IVOA-Theory
Micro-Simulations
BaSTI:
database and queries
for stellar evolution models

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IVOA - Theory, Trieste
The Italian Theoretical Virtual Observatory as a test-bed for the inclusion of theory and related tools in the VO

- ITVO project:
  - is develop under EuroVOTech and EuroVO-DCA WP4 and WP5 and it deals with cosmological and stellar models

- Things to do:
  - Standard format (VOTable and/or FITS binary table)
  - Standard Access Protocol
  - Web services for theoretical data, also using the Grid infrastructure;
The aims

• Store the theoretical metadata inside a relational DB to allow an easy search of these data on multiple choice of parameters;

• public theoretical data (inside a Registry) so to reuse expensive data in term of CPUs time, like cosmological simulations or output of stellar evolutionary code;

• permit an easy comparison between observational and theoretical data, using the same tools and services for both kind of data (married the VO philosophy);
Information produced by stellar evolution model
(slide by S. Cassisi)

The evolutionary stellar models provide:

- Evolutionary lifetimes ⇒ Star counts
- Bolometric luminosity
- Effective temperature
- Mass - different than the initial one (!)
- Gravity
  \[ T_{\text{eff}} \]
- Bolometric correction(s) + color-\( T_{\text{eff}} \) relations
- Magnitudes & Colors
- Surface chemical composition predictions
- Nuclear yields

spectroscopy

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Archives + DBs + services

- Archives contain the output files of the simulation;
- Databases contain the metadata of the simulation that should include all the parameters to perform the running not only the physical ones;
- Data access: it could be performed via Web Portal or Web services or in future via Grid infrastructure also creating on demand new simulated data.

Stellar evolutionary computations are extremely time consuming

They are perfectly suited for running on “distributed computing facilities” (GRID)
Uses cases of stellar models

These model are important for:
• testing the “physics” in the regime of high density/low temperature;
• Investigating the IMF in various enviroments;
• Simulated evolutionary tracks and isochrones;
• Simulated the HB for sampling different evolutionary phases and study pulsating stars;
• Study M/L relation and M/R relation and confrontation with observational data;
• Optical photometric bands / near –infrared one;
• Comparison with star clusters, binary systems;
• Study fundamental ingredient for population synthesis;
• Analyze the integrated magnitudes, colours and spectra of composite stellar populations;

(informations taken from S. Cassisi VO-DCA WP4 talk)
The stellar theorists’ wishes

- Easy “access” to physical inputs databases;
  - Clear explanations of HOW the physical inputs have been computed;
  - Possibility to perform online computations by using user-specified conditions;
  - Standard outputs;
- Reliable color- Teff relations
  - As many as possible different calibrations;
  - Possibility to perform online computations for the new photometric systems;
- Direct access to other stellar model archives
  - Information about the adopted inputs and physical assumptions;
  - User friendly access;
- Direct access to suitable empirical constraints
  - For clusters stars;
  - For single stars;

(informations taken from S. Cassisi VO-DCA WP4 talk)
The stellar model users’ dream
(slide by S. Cassisi)

- Updated stellar models
- Accuracy
- Homogeneity
- Completeness
- Standardization
- “User friendly” access
- Online computational facilities

Helper Applications:
- TOPCAT: tabular data & manipulation
- VOPlot: handling with VOTable data
- Etc...

Tools to analyse and visualise end & intermediate data products

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BaSTI

a Bag of Stellar Tracks and Isochrones

Web portal: [http://albione.oa-teramo.inaf.it/](http://albione.oa-teramo.inaf.it/)
stellar evolution data computed using FRANEC code are stored into BaSTI:

- 32010 Isochrones;
- 17489 Tracks;
- 4438 HB (Horizontal Branch) –tracks;
- 121 ZAHB (Zero Age Horizontal Branch);
- 121 end-He (end Helium burning);
- 198 summary tables;
Stellar evolution model: the “building blocks”

(slides of S. Cassisi)

The Evolutionary Code
- Stellar structure equations
- Surface boundary conditions
- ... numerics...

physical inputs
- EOS (eq. of state)
- Opacity
- Nuclear reaction rates
- Neutrino energy losses

Microscopic mechanisms
- Atomic diffusion
- Radiative levitation

(in)famous unknown...
- Mass loss
- Dredge-up efficiency (AGB)
- Impact of mixing on opacity

Mixing scheme
- Semiconvection
- Overshooting
- Breathing pulses
- Turbulence

Magnetic field
Rotation & Rotational mixing

1st step: how maps these structure inside a relational DB
2nd step: … (discussion) it fit with the theoretical DM
Stellar evolution DB structure: BaSTI
(A Bag of Stellar Tracks and Isochrones)

The 1\textsuperscript{st} relational database for a large range of masses and initial chemical composition for stellar evolution models, obtained with FRANEC code.

DB contains 49939 rows in the OUT\_FILE table.
BaSTI web portal

- Query the stellar evolutionary DB;
- Personalized the SQL query;
Queries and access protocol

A simple access protocol to search stellar evolution files

• Tracks:
  – Mass;
  – Metallicity;
  – ….

• Isochrones:
  – Age;
  – Metallicity;
  – ….

These will be matter of discussion…..

Could we use a protocol like TSAP (SSAP for theoretical spectra)? (see Carlos Rodrigo talk)
The tools will be transformed in web-services:

- Isochrones- tracks extractor;
- Luminosity function
- Syntetic color – Magnitude diagrams (stellar population synthesis program)

All is written in PERL.
### BaSTI

**A Bag of Stellar Tracks and Isochrones...**

#### Isochrone/track Extractor

<table>
<thead>
<tr>
<th>Output Type</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Isochrone (for a given age)</td>
<td></td>
</tr>
<tr>
<td>Interpolated track (for a given mass)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heavy Elements Mixture</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaled to solar mixture</td>
<td></td>
</tr>
<tr>
<td>Alpha enhanced mixture (not yet available)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color-temperature Transformation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>UBVRIJHKL (Scaled solar or Alpha enhanced)</td>
<td></td>
</tr>
<tr>
<td>ACS (Scaled solar only)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model Type</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard - ( \eta = 0.2 ) - (without overshooting)</td>
<td></td>
</tr>
<tr>
<td>Non-standard - ( \eta = 0.4 ) - (with overshooting)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chemical composition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( Z = 0.0001 \ Y = 0.245 )</td>
<td>( Z = 0.008 \ Y = 0.256 )</td>
</tr>
<tr>
<td>( Z = 0.0003 \ Y = 0.245 )</td>
<td>( Z = 0.01 \ Y = 0.259 )</td>
</tr>
<tr>
<td>( Z = 0.001 \ Y = 0.246 )</td>
<td>( Z = 0.0198 \ (\text{Sun}) \ Y = 0.273 )</td>
</tr>
<tr>
<td>( Z = 0.002 \ Y = 0.248 )</td>
<td>( Z = 0.03 \ Y = 0.288 )</td>
</tr>
<tr>
<td>( Z = 0.004 \ Y = 0.251 )</td>
<td>( Z = 0.04 \ Y = 0.303 )</td>
</tr>
</tbody>
</table>

© 2004 web initiative written by Gianni Cubarsi
Synthetic Colour-Magnitude diagrams
The output of BaSTI is an **ASCII file** so the natural tool to analyze these data is TOPCAT. We transform it in a **VOTable** (or **FITS-Table**).
Isochron ASCII file transform in a VOTable

(thanks to M. Molinaro)
...start the discussion

- Standard format;
- DM....
- Access protocol...
- .....