Search for pulsations in HgMn stars with CoRoT

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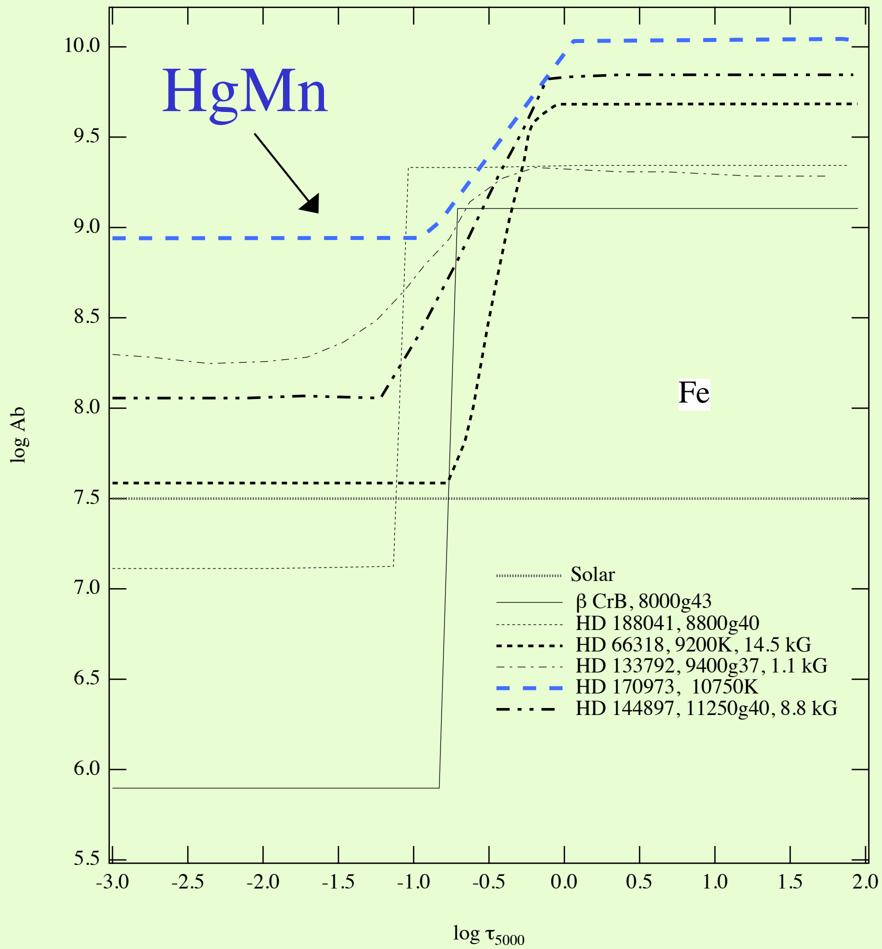
HgMn stars main properties

- **Main sequence stars (late B-type) chemically peculiar stars (CP)**
- **Supposed to be rather quiet stars:**
  - Very slow rotation
  - Sharp lines
  - No superficial convection zone
  - No detection of magnetic field (very weak field?)
  - Not classified among variable stars
  - More often binaries than “normal” stars.
- **Abundance stratifications due to atomic diffusion**

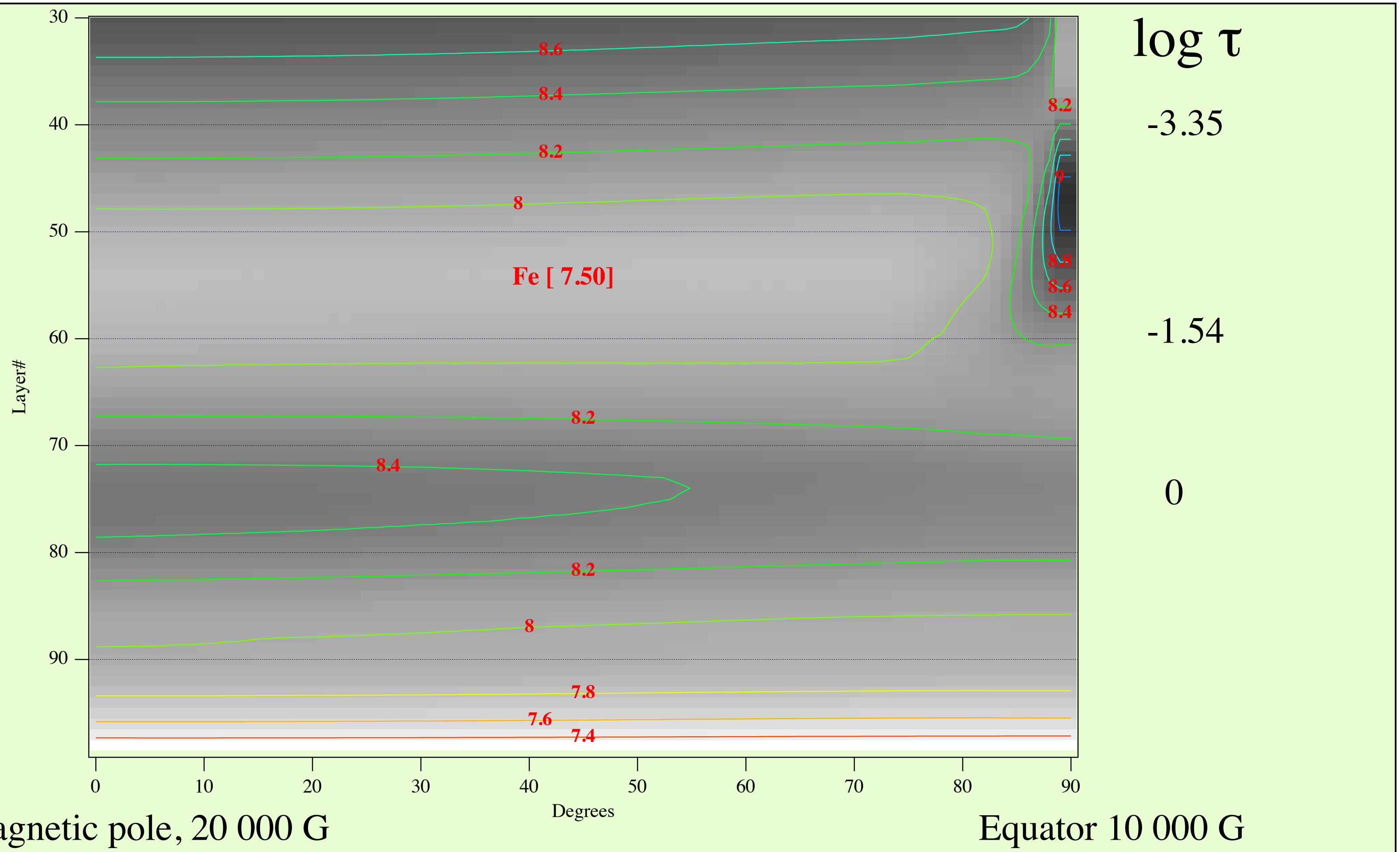
Stratifications of elements in atmospheres



(Levels of overabundances are possibly overestimated. Stift et al 2010)

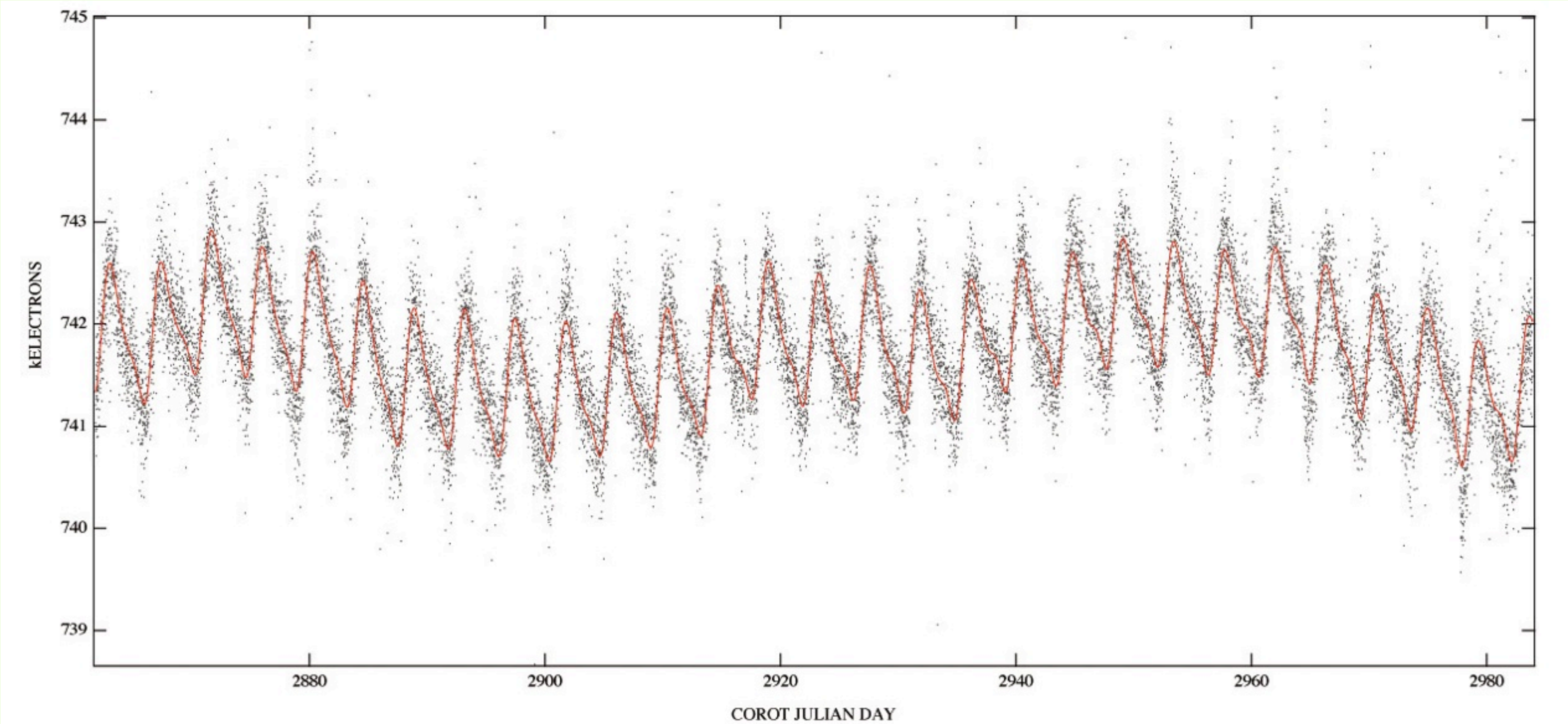
Compilation of Fe stratifications determined from the spectra of six CP stars (compilation by Ryabchikova 2008)

Bi-dimensional stratification of Fe (calculated, equilibrium) in magnetic Ap stars. Dipolar field. (Alecian & Stift 2010)



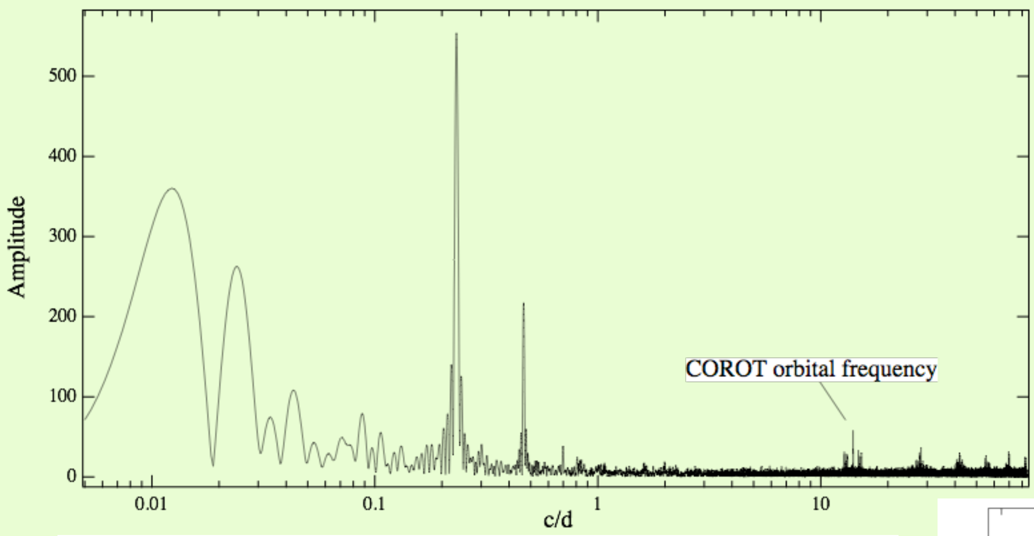
A CoRoT signal !

(Alecian, Gebran, Auvergne, Richard, Samadi, Weiss, Baglin, A&A 2009)



Lightcurve from the "exofield" Amplitude ≈ 1.6 mmag

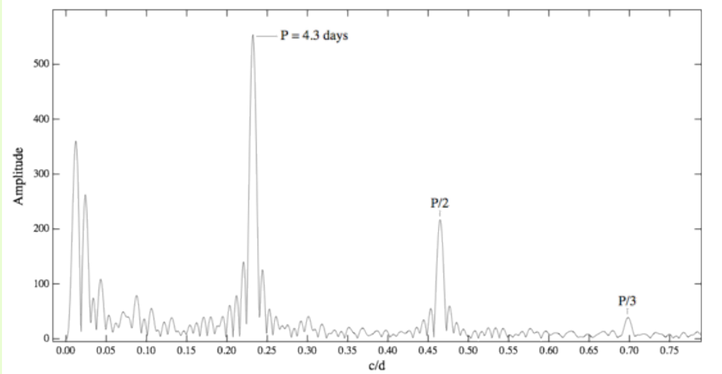
Frequencies from the CoRoT lightcurve



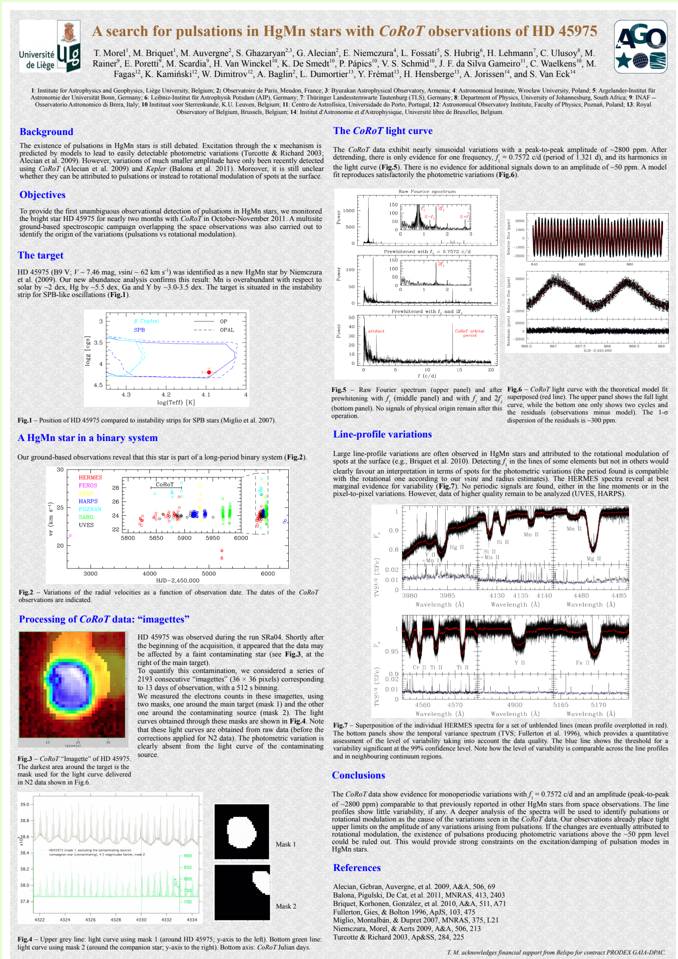
USNO-A2: 0825-03036752
$T_{eff} \approx 13500K$, log g≈4
(HgMn)

Rotational modulation cannot be excluded !

N	c/d	μHz	Ampl.	Phase	Period (days)
1	0.0114	0.132	413.9	0.7943	88.007
2	0.0146	0.169	106.3	0.8962	68.412
3	0.0251	0.290	174.6	0.0849	39.880
4	0.0436	0.505	74.1	0.7371	22.913
5	0.0877	1.015	73.5	0.4033	11.401
6 (P)	0.2324	2.689	552.9	0.9211	4.304
7 (P/2)	0.4648	5.379	212.7	0.6286	2.152
8 (P/3)	0.6982	8.081	37.1	0.5796	1.432



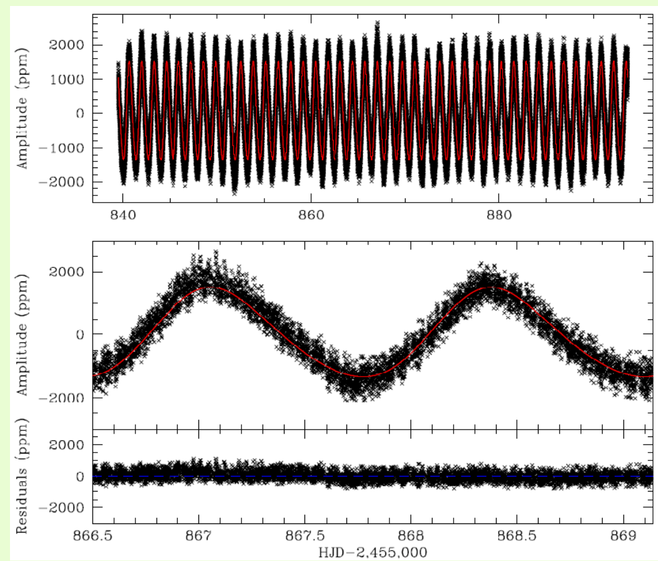
New results for HD 45975 (HgMn)



See the poster:

A search for pulsations in HgMn stars with CoRoT observations of HD 45975

(Morel et al. 2013)



f = 0.7572 c/d (1.321 d)

$T_{eff} \approx 12500$K

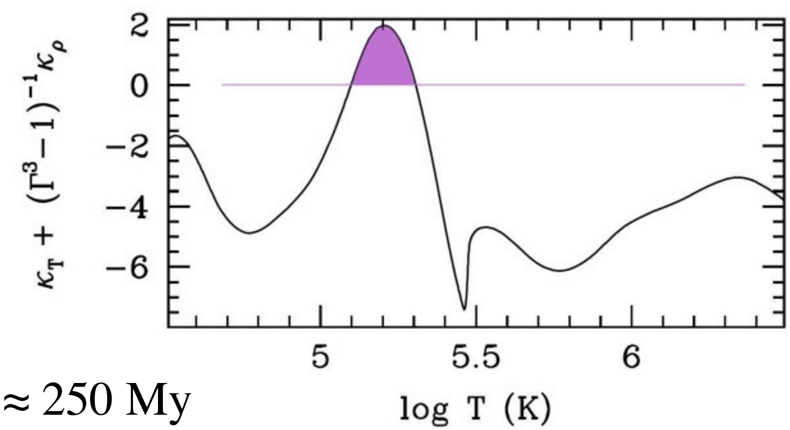
Not all the HgMn stars!

The case of HD 175640
bright B9-V type star with 6.21 apparent magnitude. It was well identified as belonging to the HgMn group and studied in detail through high resolution UVES-VLT spectra by Castelli & Hubrig (2004).

It was observed by CoRoT astero channel during SRc02 (2008). No significant signal above the noise level *(Ghazaryan et al 2013, submitted)*

Pulsations ?

Model of Turcotte & Richard 2003:
Oscillations could be driven by ϰ-mechanism, as for SPB stars.
But, it is not clear whether HgMn stars are really inside the SPB instability strip, because of abundance stratifications deep inside the star (which change with the age due to atomic diffusion). This numerical model has to be improved.



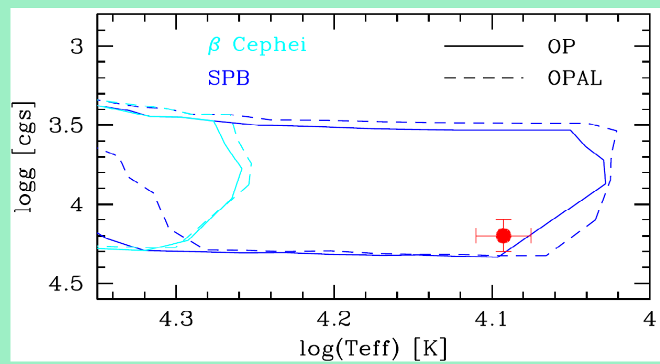
≈ 250 My

Fig. 14. Logarithmic opacity derivatives vs temperature for the 4.0 $M_\odot$ model at the same age as in Fig. 13.

$$\kappa_T = (\partial \ln \kappa / \partial \ln T)_\rho \text{ and } \kappa_\rho = (\partial \ln \kappa / \partial \ln \rho)_T$$

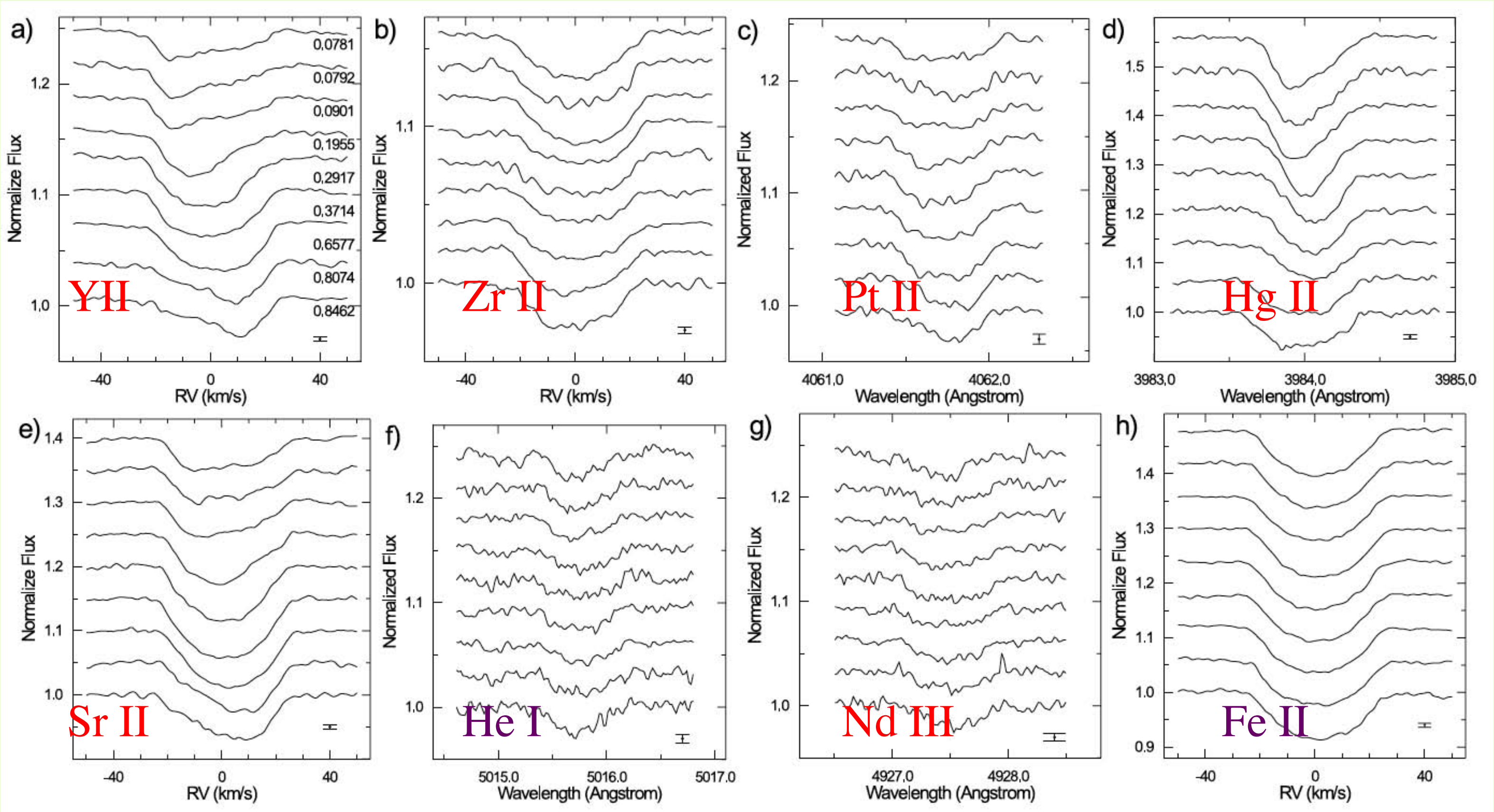
Other theoretical models are carried out for homogeneous Z ! *(Miglio et al. 2007)*

Fig. from Morel et al. 2013 (poster)



Spots ?

Hubrig et al. 2006 (eclipsing binary AR Aur, primary:HgMn)



Another case of a HgMn star with spots

HD 11753 : *Briquet et al. 2010*

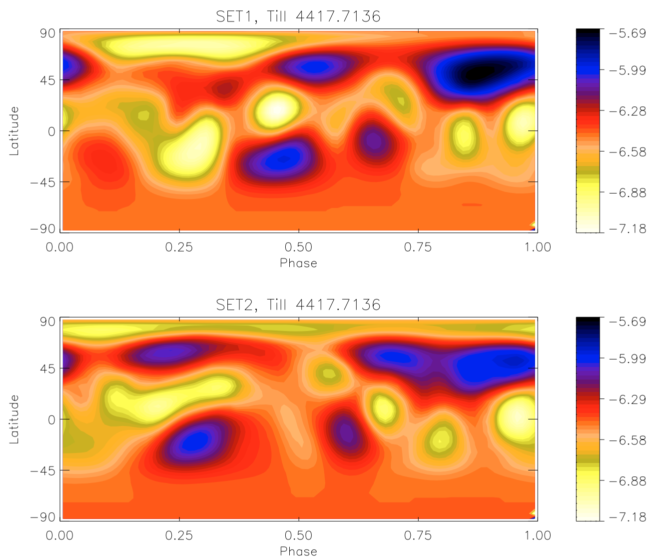


Fig. 4. Ti abundance map of HD 11753 obtained from Ti II line 4417.7136 Å for set1 and set2. The colour indicates the abundance with respect to the total number density of atoms and ions.

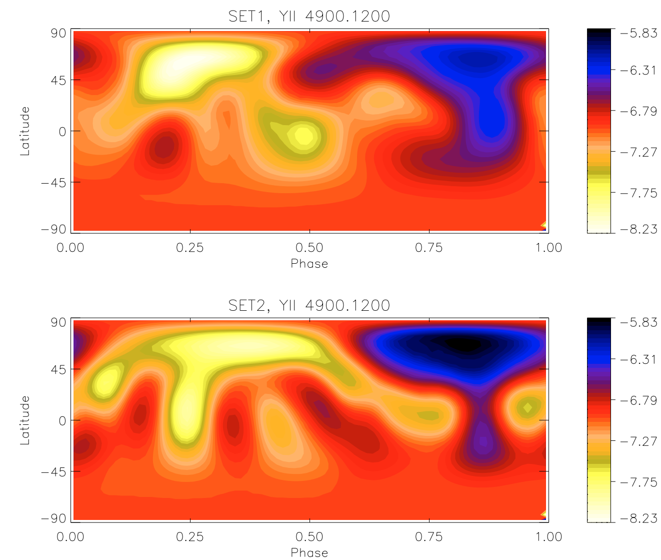
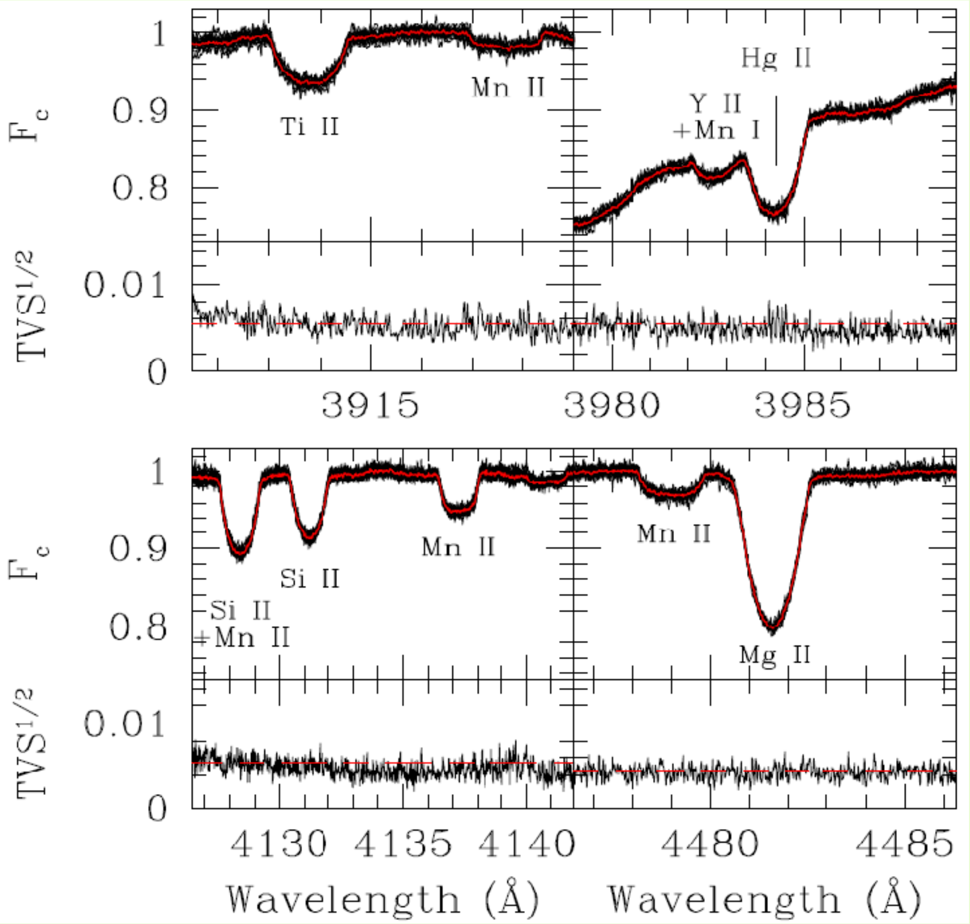


Fig. 5. As in Fig. 4, but now using the Y II line 4900.1200 Å.

Ti [⊙ $N(Ti)/N_{tot}$= -7.02]

Y [⊙ $N(Y)/N_{tot}$= -9.8]

HD 45975 *(Morel et al. 2013, the poster)*



UVES spectra

No variation

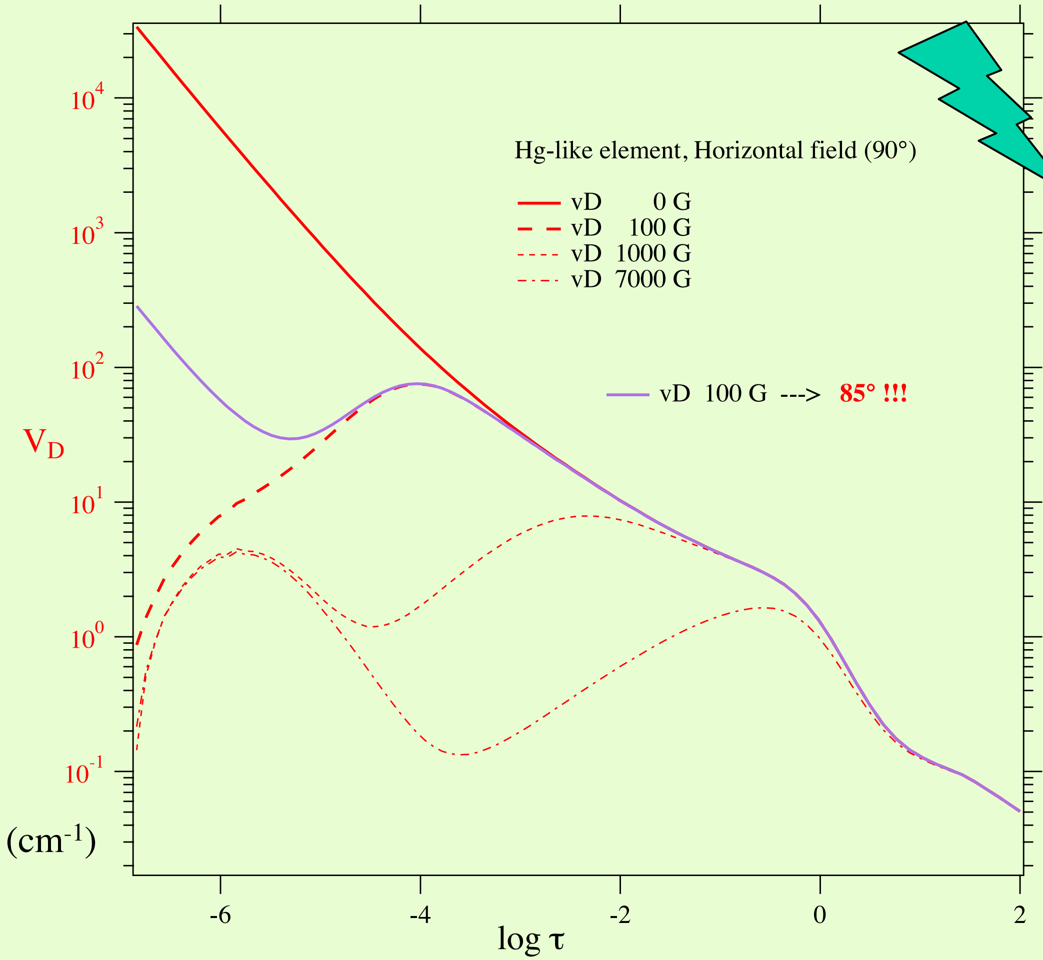
inside these lines

Spots seem to exist, but…

Spots exist in upper layers of some stars HgMn, but :

- No spots detected on HD 45975 (Morel et al. 2013), so spots are not a general property of HgMn stars.
- Such spots of Y or Hg like-elements can they explain the photometric variations observed in the star discussed by Alecian et al. 2009, and in HD 45975 (even if there were spots)? :
    - different phases from line to line,
    - amplitude problem.

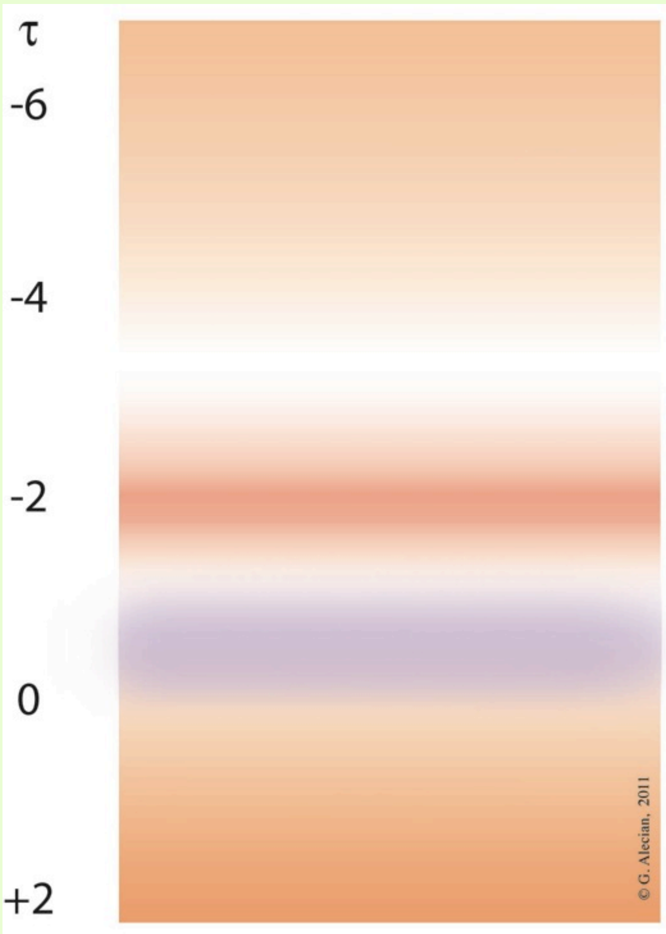
Diffusion velocity, with and without **B**

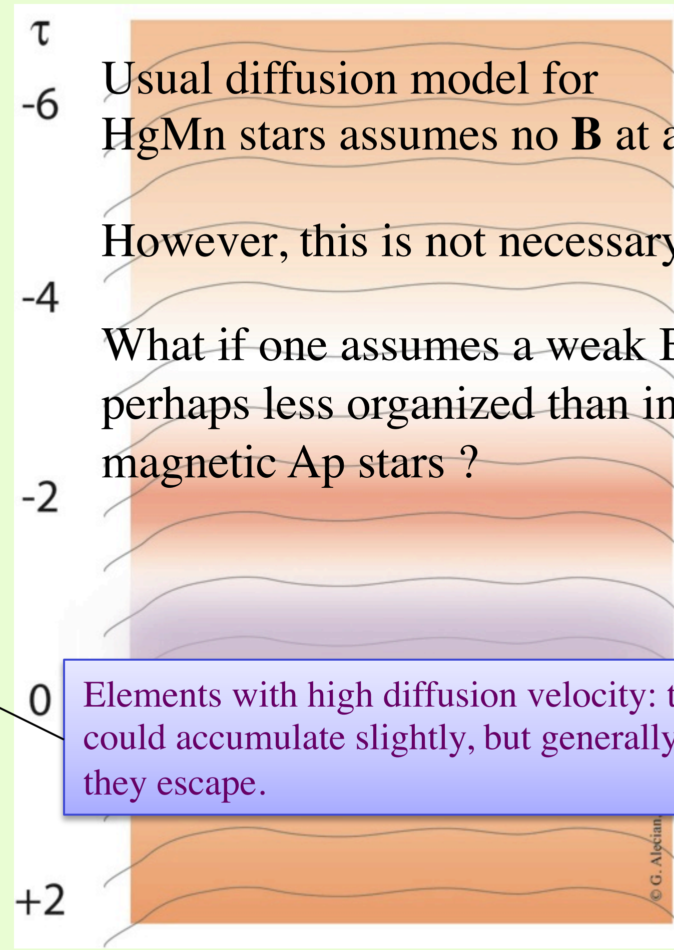


Weak fields (<100G) have effect above $\tau \approx 10^{-3}$!

The maximum effect of **B** is for angles VERY close to 90° !

HgMn star with weak, unorganized **B** ?





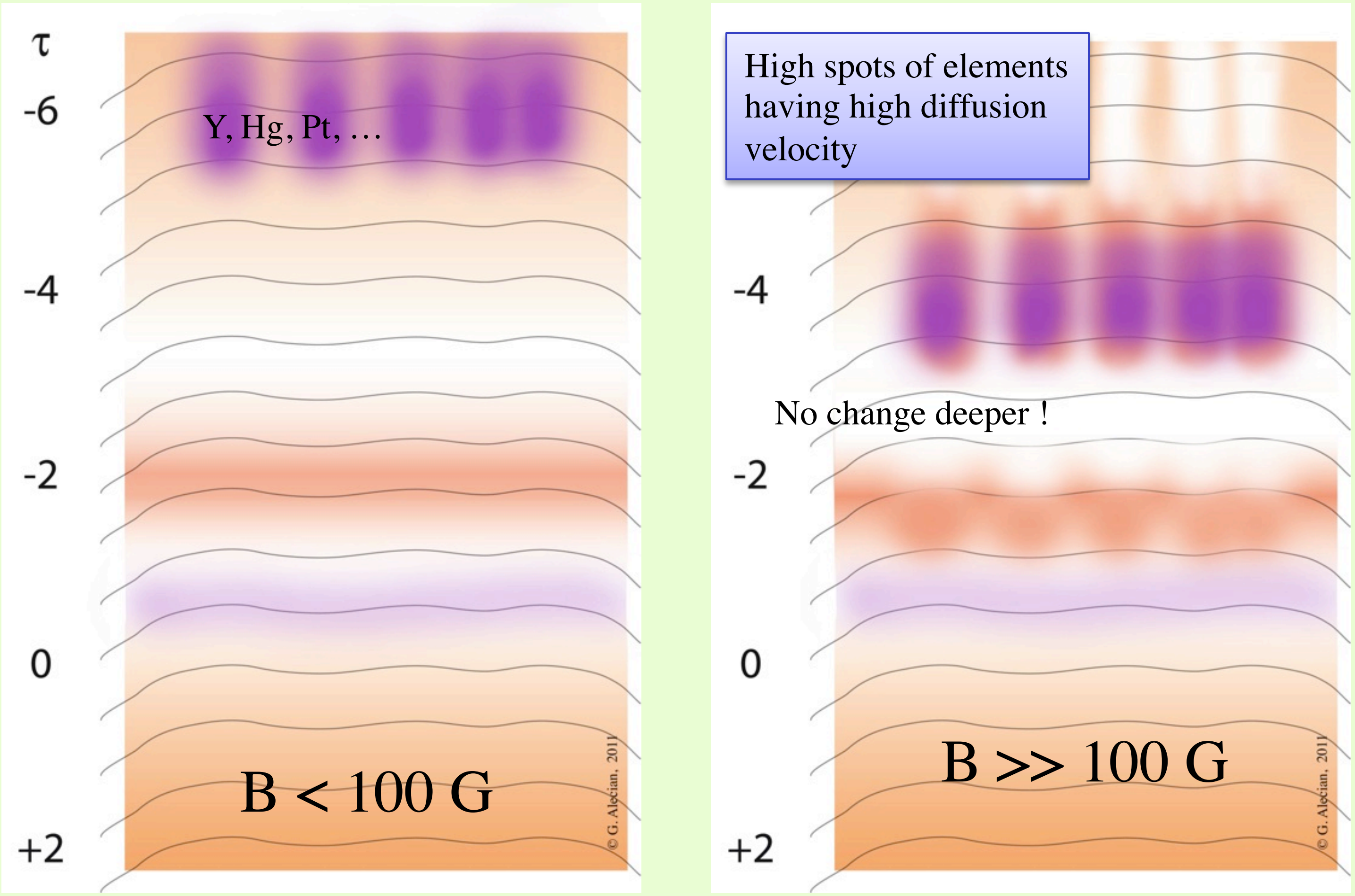
Usual diffusion model for HgMn stars assumes no **B** at all.

However, this is not necessary !

What if one assumes a weak B, perhaps less organized than in magnetic Ap stars ?

Elements with high diffusion velocity: they could accumulate slightly, but generally they escape.

With magnetic fields



Conclusions

- Photometric variations, P ≈ 1 to 5 days in some HgMn stars.

- Pulsations (SPB type) or spots (rotational modulation)?

- Smooth stratifications of abundant metals (iron peak) can coexist with high and spotty clouds of heavy elements. But, are such spots able to produce the observed photometric variations ?
    - ✓ my feeling: rather no ➔ pulsations

- Atomic diffusion in weak B, with clouds formation :
    - ✓ explains small variations in the centre of some spectral lines,
    - ✓ high altitude clouds could be unveiled by propagating waves *(Mkrtichian et al. 2008)*.

Diffusion timescale in atmospheres