The evolution of chemically peculiar stars

Martin Netopil
Masaryk University, DTPA, CZ

Brussels, May 5th., 2015

What are CP stars?

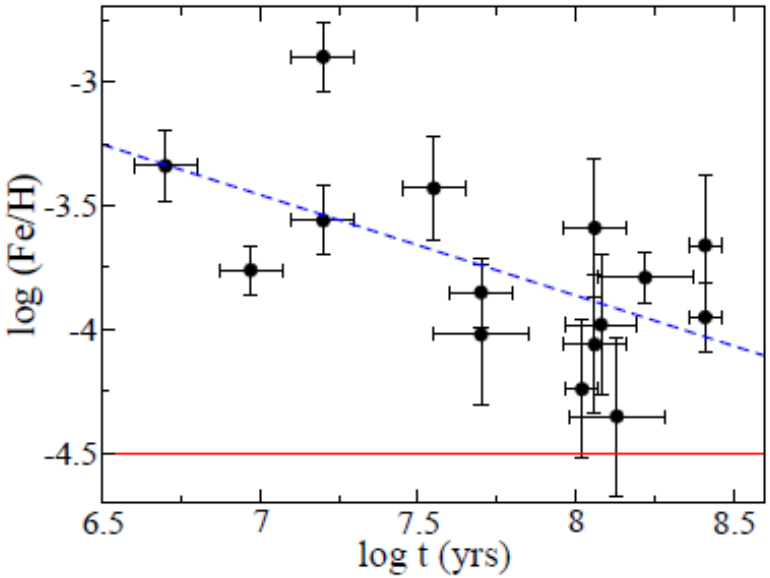
- ☒ discovery in 1897 by Antonia Maury
- ☒ show peculiar and often variable line strengths
- ☒ some groups (**CP2, CP4**) show **strong magnetic fields** (up to 40 kG !)
- ☒ **overabundances for heavy elements** such as Silicon, Strontium, …
- ☒ stable spots (e.g. Si) on the surface
- ☒ **slow rotation**
- ☒ current known incidence ~ 5 - 10% of B to F type stars

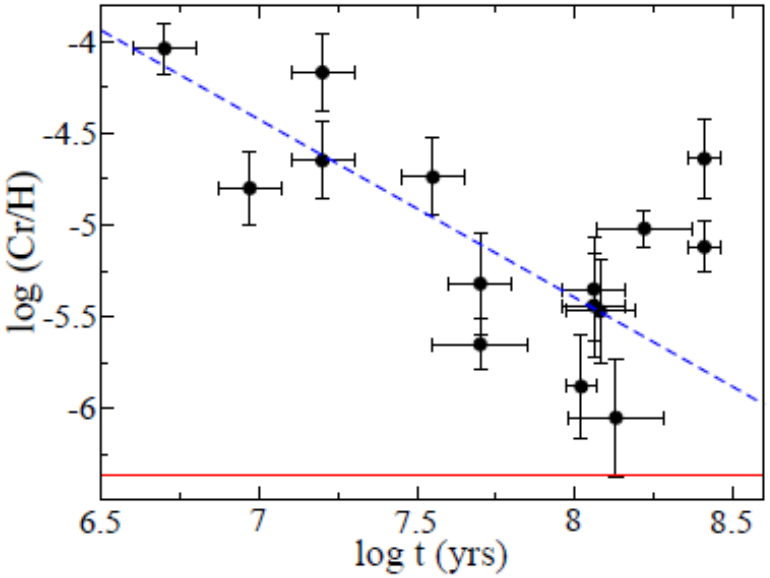
there are also several other CP groups: Am, HgMn, …

This talk deals mainly with the magnetic CP groups (a.k.a. Bp/Ap, mCP)

Evolutionary properties

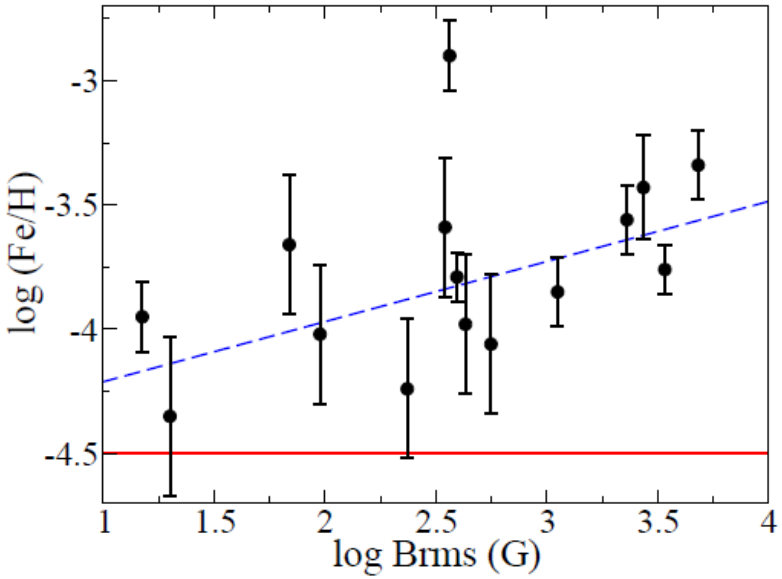
The evolution of abundances and magnetic field strengths





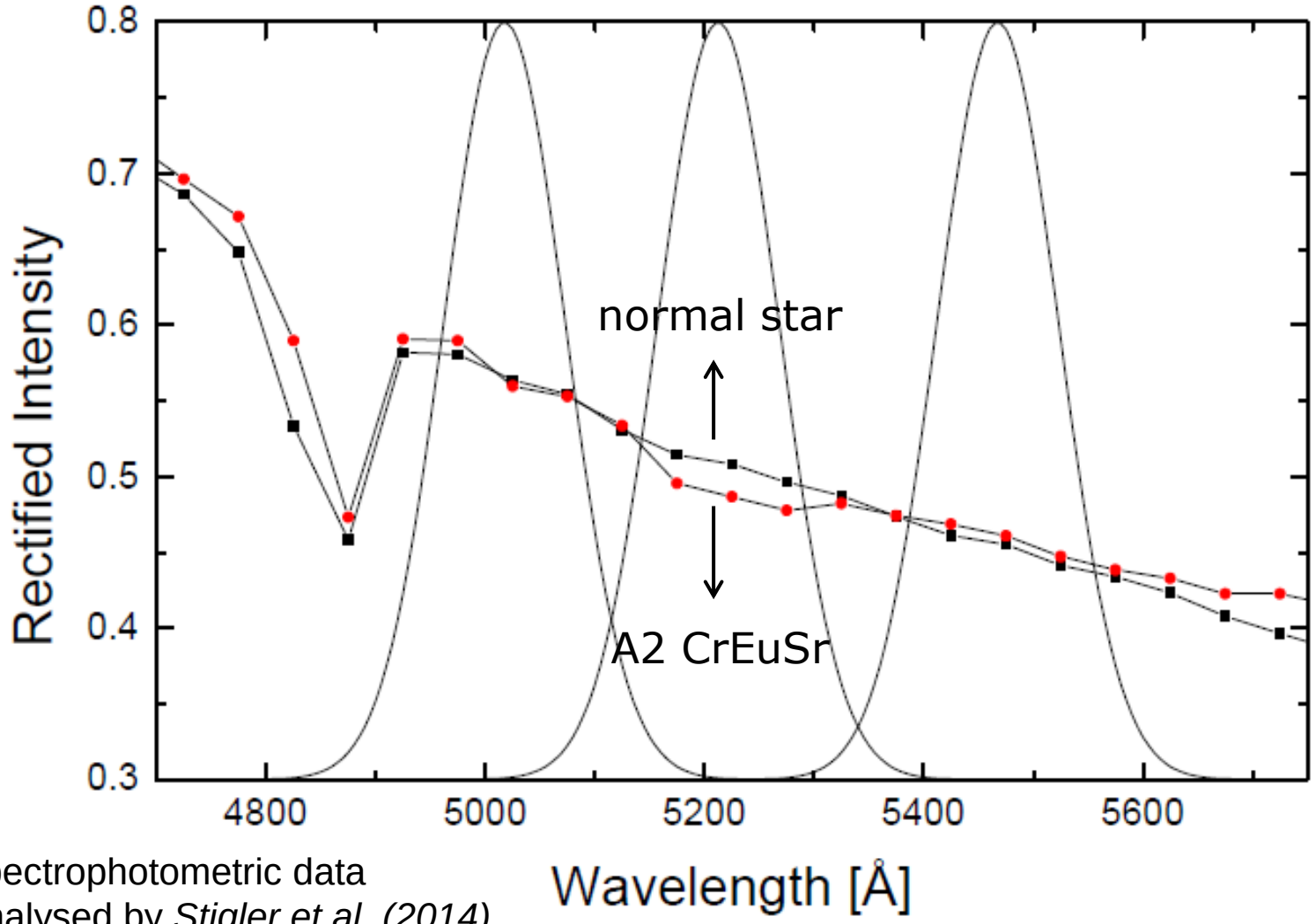
Bailey et al. 2014:
using main-sequence cluster stars in the mass range 3-4 M⊙

decline of magnetic field strength with age already found by *Landstreet et al. 2007*



CP star detection - The Δa photometric system

Δa is a three filter intermediate band
photometric system introduced by *Maitzen 1976*



spectrophotometric data
analysed by *Stigler et al. (2014)*

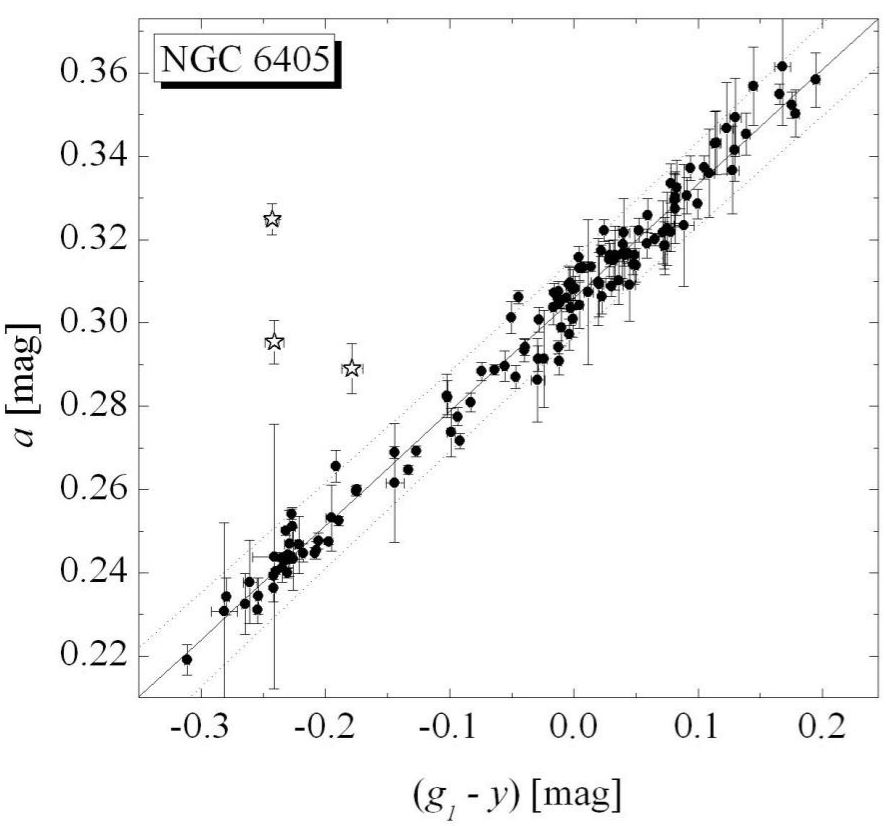
The Δa photometric system

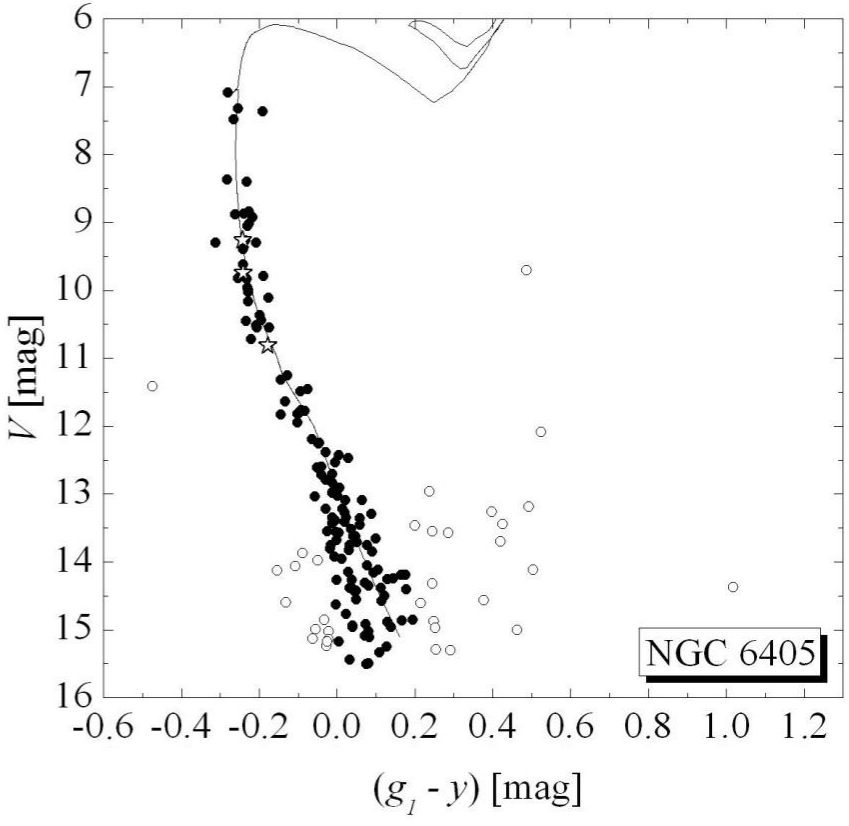
assuming that all stars exhibit the same interstellar reddening, peculiar objects deviate from the „normality line“ by more than 3σ.

$$a = g_2 - \left(\frac{g_1 + y}{2} \right)$$

$$\Delta a = a - a_0$$

about 95% of the magnetic CP stars
can be detected with Δa (*Paunzen et al. 2005*).

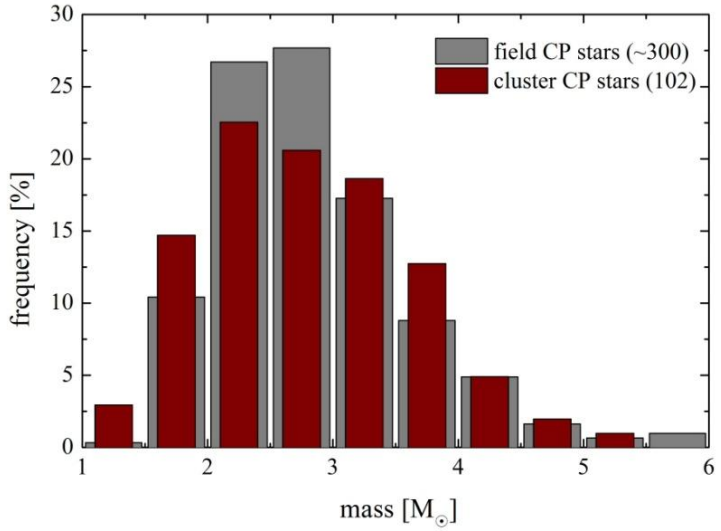




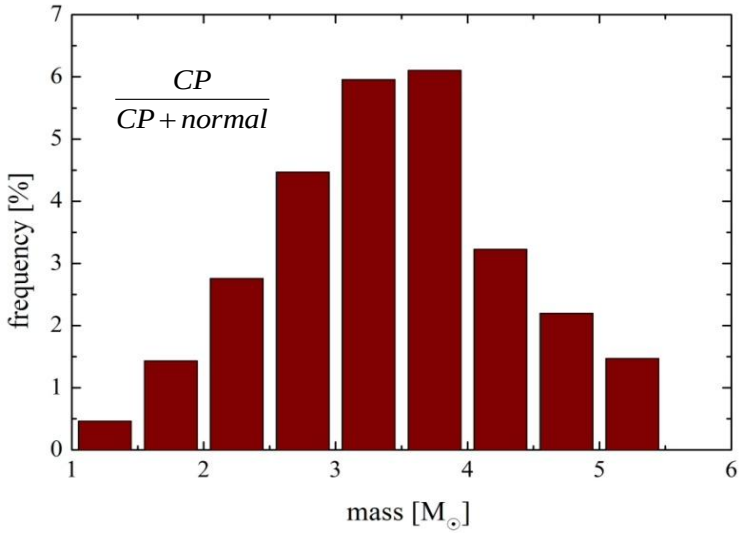
CP mass distribution

Netopil et al. 2015 (in prep.)

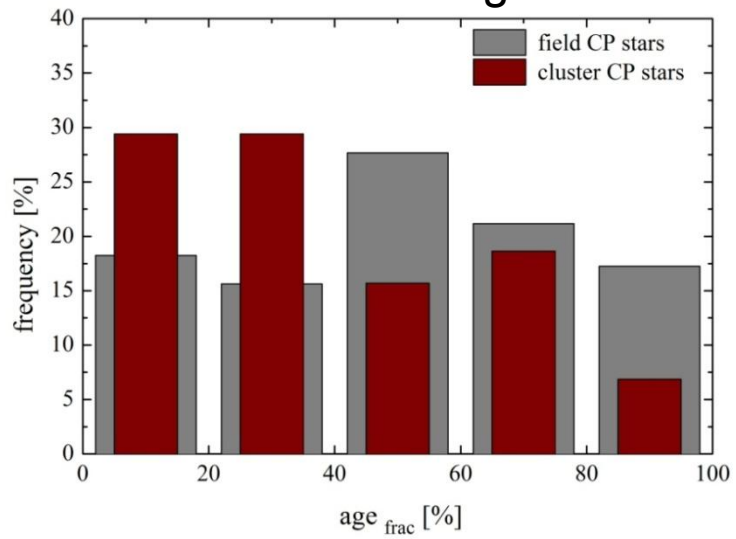
mass distribution



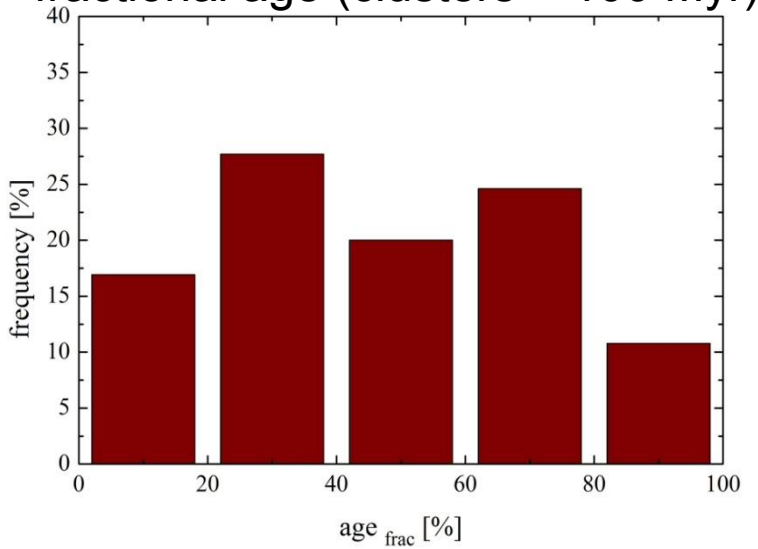
CP stars in relation to normal cluster stars



fractional age

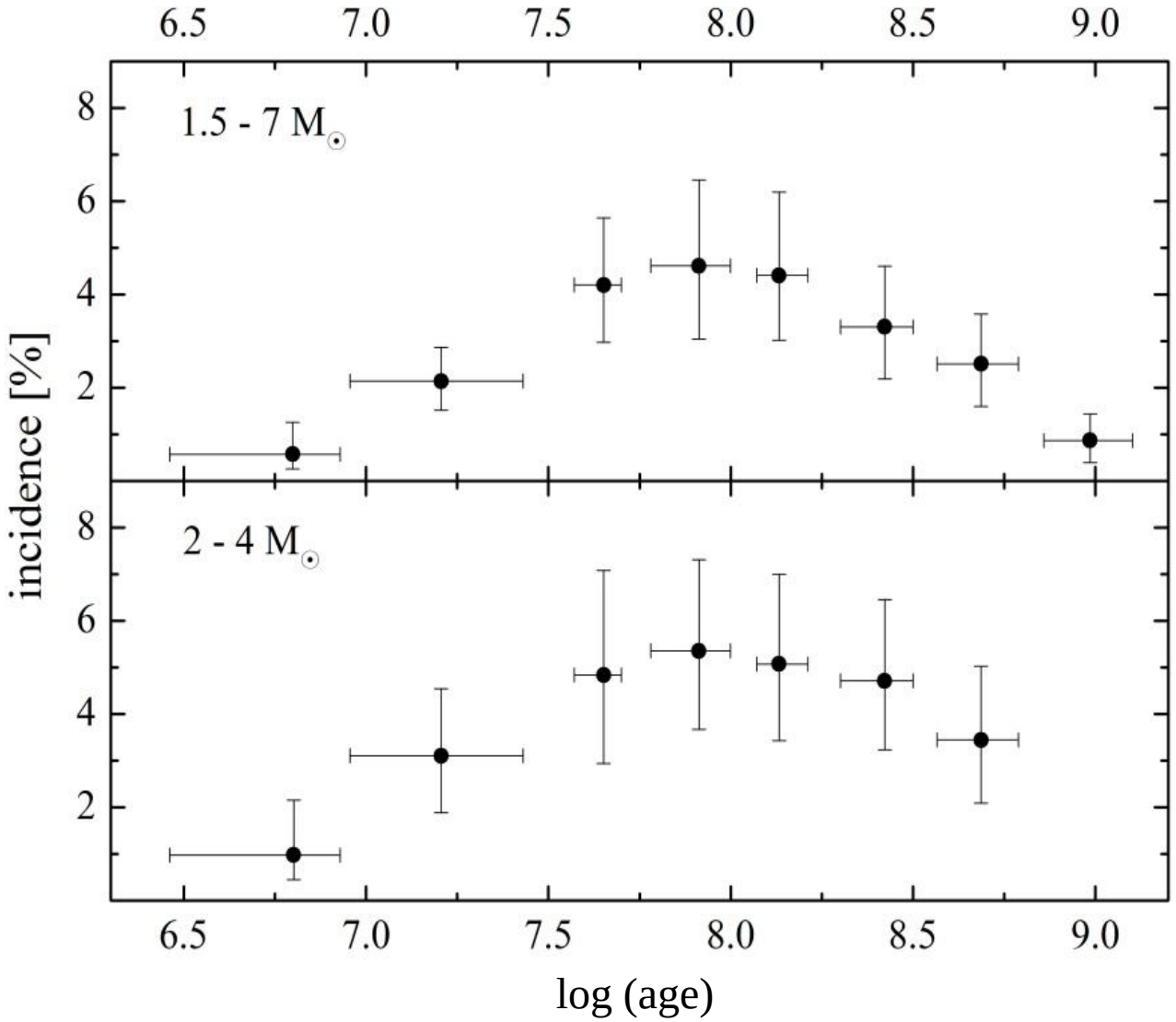


fractional age (clusters > 100 Myr)



CP incidence vs. age

8 age groups defined (each consists of 7-14 clusters)
only MS stars (normal + peculiar)



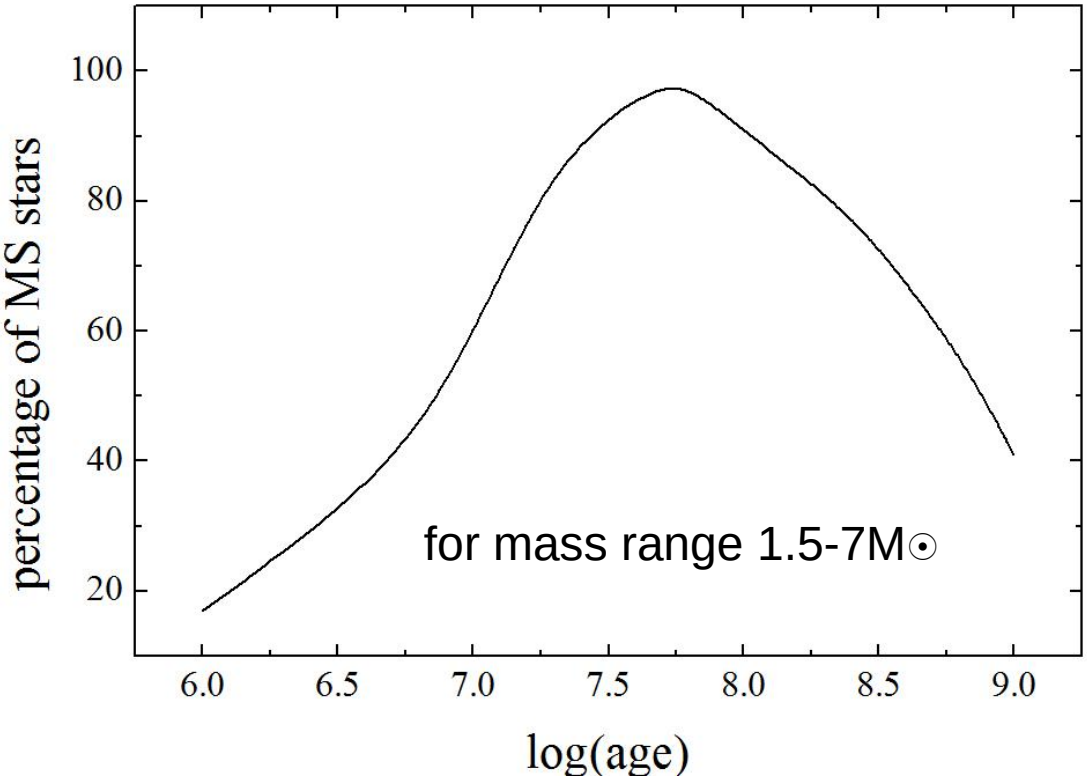
CP incidence vs. age

intrinsic evolution or not?

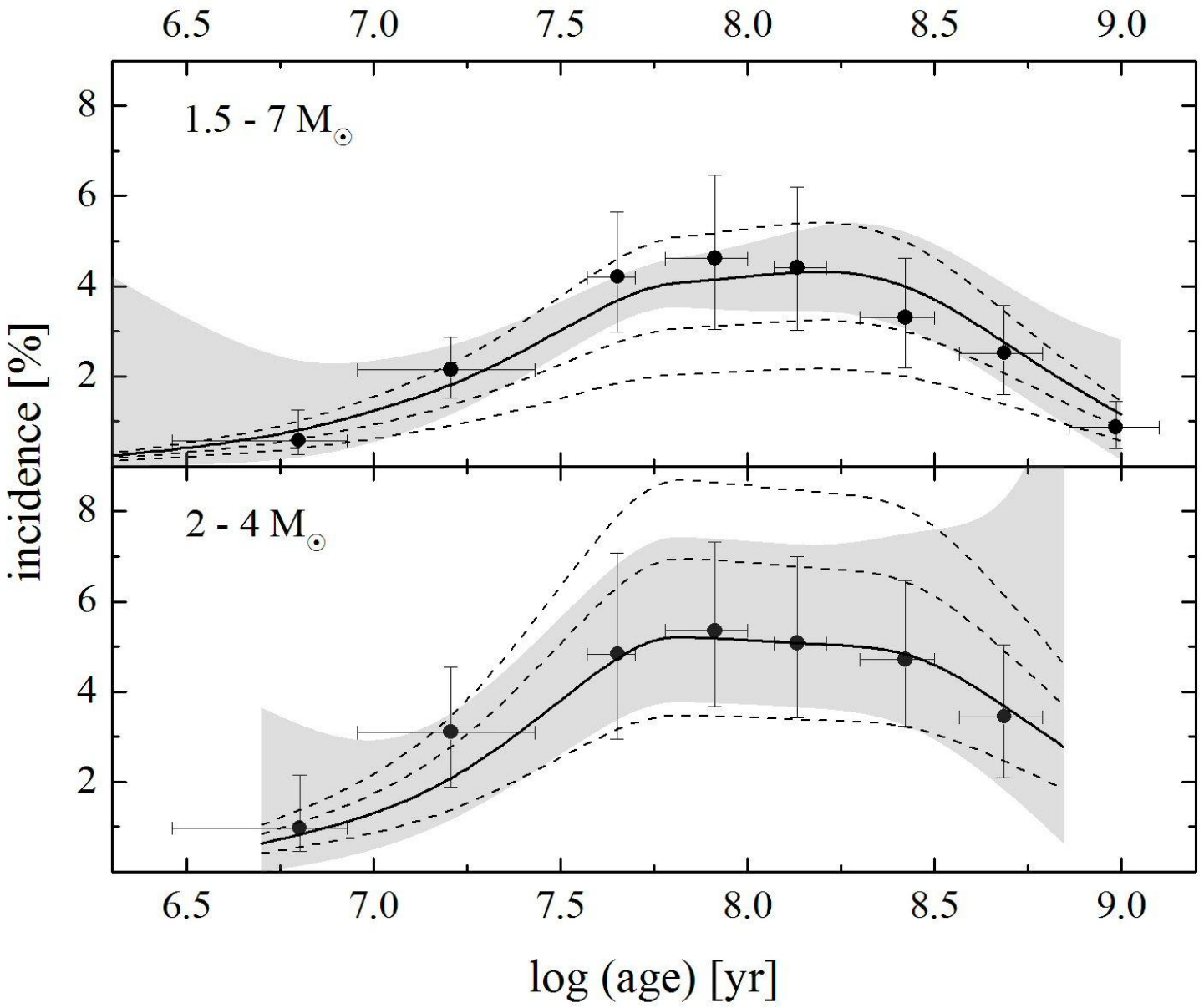
let‘s try to calculate a kind of „semi-theoretical“ CP frequency

based on stellar evolutionary models, and observed CP distribution (mass, fractional ages)

+ „simulated“ cluster evolving in time (IMF + evolutionary models)



CP incidence vs. age



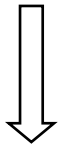
first summary …

due to agreement between observed and „theoretical“ CP incidence, the last assuming a fixed number of CP stars for all ages …

⇨ no intrinsic evolution of CP content, it is just a result by CP mass distribution and stellar evolution

⇨ CP stars should be „developed“ as they arrive ~ on the MS (or even before) and remain peculiar at least until the end of MS

⇨ further strong hint of fossil origin for the magnetic field



magnetic fields in Herbig Ae/Be already found
(~ 7%; *Alecian et al. 2013*)

The first PMS Am star

1 mCP candidate detected in the very young (~3-8Myr) open cluster Stock 16 (Δa = 24 mmag; V ~ 13.4mag)

low resolution spectra were inconclusive

next step: high-quality spectroscopic data

3 UVES spectra + 1.7h @ FORS2

⇨ Am star!!!; no magnetic field (<Bz> -11 ± 76) – *Netopil et al. (2014)*
Δa was influenced by strong differential reddening

Am stars are commonly found in close binary systems …
but radial velocities obtained at three epochs agree ± 1km/s

⇨ single star, unless it is a very wide binary system

PMS nature confirmed by IR-Excess, massive interstellar absorption lines, cluster membership, position in HRD

How GES can contribute?

GES will cover ~100 open clusters

⟹ more „direct“ tracing of the CP star evolution

- detection of stars with weak(er) peculiarities
- can identify/exclude other peculiar objects
- improving evolution of elemental abundances
- Am star incidence vs. Age is not known
- better cluster membership (radial velocities)

⟹ detection of very young CP stars / diffusion theory

- photometry influenced by diff. reddening and emission in PMS stars
- thus, GES can significantly contribute to a better understanding and to improve models

SCYON – The Star Clusters Young and Old Newsletter

A Newsletter devoted to stellar clusters
(open clusters, globular clusters, associations, in the Milky Way and beyond)

edited by Giovanni Carraro, Martin Netopil, and Ernst Paunzen

http://www.univie.ac.at/scyon

currently 4 issues per year, next one mid of May

some GES cluster papers were submitted to SCYON, but by far not all …