SweGrid Seminar 2003-04-09

Radiation Hydrodynamics Simulations of a Red Supergiant Star

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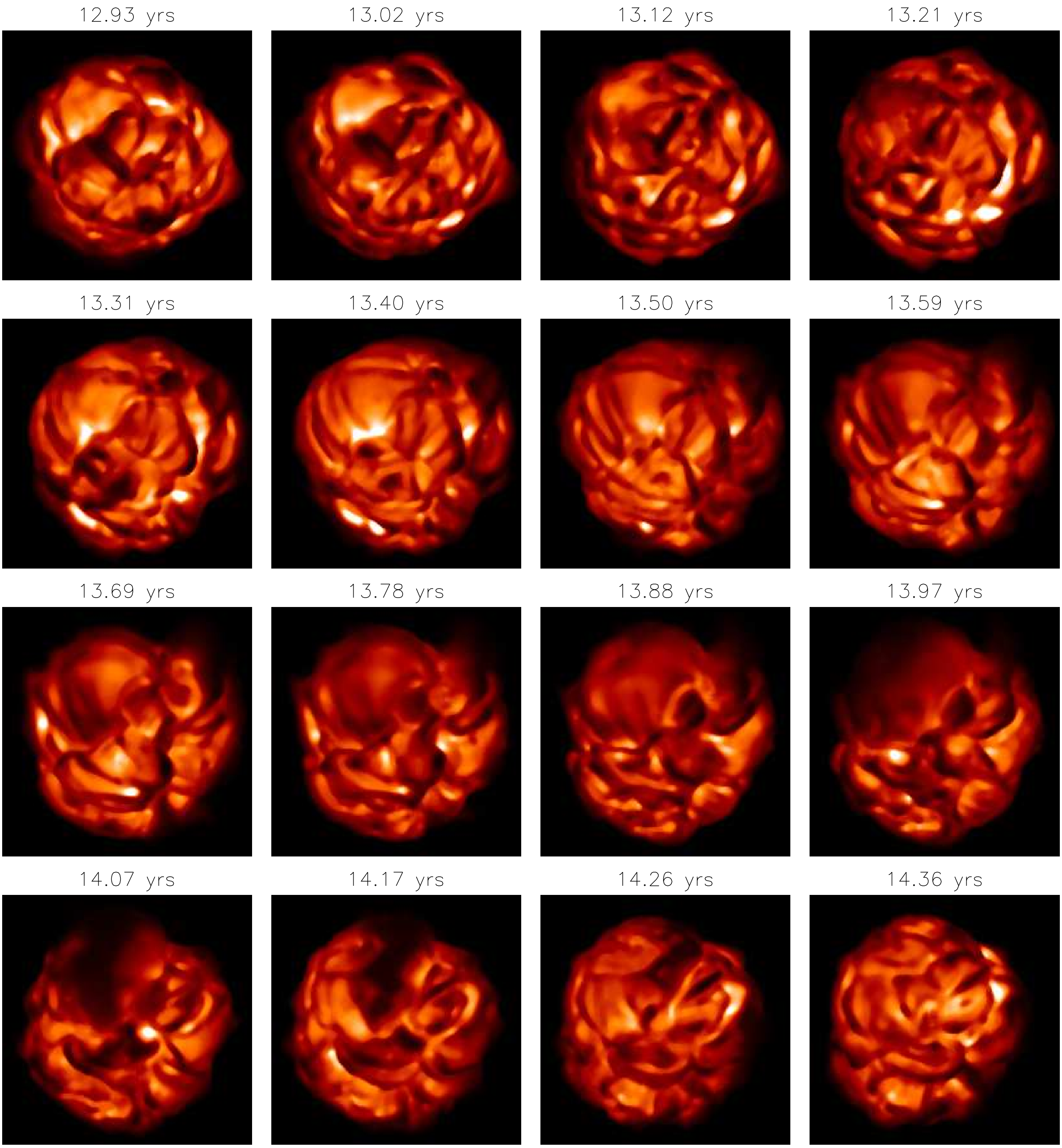
Envelope convection of a red supergiant

- Prototype: Betelgeuse in Orion
- Observations: brightness variations, “hot-spots”
- Explanation: giant stellar convection cells
- Open questions: reason for high velocities, shock formation, wind mechanism
- 3D radiation hydrodynamics simulations with CO^5BOLD

Intensity sequence



Properties of radiative transport

- Non-local coupling between (essentially) all grid points
- Detailed description of microphysics necessary
  (e.g. frequency-dependent opacities)

Types of radiative transfer calculations

- Stationary models, very detailed physics,
  huge memory requirements
- Time-dependent simulations, some detailed physics,
  moderate memory requirements

Problems of time-dependent simulations

- Hydrodynamics:
  - supersonic flows, shocks
  - strong gravity
  - ionization
- Radiation transport:
  - most CPU-time demanding part
  - non-local coupling
  - temperature sensitivity of opacity

Computational needs

- Computational resources per model:
  CPU-time: 3000 - 10000 PC hours
  primary memory: 0.3 - 2 GByte
  disk space: 10 - 40 GByte
- Inter-processor communication:
  MBytes/MFlops: Large
- Primary memory:
  $<$ 2 GByte/processor,
  64-bits only for large shared-memory machine
- Secondary storage:
  necessary: only during simulations
  convenient: years
- Data re-accessment frequency: depends
- Data bases: none
- Status of the software:
  existing and running: OpenMP version
  planned (if machine available): MPI version