Interesting problems in stellar astronomy

Stars for All in Lund
February 6-7, 2012

Bengt Gustafsson
Dept of Physics and Astronomy
Uppsala University
The virtues of stars

- Simplicity
- Calculability
- Separability
- Observability
- Multitude
- Diversity, Ranges
Ex: "Don’t we already know everything about Polaris?"
Nancy R. Evans (Science 249; 2000)

• 1832 – 1969: 82 papers with "Polaris" in title
• 1970 -- 1999: 79 papers
• 2000 - 2011: 87 papers

Cepheid, astrometric binary, Hipparcos parallax, interferometric diameter, dynamical mass: 4.5 M_{sun}

dP/dt = 4.5 ± 1.5 s/y. Evolution: > 15 s/y or < 1 s/y
Mass loss? 10^{-6} M_{sun}/y (Neilson et al., 2012)
X-ray and UV emission.
Solves evolution/pulsational mass discrepancy?
"Interesting problems"?

- for fundamental physics
- ... stellar physics
- ... interstellar medium physics
- ... planetary systems research
- ... Galactic astronomy
- ... galaxy research
- ... cosmology
- ... astrobiology
- ... climatology
Stars and fundamental physics

- Solar energy source
- Solar neutrino problem
- Origin of the elements
- Gravitational redshift, Double pulsar, Kerr metrics
- Dynamical systems, structure formation?
- Atomic and molecular physics
... stellar physics

**Massive stars**: VLT-FLAMES survey
(800 stars, Galaxy and MC:s)
http://star.pst.qub.ac.uk/~sjs/flames/
Rotational mixing/binarity ??
Hunter et al. (2010)
... stellar physics

**Massive stars**: VLT-FLAMES survey
(800 stars, Galaxy and MC:s)
http://star.pst.qub.ac.uk/~sjs/flames/

Rotational mixing/binarity ??

Magnetic fields? Formation? Mergers?
Winds? Clumps?
# of yellow supergiants?
LBV eruptions?
SNII explosions?
... stellar physics

**Solar-type stars:** Formation
(episodic accretion, fully mixed?)

Magnetic field: origin, effects --
  early, middle, late

Activity
  ”Diffusion”

Angular momentum
Late evolution: mixing, mass-loss

Single star PNe?

KEPLER, GAIA, Solar studies, ...
Melendez et al. (2009)
abundance vs cond. temp.

Baraffe & Chabrier (2010); episodic accretion models
... stellar physics

**Red and brown dwarfs**: Formation: IMF,
   Magnetic coupling disk/star
Denis, 2MASS, SDSS: > 1000 brown dwarfs
   L, T, Y (300-500K).
Magnetic activity: kgauss fields, different from solar
Thunderstorms?
Clouds in L atmospheres
Radigan et al. (2011)
... interstellar medium research

Linked to massive stars, in particular radiation fields, winds, SNe
... planetary systems research

Planet-host characterisation

Santos et al. (2005)

Considering stellar variability
… Galactic astronomy

Bensby et al. (2010)

"… we speculate on the origin of the Bulge and must conclude that it is still poorly constrained."
... galaxy research

Frebel (2011)
... cosmology

- Li abundances in old stars - Baryon content of the Universe
- Globular-cluster ages - Cosmic acceleration, Dark energy
- First stars - Reonization, galaxy formation
Melendez et al. (2010)

Spite & Spite (1982)
Pont et al. (1998)

M92

\[(m-M)_V = 14.67\]
\[E(B-V) = 0.02\]

\[[\text{Fe/H}] = -2.14\]
\[[\alpha/\text{Fe}] = 0.3\]
8(2)18 Gyr

\[\delta(B-V) = +0.012\]
Frebel et al. (2008)

Korn et al. (2009)
... astrobiology

- Why are we here?
  C from AGB:s? Mixing, mass-loss
... astrobiology

- Why are we here?
  - C from AGB:s? Mixing, mass-loss
  - N from more massive AGB:s?
… astrobiology

• Why are we here?
  C from AGB:s? Mixing, mass-loss
  N from more massive AGB:s?
  O from SNII. Explosions?
• Why are we here?
  C from AGB:s? Mixing, mass-loss
  N from more massive AGB:s?
  O from SNII. Explosions?
  Sun any special?
… astrobiology

- Why are we here?
  C from AGB:s? Mixing, mass-loss
  N from more massive AGB:s?
  O from SNII. Explosions?
  Sun any special?
  "Faint-sun paradox"??
... astrobiology

- Separating planetary spectra

![Simulated spectrum of a transiting planet atmosphere](image-url)
… climatology

- Solar variability
- Solar activity
- Solar wind,
  CME:s, …
Interesting problems?

• *There are some left*
Interesting problems?

There are some left FOR YOU!