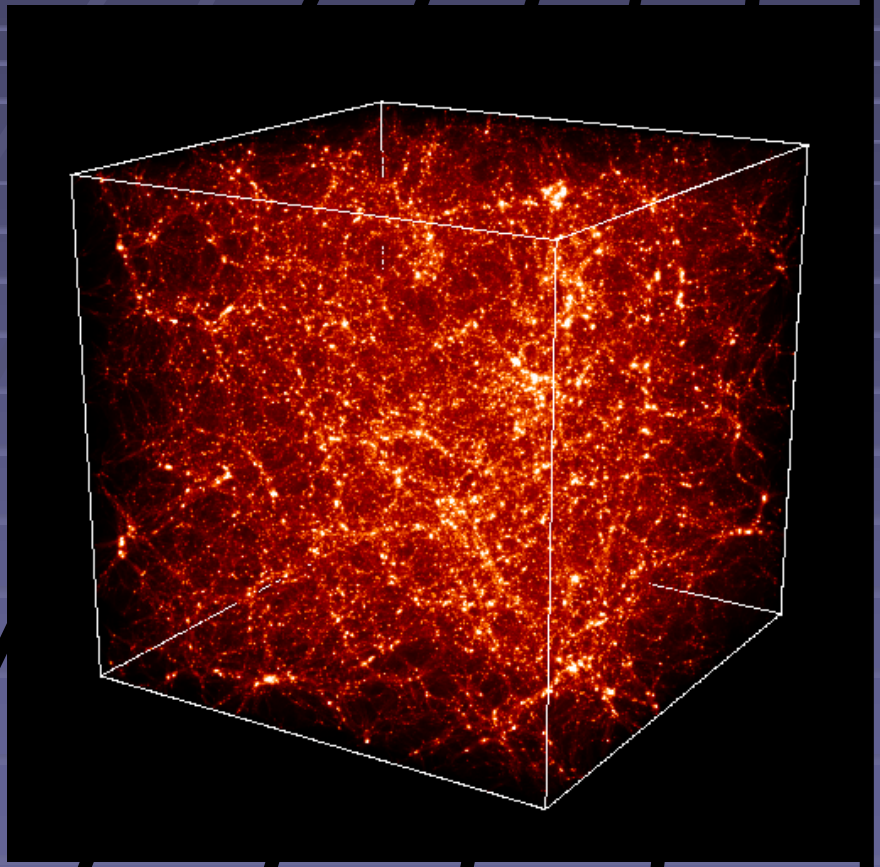
- Theory NVO demo (Teuben et al)
- Simulation data modeling (Lemson)
- Ly-α forest simulations (Nusser)
- Power-law cosmological simulations and merger-tree/halo structure models (Colberg, Sheth)
- CMD archiving (Zurek et al)
- MPA/Virgo simulations publishing (Springel, White, GAVO)
- MPA Planck simulation publishing (MPA, GAVO)
- MPE+MPA+Research Network proposal on X-Ray clusters, simulated and observed (Böhringer et al)
- British “Virtual Universe” proposal (Frenk, Lahav, Walton)

Efforts already in progress or planned (PNG 2004) (non exhaustive list… I hope!)

- GALICS (Guiderdoni et al)
- On line Galaxy modeling (Robin et al)
- Population synthesis tools (Le Borgne et al)
  - HORIZON project (Teyssier et al)

HORIZON project

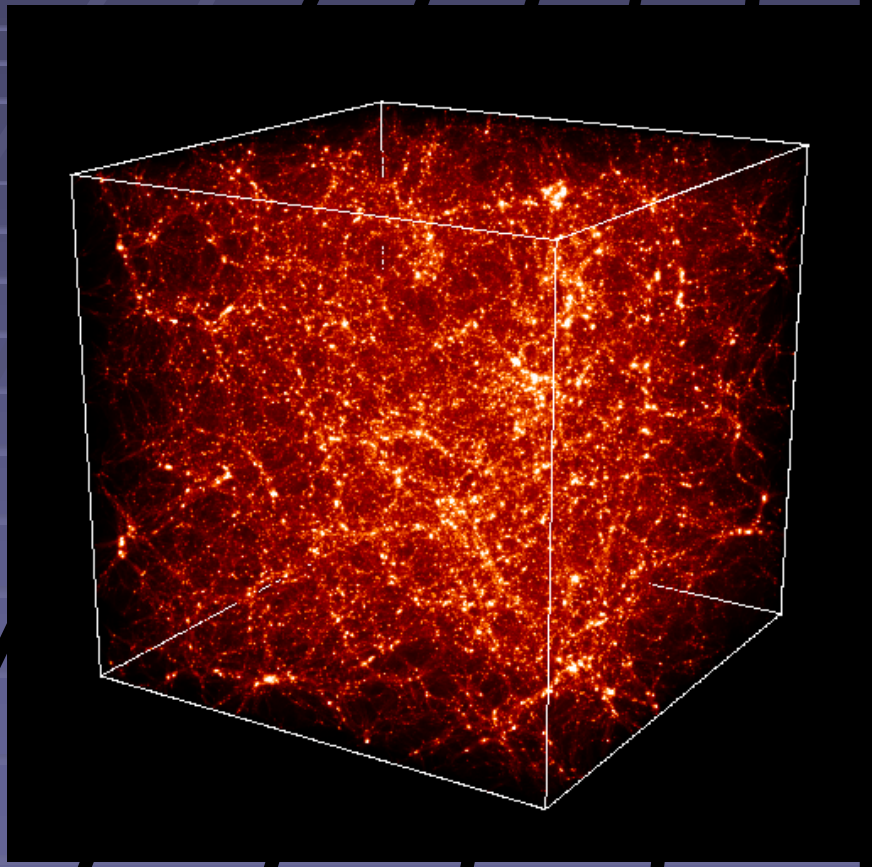
S. Colombi , F. Combes, B. Guiderdoni & R. Teyssier



Federation of people involved in numerical simulation of formation and evolution of galaxies in a cosmological framework

PNC, PNG, ASSNA

HORIZON project



4 co-I (CEA/Sap, IAP, LERMA, CRAL)
1 steering committee (8 external members)
18 ‘horizon’ scientists (8 fte)
7 Ph D students (2 fte)
15 associated scientists
9 numerical codes (of which GALICS, MoMAF)

Kickoff meeting in september

HORIZON goals

- Numerical study of galaxy formation in a cosmological framework
- Development of forefront techniques in parallel computing and applied mathematics for the formation of galaxies.
- Development of tools to predict observational signatures of galaxy formation, as a function of various physical recipes.
- Extensive know-how exchanges between experts, melting-pot of numerical codes, efficient and rational access to supercomputing resources.
- Simulation products dissemination. Availability for the community (observers and theorecists, PNC, PNG) $\Rightarrow$ TVO

HORIZON numbers

- 10^{10} particles in 1 Gpc^3
- 100 000 h CPU time ?
- Re-simulations of smaller boxes (interacting or isolated galaxies, e.g. Milky Way) in a cosmological context.
- Multi-? mock catalogues to prepare future observatories (ALMA, SKA) and space missions (e.g. JWST)

HORIZON products

- Cône d'espace-temps de relevés virtuels de galaxies avec leurs propriétés observationnelles et physiques
- Images de galaxies individuelles en plusieurs longueurs d'onde, ainsi que leurs propriétés physiques
- Cartes du ciel de l'effet Sunyaev-Zel'dovich
- Carte de cisaillement gravitationnel
- Listes de photons X ou « event list ».