MODEST-7c
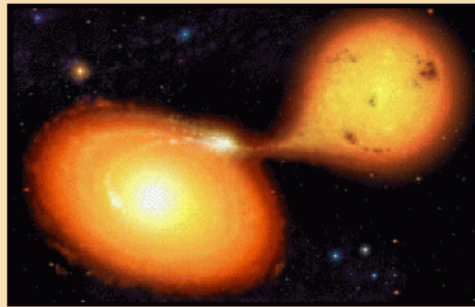
Multi-Scale, Multi-Physics Software Frameworks in Computational Physics

WG1 | WG2 | WG3 | WG4 | WG5 | WG6 | WG7 | WG8 | WG9 | WG10
MODEST-1 | MODEST-2 | MODEST-3 | MODEST-4 | MODEST-5 | MODEST-6 | MODEST-7 | MODEST-8

MODEST

MOdeling DEnse STellar systems

FAQs

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Other Links

Most stars in most galaxies will never experience a collision or even a close encounter with another star. Typical collision time scales in the solar neighborhood of the Milky Way galaxy exceed the age of the universe by many orders of magnitude, so physical stellar interactions are extremely rare. However, in some parts of the universe -- in galactic nuclei and some star clusters -- circumstances have conspired to create conditions in which physical collisions between stars are commonplace events. Such *dense stellar systems* stand at the interface between stellar dynamics and stellar evolution. Often owing their existence to purely dynamical processes, dense stellar systems offer wholly new channels for stars to evolve, allowing the formation of stellar species completely inaccessible by standard stellar and binary evolutionary pathways.

MODEST is a loosely knit collaboration between various groups working in stellar dynamics, stellar evolution, and stellar hydrodynamics. Our aim is to provide a software framework for large-scale simulations of dense stellar systems, within which existing codes for dynamics, stellar evolution, and hydrodynamics can be easily coupled. While many of us have talked for years about combining `live' stellar evolution codes directly with N-body simulations, we have now reached a consensus between various groups about standards and interfaces, what is needed, and what is doable. On this web site we will provide up-to-date information about our activities, and pointers to various projects in progress, including coordination with numerous Virtual Observatory projects around the world.

Although neither we nor our project goals could possibly be described as modest, we use the name also to indicate that we intend only MODEST modifications of existing codes, in order to model dense stellar systems. So the acronym can also be read as MODifying Existing STellar codes.

The MODEST web site is hosted by the manybody consortium.

MODEST research

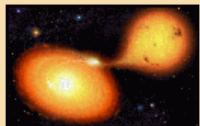- dense stellar systems

MODEST research

- dense stellar systems

- physical processes
  - stellar dynamics
  - stellar evolution
  - stellar encounters and collisions

- broad range in spatial and temporal scales
  - most stars evolve in isolation most of the time

- physical interactions among stars
  $\Rightarrow$ software integration becomes essential

MODEST: Workshops

The MODEST group holds regular workshops at locations around the world (for a summary of the first three workshops, see the following short review paper). Here is the current list of recent and planned meetings.

- MODEST-1 (New York, USA, June 17 - 21, 2002)   [summary paper]
- MODEST-2 (Amsterdam, the Netherlands , December 16 - 17, 2002)   [summary paper]
- MODEST-3 (Melbourne, Australia, July 9 - 11, 2003)
- MODEST-4 (Geneva/Lausanne, Switzerland, January 12 - 14, 2004)
- MODEST-5 (Hamilton [Ontario], Canada, August 11 - 14, 2004)
- MODEST-6 (Evanston [Illinois], USA, August 29 - 31, 2005)
- MODEST-7 (Prague, Czech Republic, at the IAU General Assembly, August 2006)

- MODEST-8 (Bonn, Germany, December 5 - 8, 2007)

In addition to these main meetings, we also organize and encourage satellite meetings:

- MODEST-4b (Amsterdam, the Netherlands, June 7 - 8, 2004)
- MODEST-5b (Prague, Czech Republic, September 20 - 25, 2004)
- MODEST-5a (Edinburgh, UK, December 15 - 17, 2004)
- MODEST-5d (Princeton [New Jersey], USA, April 7, 2005)
- MODEST-6b (Princeton [New Jersey], USA, September 15 - 16, 2005)
- MODEST-6c (Cologne, Germany, September 26 - October 1, 2005)
- MODEST-6a (Lund, Sweden, December 12 - 15, 2005)
- MODEST-6d (Amsterdam, the Netherlands, March 27 - 28, 2006)
- MODEST-6e (Amsterdam, the Netherlands, March 21 - April 15, 2006)

- MODEST-7c (Philadelphia [Pennsylvania], USA, September 15, 2006)
- MODEST-7b (Philadelphia [Pennsylvania], USA, January 15 - 18, 2007)

Here is a list of summer schools organized by MODEST and similar initiatives:

- MODEST-4a (Strasbourg, France, March 19 - 22, 2004)
- MODEST-5c (Amsterdam, the Netherlands, July 24 - 30, 2005)
- Sixth Summer School in Supercomputational Cosmology (Potsdam, Germany, July 17 - August 11, 2006)
- International School on Galactic and Cosmological N-Body Simulations (Puebla, Mexico, July 23 - August 5, 2006)

MODEST Goals

- "competitive collaboration"
- high-performance applications
- interoperation of software
- calibration and comparison of codes
- visualization of results
- comparison of simulations with observations
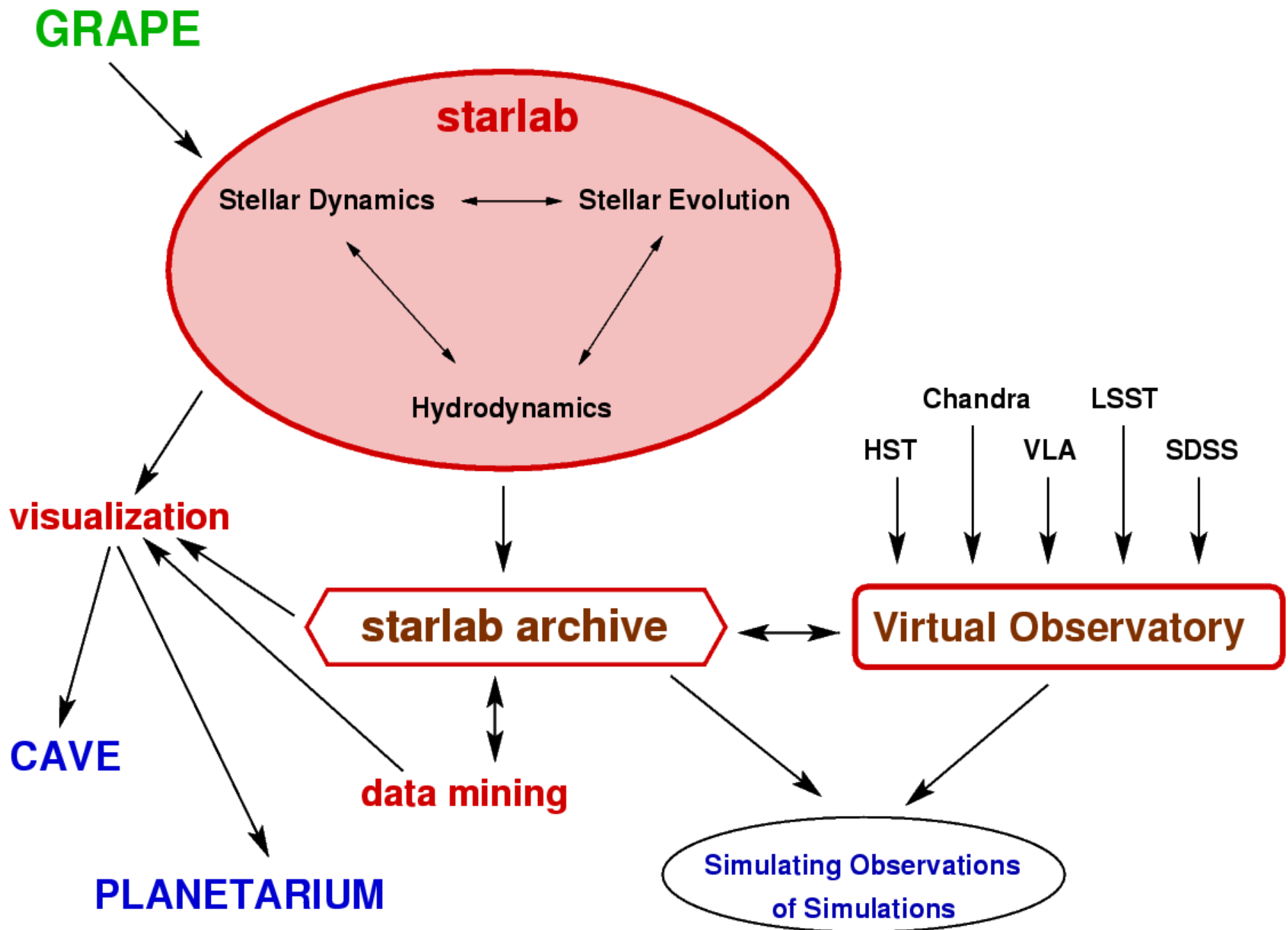
Collaborative Software Development

- software engineering
  - modules
  - data structures
  - interfaces
  - schedulers
  - etc.

- legacy codes

Collaborative Software Management

- social engineering
  - broad range in programming styles
    - "legacy programmers"
    - modularity and structure
  - generational and cultural differences
  - open source
  - contributed software

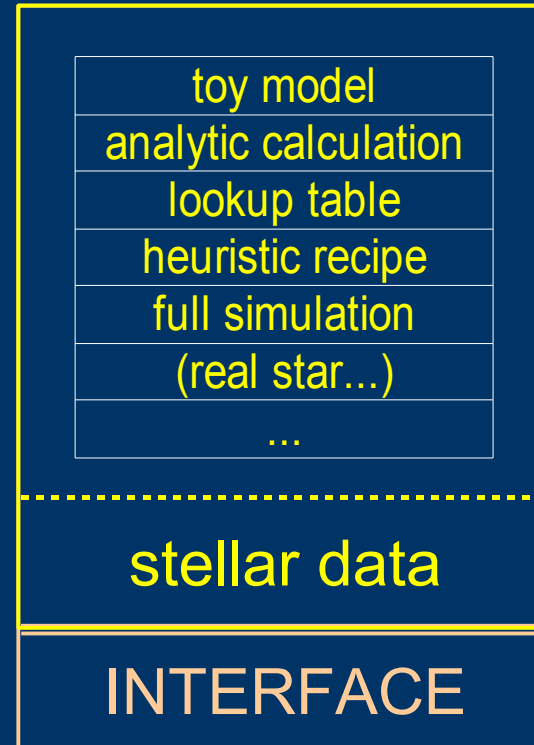# *MUSE (Multiscale Multiphysics Scientific Environment)*

- wiki: http://london.science.uva.nl:8000/muse

- modules for stars, dynamics, collisions, etc.
- implemented as "black boxes" with wrappers
- all modules provide prediction time scales
- coordinated by "blind" scheduler
- top level "glue" — swig/python

Star module

toy model
analytic calculation
lookup table
heuristic recipe
full simulation
(real star...)
...

stellar data

INTERFACE

initialization

mass, composition →

← star ID

ID, time

query

mass
radius
temperature
(structure)
...

ID Δt
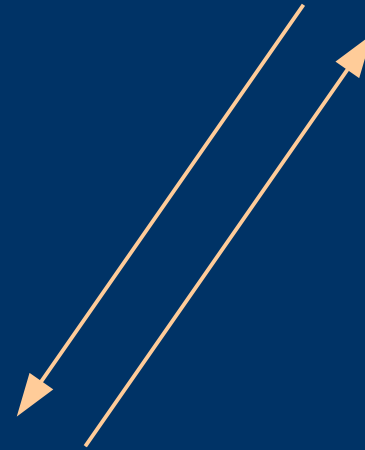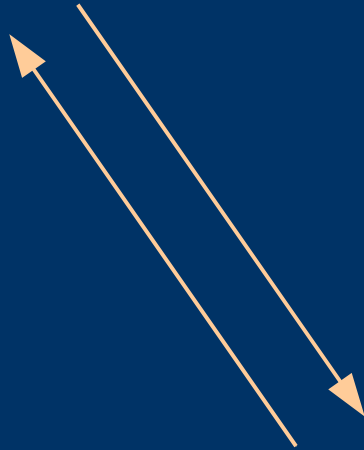
scheduling
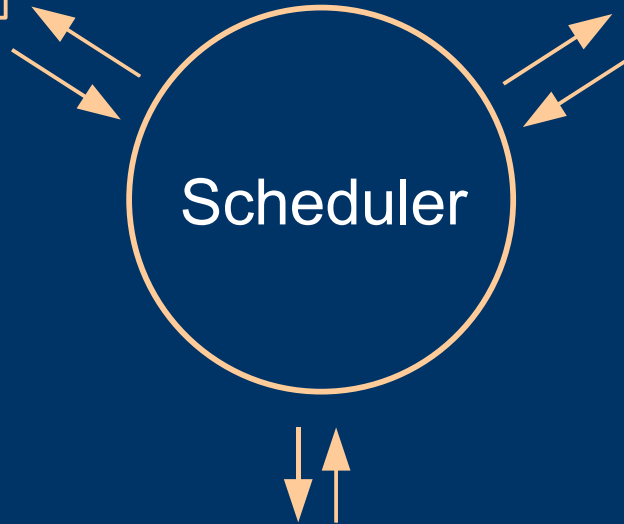
```python
import gravity.hermite.muse_dynamics as dyn
import stellar.EFT89.muse_stellar as star
import collisions.sticky_spheres.muse_hydro as coll
.
.     (initialization)
.
while time < t_max:

    time += dtime
    dyn.evolve_dynamics(time)
    star.evolve_stellar(time)

    for i in range(nd):
        id = star.get_stellar_identity(i)
        dyn.set_dynamical_mass(id, star.get_mass(id))
        dyn.set_dynamical_radius(id, star.get_radius(id))

    id1, id2 = dyn.get_colliding_pair()
    if id1 >= 0 and id2 >= 0:
        nd, ns = collide_stellar_pair(nd, id1, id2)

print "end at t = ", time, ", Ndyn = ", nd, ", Nstars= ", ns
```

MUSE Summary

- clean separation of functionality
- modular design encourages experimentation
- "easily" incorporates legacy code

- is it efficient?
- can it be extended to more complex physics?

- what other ways are there of interfacing programs and sharing data?

Program

- Morning

  9:00   MODEST and the MUSE project

  9:30   Common Component Architecture

              D. Bernholdt (Oak Ridge National Lab)

  10:30   coffee

  11:00   The Cactus Environment

              E. Schnetter (LSU)

  12:00   Frameworks for Climate Modeling

              V. Balaji (Princeton)

  1:00   lunch

- Afternoon

  2:30   Open discussion / demonstrations