

# IVOA-Theory Micro-Simulations



## BaSTI: database and queries for stellar evolution models

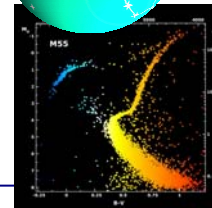


**P. Manzato**  
**INAF**  
ISTITUTO NAZIONALE  
DI ASTROFISICA  
NATIONAL INSTITUTE  
FOR ASTROPHYSICS

In collaboration with:

A. Pietrinferni  
S. Cassisi  
M. Salaris  
D. Cordier

M. Molinaro  
F. Gasparo  
G. Taffoni  
F. Pasian

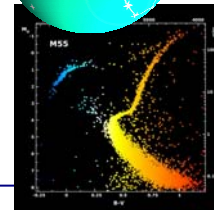


# ITVO@Vobs.it



## 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);

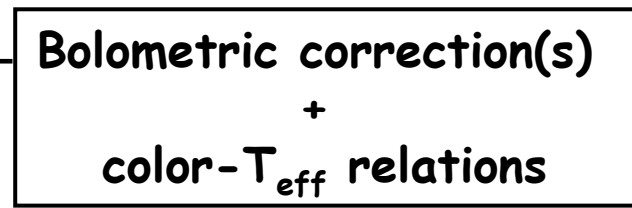
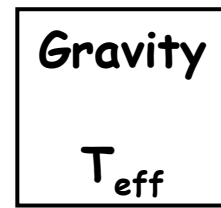
## Information produced by stellar evolution model

(slide by S. Cassisi)

The evolutionary stellar models provide:

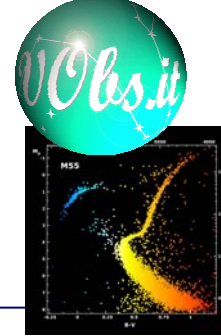
- Evolutionary lifetimes  $\Rightarrow$  Star counts

- Bolometric luminosity
- Effective temperature
- Mass - different than the initial one (!)

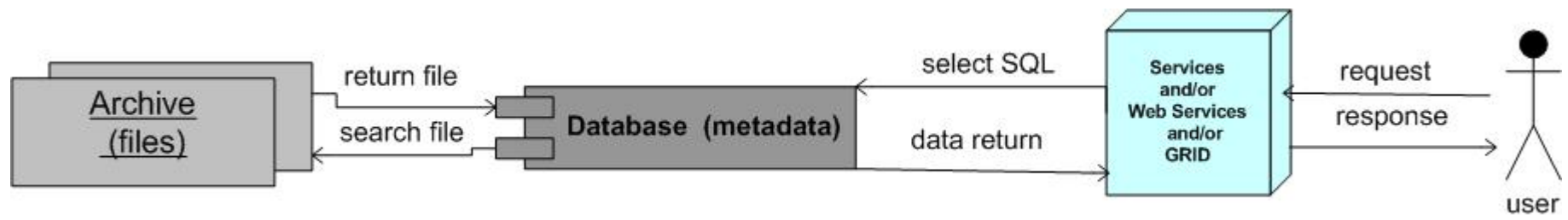
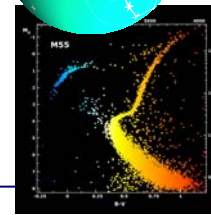


- Surface chemical composition predictions  $\Rightarrow$  spectroscopy

- Nuclear yields



# Archives + DBs + services



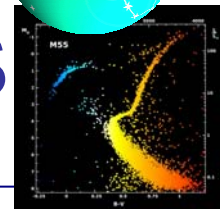
- Archives contain the output files of the simulation;
- Databases contain the metadata of the simulation that should include all the parameters to perform the running not only the physical ones;
- Data access: it could be performed via Web Portal or Web services or in future via Grid infrastructure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

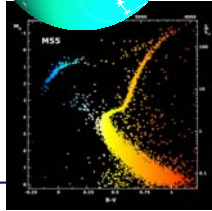


These model are important for:

- 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 populaion syntesis;
- Analyze the integrated magnitudes, colours and spectra of composite stellar populations;

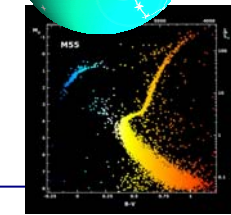
(informations taken from S. Cassisi VO-DCA WP4 talk)

# 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

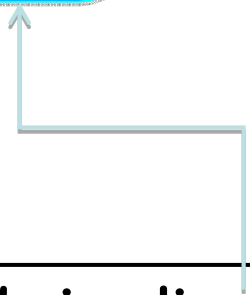
## Helper Applications:

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

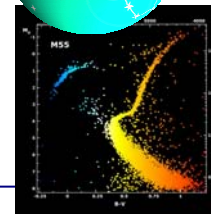
- Standardization
- "User friendly" access
- Online computational facilities



Tools to analyse and visualise  
end & intermediate  
data products





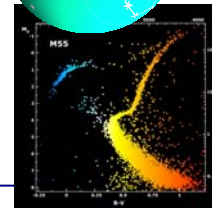


## a Bag of Stellar Tracks and Isochrones



Web portal: <http://albione.oa-teramo.inaf.it/>

# Stellar evolution archive



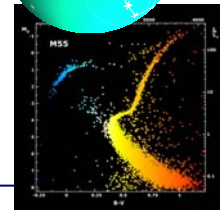
**stellar evolution data** computed using **FRANEC** code are stored into **BaSTI** :

- 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 data

# Stellar evolution model: the “building blocks”

(slide 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

**(in)famous unknown...**

- Mass loss
- Dredge-up efficiency (AGB)
- Impact of mixing on opacity

**Mixing scheme**

- Semiconvection
- Overshooting
- Breathing pulses
- Turbulence

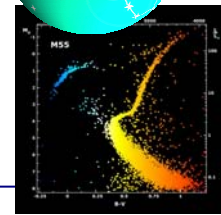
**Microscopic mechanisms**

- Atomic diffusion
- Radiative levitation

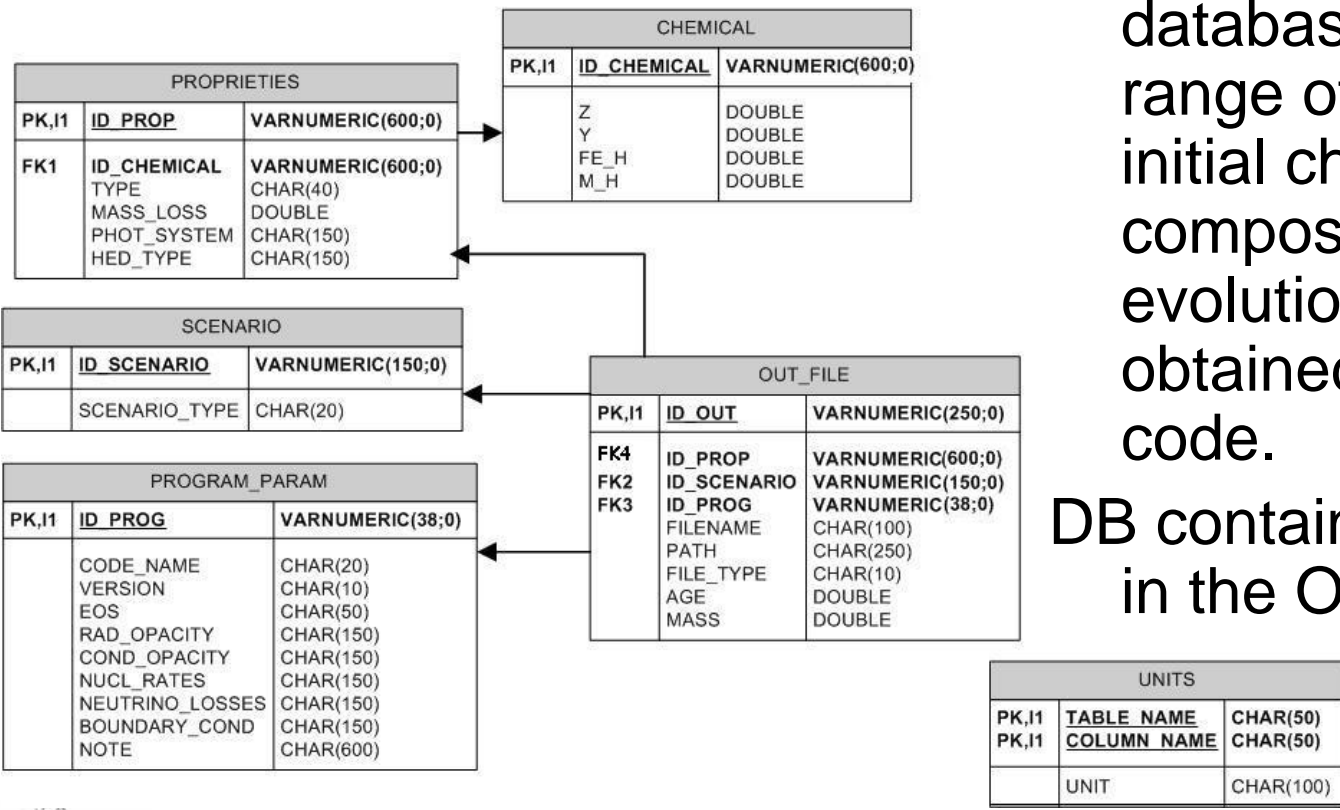
Magnetic field  
Rotation & Rotational mixing

1<sup>st</sup> step: how maps these structure inside a relational DB  
2<sup>nd</sup> step: ... (discussion) it fit with the theoretical DM

# Stellar evolution DB structure: BaSTI (A Bag of Stellar Tracks and Isochrones)



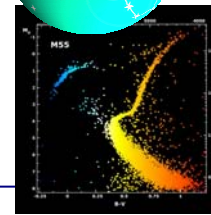
**BaSTI Database**



The 1<sup>st</sup> 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;

BaSTI Home Page - Windows Internet Explorer

http://albione.oa-teramo.inaf.it/

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

**BaSTI Menu**

- Home
- Database
- Bibliography
- News
- Info
- FAQ
- Contact us
- Links
- STAFF only

7,851 Visitors  
Since February 2, 2004

last update:  
10-01-2008

BaSTI database is maintained by: [Santi Cassisi](#), [M...](#)

Create Query on BaSTI DB				How to use the interface	
Filename:	<input type="text"/>		Scenario:	CANONICAL	
<input checked="" type="checkbox"/> Data type:	ISOCHRON	<input checked="" type="checkbox"/> Age: (Gyr)	min: 0.02 max: 0.5	<input type="checkbox"/> Mass: (Msun)	min: max:
<input checked="" type="checkbox"/> Z:	min: max:	<input checked="" type="checkbox"/> Y:	min: max:	<input checked="" type="checkbox"/> [M/H]:	min: max:
<input checked="" type="checkbox"/> [Fe/H]:	min: max:	<input checked="" type="checkbox"/> Type:	AGB EXTENDED	<input checked="" type="checkbox"/> Mass loss:	0.2
<input checked="" type="checkbox"/> Photometric system:	JOHNSON CASTELLI	<input checked="" type="checkbox"/> Mixture:	SCALED SOLAR		
Advanced Search					
<input type="checkbox"/> Code version:	FRANECPCS 2003	<input type="checkbox"/> Rad. opacity:	Alexander & Ferguson 1994		
Show selected fields.		<b>SEARCH</b>		Personalize SQL: <b>GO</b>	
<b>RESET</b>					

Powered by IA2 (INAF - Teramo Astronomical Observatory)  
For any problem please contact: [BaSTI team](#)

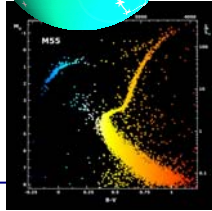
**Personalize SQL:**

```

TYPE, MASS_LOSS, PHOT_SYSTEM, HED_TYPE, SCENARIO_TYPE, VERSION,
RAD_OPACITY
from
ARCHA.OUT_FILE, ARCHA.PROPRIETIES, ARCHA.SCENARIO,
ARCHA.PROGRAM_PARAM, ARCHA.CHEMICAL
where
OUT_FILE.ID_PROP = PROPRIETIES.ID_PROP and OUT_FILE.ID_SCENARIO =
SCENARIO.ID_SCENARIO and OUT_FILE.ID_PROG = PROGRAM_PARAM.ID_PROG
and upper(SCENARIO_TYPE) like upper('CANONICAL*') and AGE >= 0.02
and AGE <= 0.5 and upper(FILE_TYPE) like upper('ISO*') and upper
(TYPE) like upper('AGB EXTENDED*') and MASS_LOSS = 0.2 and upper
(PHOT_SYSTEM) like upper('JOHNSON CASTELLI*') and upper(HED_TYPE)
like upper('SCALED SOLAR MODEL*')
order by FILENAME
                    
```

**SEARCH**

# Queries and access protocol



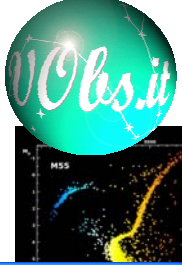
A simple access protocol to search stellar evolution files

- 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)

# EUROVO BaSTI tools – developed by OATeramo



The tools will be transformed in web-services:

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

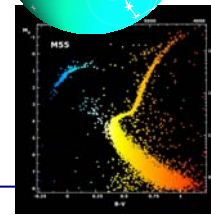
All is written in PERL.



20/05/2008

P. Manza

# Tool: isochrone/track extractor



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

## Isochrone/track Extractor

**Output Type**

- Isochrone (for a given age)
- Interpolated track (for a given mass)

---

**Heavy Elements Mixture**

- Scaled to solar mixture
- Alpha enhanced mixture (not yet available)

---

**Color-temperature Transformation**

- UBVRJHKL (Scaled solar or Alpha enhanced)
- ACS (Scaled solar only)

---

**Model Type**

- Standard -  $\eta=0.2$  - (without overshooting)
- Non standard -  $\eta=0.4$  - (with overshooting)

---

**Chemical composition**

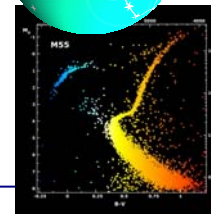
<input checked="" type="radio"/> Z= 0.0001 Y= 0.245	<input type="radio"/> Z= 0.008 Y= 0.256
<input type="radio"/> Z= 0.0003 Y= 0.245	<input type="radio"/> Z= 0.01 Y= 0.259
<input type="radio"/> Z= 0.001 Y= 0.246	<input type="radio"/> Z= 0.0198 (Sun) Y= 0.273
<input type="radio"/> Z= 0.002 Y= 0.248	<input type="radio"/> Z= 0.03 Y= 0.288
<input type="radio"/> Z= 0.004 Y= 0.251	<input type="radio"/> Z= 0.04 Y= 0.303

Submit





# Synthetic Colour-Magnitude diagrams



The BASTI Population Synthesis Program Web Interface - Mozilla Firefox

http://astro.enscm-rennes.fr/bastisynth\_pop\_v3.0/

### Stellar Population Synthesis Program

User Id:

**Photometric error**

- No error
- Gaussian error with the mean photometric error:  (in mag)
- User Specified error law table  
Number of values:  (Max. 200)

**Mean spectroscopic error**

(in dex)

**Colour excess E(B-V)**

**Total spatial depth of the population**

**Distance modulus**

**Fraction of unresolved binaries**

(e.g. 1/10 -> 0.1)

**Minimum mass ratio for binary systems**

**Scale factor for SFR**

(Max. 8 digits integer)

**Mass range**

- Default mass range (0.1-120  $M_{\text{sun}}$ )
- User-specified lower mass limit:  (solar masses)

**Initial Mass Function**

IMF type

- Single power law
- Kroupa, Tout, Gilmore (1993)

IMF exponent (in case of single power law)

**Stellar Formation History**

Fixed Stellar Formation Histories (SFH)

- NGC6822 (\*)
- Milky Way bulge
- SMC (\*)
- Sextans A
- LMC (bar field)
- LGS3
- Local disk
- (\*) (global SFH)

User Specified SFH  
Number of age values:  (max. 200)

**Search for variable stars**

yes  no

**Selected set of isochrones**

Heavy Elements Mixture

- Scaled to solar mixture
- Alpha enhanced mixture

Mass loss

- $\eta=0.2$
- $\eta=0.4$

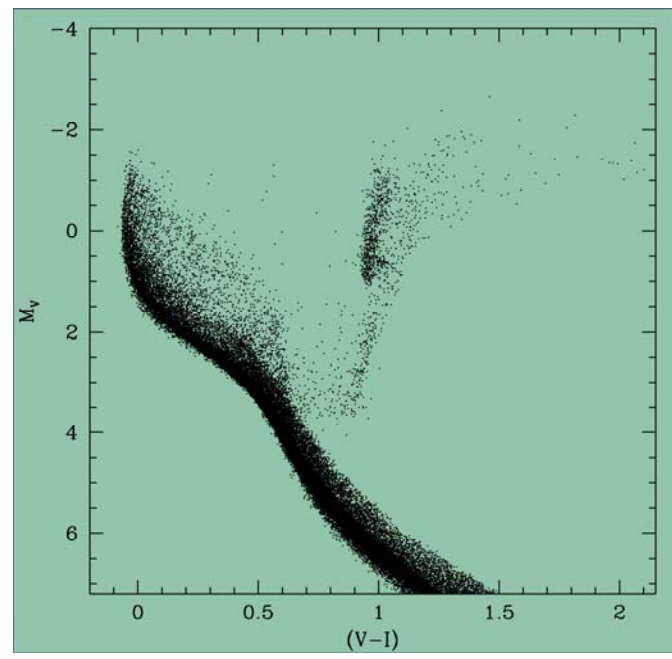
Extra core mixing

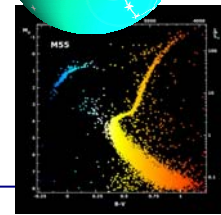
- Standard (No overshooting)
- Overshooting

**Random numbers generating**

- The random number generator is automatically initialized through the Web taking a seed from <http://www.random.org> (recommended option)
- The random number generator is initialized with seeds provided by the user:

Seed 1:  Seed 2:





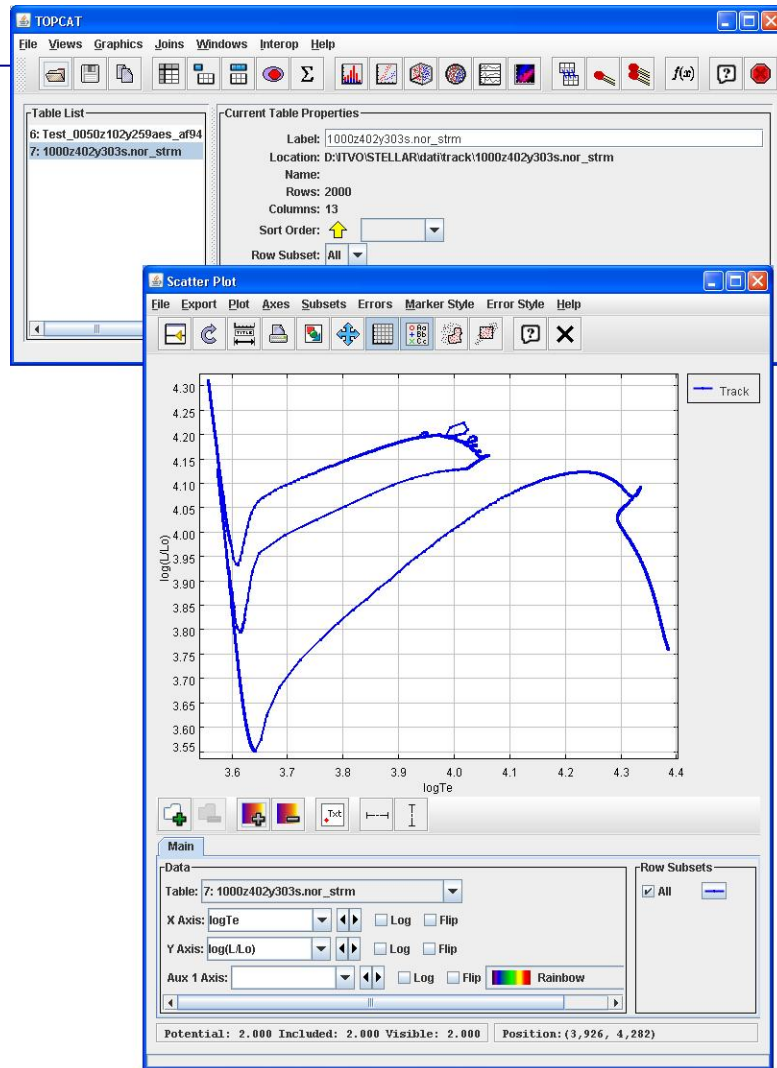
# BaSTI and VVO tool



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**).



# VOTable



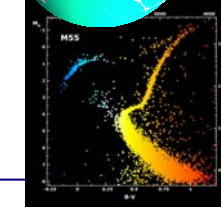
Isochron ASCII file  
trasform  
in a VOTable

(thanks to M. Molinaro)

```

Mozilla Firefox
File Modifica Visualizza Cronologia Segnalibri Strumenti 2
file:///C:/molinaro/BA5TASCI2V0/wz102y259o.t600030_acs_hst.xml
Bookmarks Varie Virtual Observatories TUTOR -- Login WebMail Tomcat Palatir 1

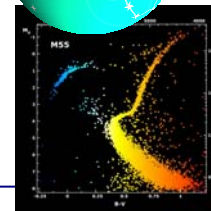
-<VOTABLE version="1.1" xmlns:namespaceSchemaLocation="http://www.ivoa.net/xml/VOTable/v1.1">
-<DESCRIPTION>
  Isochrone by Pietruferri - Cassisi - Salari - Castelli 2006 :: Non Standard Model - Scaled solar model & transformations for ACS (Castelli 2004)
</DESCRIPTION>
-<RESOURCE>
-<DESCRIPTION>
  For further information on PARAM(s) and FIELD(s) see: "http://www.oats.inaf.it/IA2/index.php?option=com_wrapper&Itemid=87"
</DESCRIPTION>
+<PARAM arraysize="*" datatype="char" name="Filename" ucd="meta.id.meta.file" unit="*" value="wz102y259o.t600030_acs_hst"></PARAM>
+<PARAM arraysize="*" datatype="char" name="DataType" ucd="meta.note" unit="*" value="Isochrone"></PARAM>
-<PARAM arraysize="*" datatype="char" name="Mixture" ucd="meta.note" unit="*" value="Scaled Solar">
  <DESCRIPTION>Heavy elements distribution</DESCRIPTION>
-<VALUES>
  <OPTION>Scaled Solar</OPTION>
  <OPTION>alfa-enhanced</OPTION>
</VALUES>
</PARAM>
+<PARAM datatype="boolean" name="Overshooting" ucd="meta.code" unit="*" value="T"></PARAM>
+<PARAM datatype="float" name="MassLoss" ucd="phys.mass.loss" unit="*" value="0.4"></PARAM>
+<PARAM arraysize="*" datatype="char" name="PhotSystem" ucd="meta.note" unit="*" value="ACS-HST"></PARAM>
+<PARAM arraysize="*" datatype="char" name="Type" ucd="meta.note" unit="*" value="Normal"></PARAM>
+<PARAM arraysize="*" datatype="char" name="CodeVersion" ucd="meta.note" unit="*" value="2007"></PARAM>
+<PARAM arraysize="*" datatype="char" name="RadOpacity" ucd="meta.note" unit="*" value="Ferguson 2005"></PARAM>
+<PARAM datatype="int" name="Np" ucd="meta.number" unit="*" value="2000"></PARAM>
+<PARAM datatype="float" name="[M/H]" ucd="phys.abund.Z" unit="[%]" value="-.253"></PARAM>
-<PARAM datatype="float" name="Z" ucd="phys.abund.Z" unit="%" value="0.100">
  <DESCRIPTION>
    The mass fraction of the initial heavy elements abundance
  </DESCRIPTION>
-<VALUES>
  <MIN>0.0001</MIN>
  <MAX>0.04</MAX>
</VALUES>
</PARAM>
+<PARAM datatype="float" name="Y" ucd="phys.abund.Y" unit="%" value="0.259"></PARAM>
+<PARAM datatype="float" name="Age" ucd="time.age" unit="Gyr" value="0.0300"></PARAM>
+<PARAM arraysize="*" datatype="char" name="CheckDate" ucd="time.processing" unit="DD-MM-YYYY" value="16-05-2005"></PARAM>
-<TABLE>
  <DESCRIPTION>Output Data Table. Number of rows: 2000</DESCRIPTION>
+<FIELD datatype="float" name="(M/Mo)in" ucd="phys.mass.arith.ratio" unit="%"></FIELD>
+<FIELD datatype="float" name="(M/Mo)" ucd="phys.mass.arith.ratio" unit="%"></FIELD>
+<FIELD datatype="float" name="log(L/Lo)" ucd="phys.luminosity.arith.ratio" unit="[%]"></FIELD>
-<FIELD datatype="float" name="logTe" ucd="phys.temperature.effective" unit="[K]">
  <DESCRIPTION>Logarithmic value of the effective temperature</DESCRIPTION>
</FIELD>
+<FIELD datatype="float" name="F435W" ucd="phot.mag" unit="mag"></FIELD>
+<FIELD datatype="float" name="F475W" ucd="phot.mag" unit="mag"></FIELD>
+<FIELD datatype="float" name="F555W" ucd="phot.mag" unit="mag"></FIELD>
+<FIELD datatype="float" name="F606W" ucd="phot.mag" unit="mag"></FIELD>
+<FIELD datatype="float" name="F625W" ucd="phot.mag" unit="mag"></FIELD>
+<FIELD datatype="float" name="F775W" ucd="phot.mag" unit="mag"></FIELD>
+<FIELD datatype="float" name="F814W" ucd="phot.mag" unit="mag"></FIELD>
-<DATA>
  <TABLEDATA>
    <TR>
      <TD>5000000000</TD>
      <TD>4999876494</TD>
      <TD>-1.32717</TD>
      <TD>3.60453</TD>
      <TD>10.272</TD>
      <TD>9.769</TD>
      <TD>9.059</TD>
      <TD>8.597</TD>
      <TD>8.229</TD>
      <TD>7.499</TD>
      <TD>7.392</TD>
    </TR>
  </TABLEDATA>
</TR>
</TABLE>
Completato
  
```



20/05/2008



# ...start the discussion



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