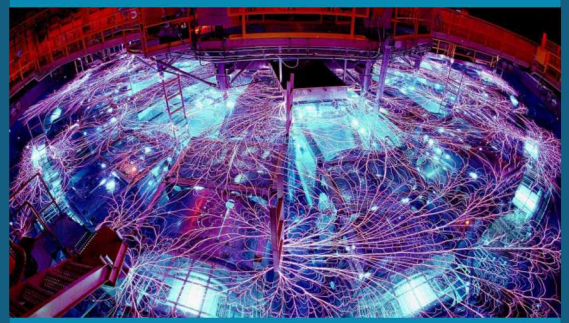
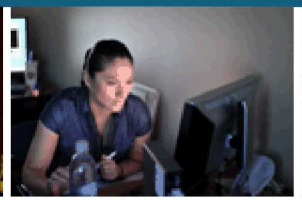
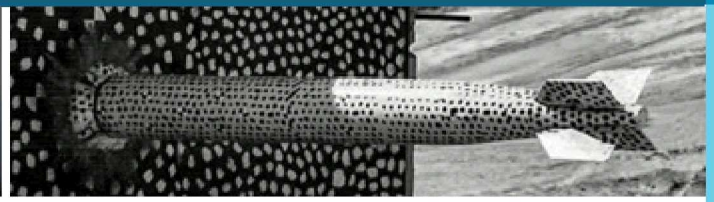
SAND2019-12382C

Laboratory measurements of discrepancies between Hβ and Hγ absorption line profiles at the conditions of White Dwarf photospheres







PRESENTED BY

M. Schaeuble, T. Nagayama, J.E. Bailey, T. Gomez, M. Montgomery, D.E. Winget

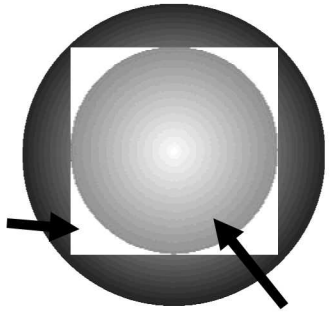
APS DPP, Fort Lauderdale

10/23/2019

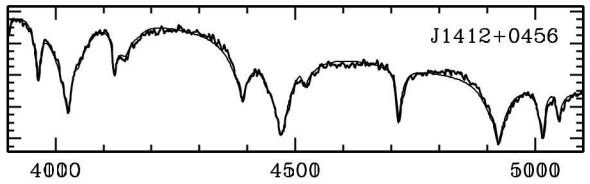
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Stellar evolution and the age of the universe can be constrained using White Dwarf (WD) stars

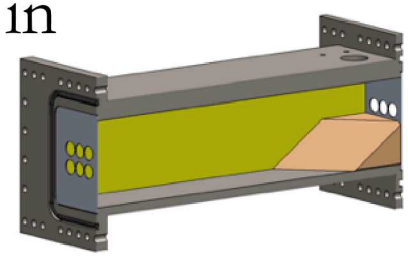
- Applying WD to astrophysical problems requires accurate stellar masses



- The main mass determination methods have deficiencies

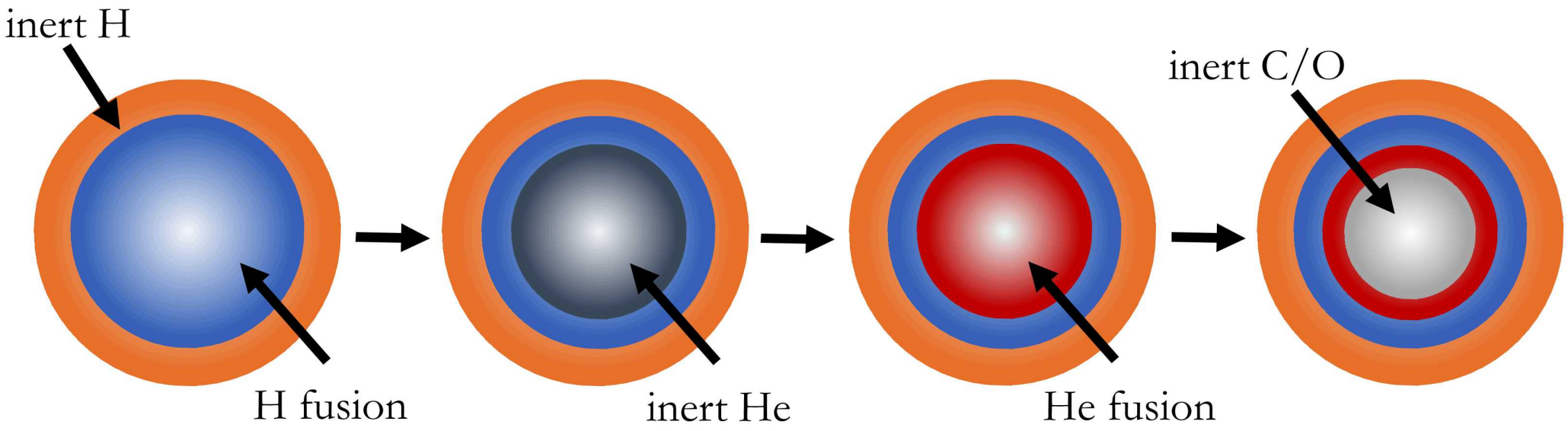


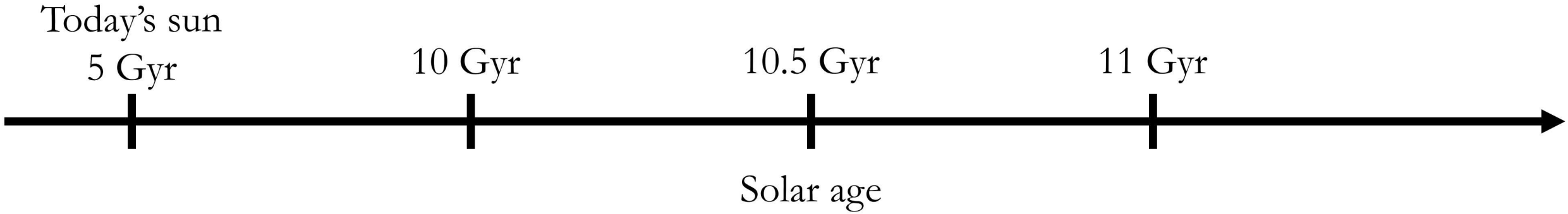
- Z-machine experiments enable scrutiny of constituent atomic physics in WD mass determination methods



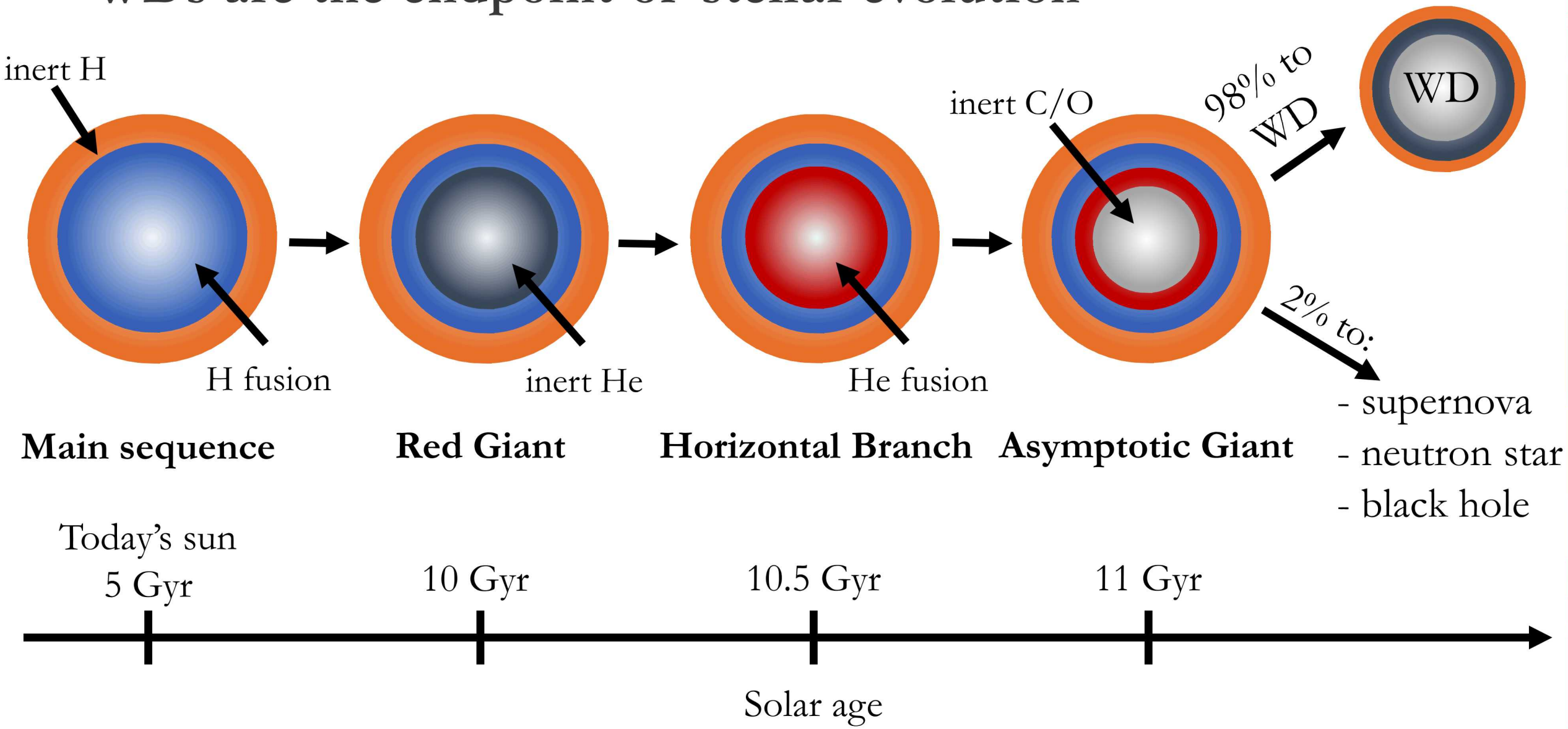
Z-machine data have highlighted deficiencies in the atomic data used for WD mass determination methods.

WDs are the endpoint of stellar evolution



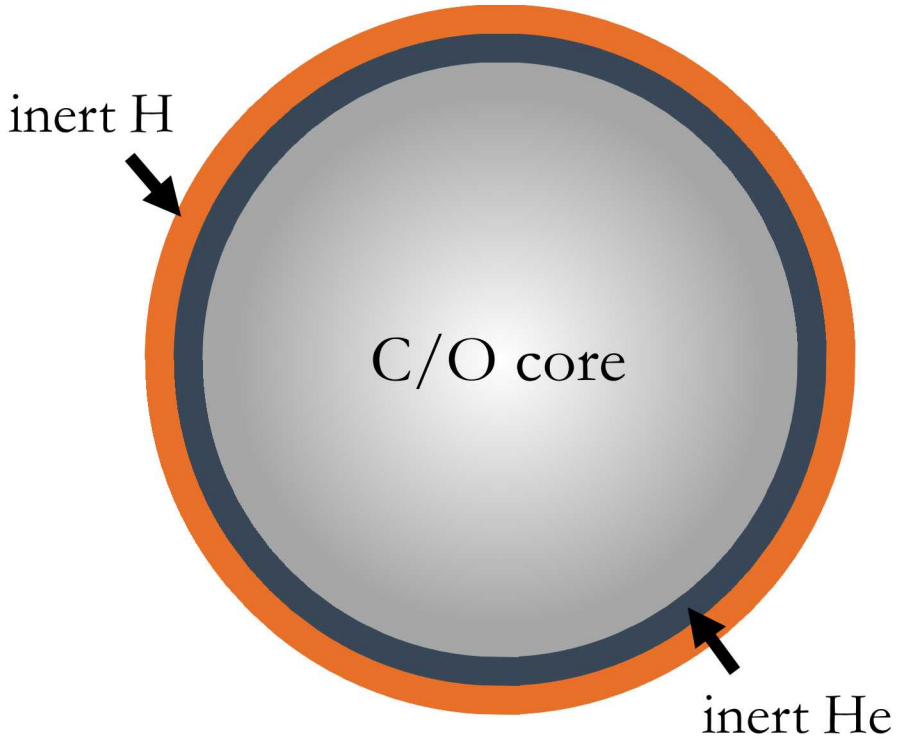


WDs are the endpoint of stellar evolution



Hydrogen WDs are the most common endpoint of stellar evolution

Hydrogen atmosphere WD



Typical hydrogen WD parameters:

Surface temperature (T_{eff}): 10,000 K (~1 eV)

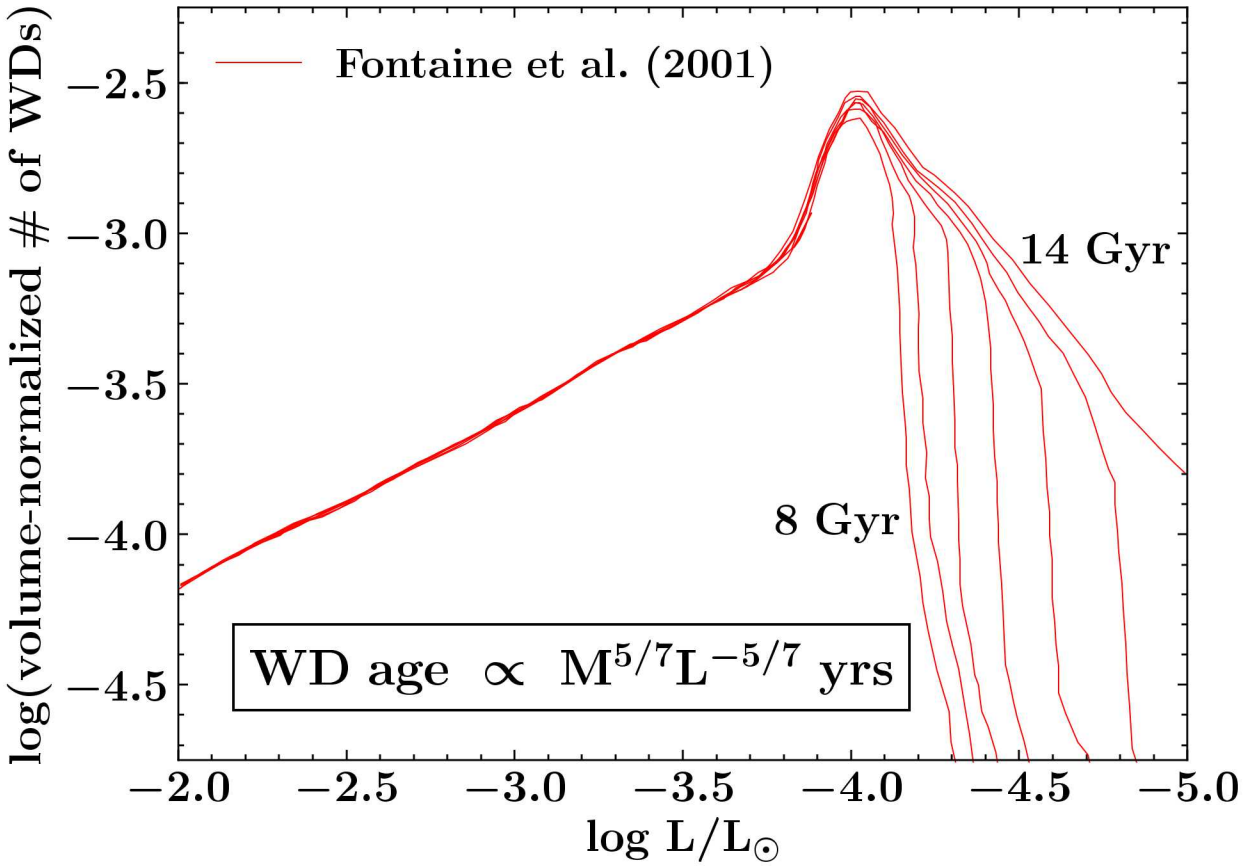
Surface gravity ($\log g$): 10^8 cm/s^2 (n_e ~10^{17} cm^{-3})

Radius: r_{earth}

Mass: ~2/3 M_{sun}

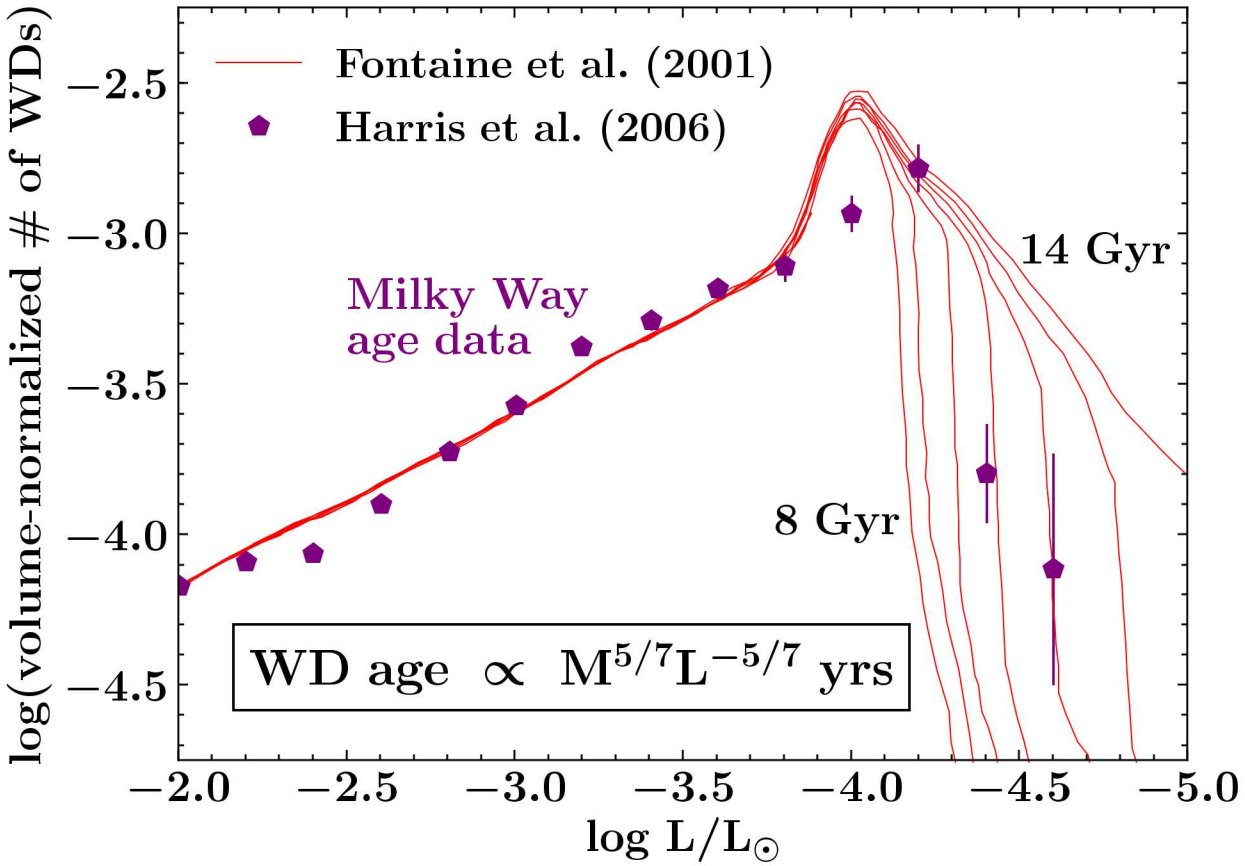
WDs are earth-sized objects with masses comparable to the sun.

Hydrogen WD masses are critical for determining the age of the universe



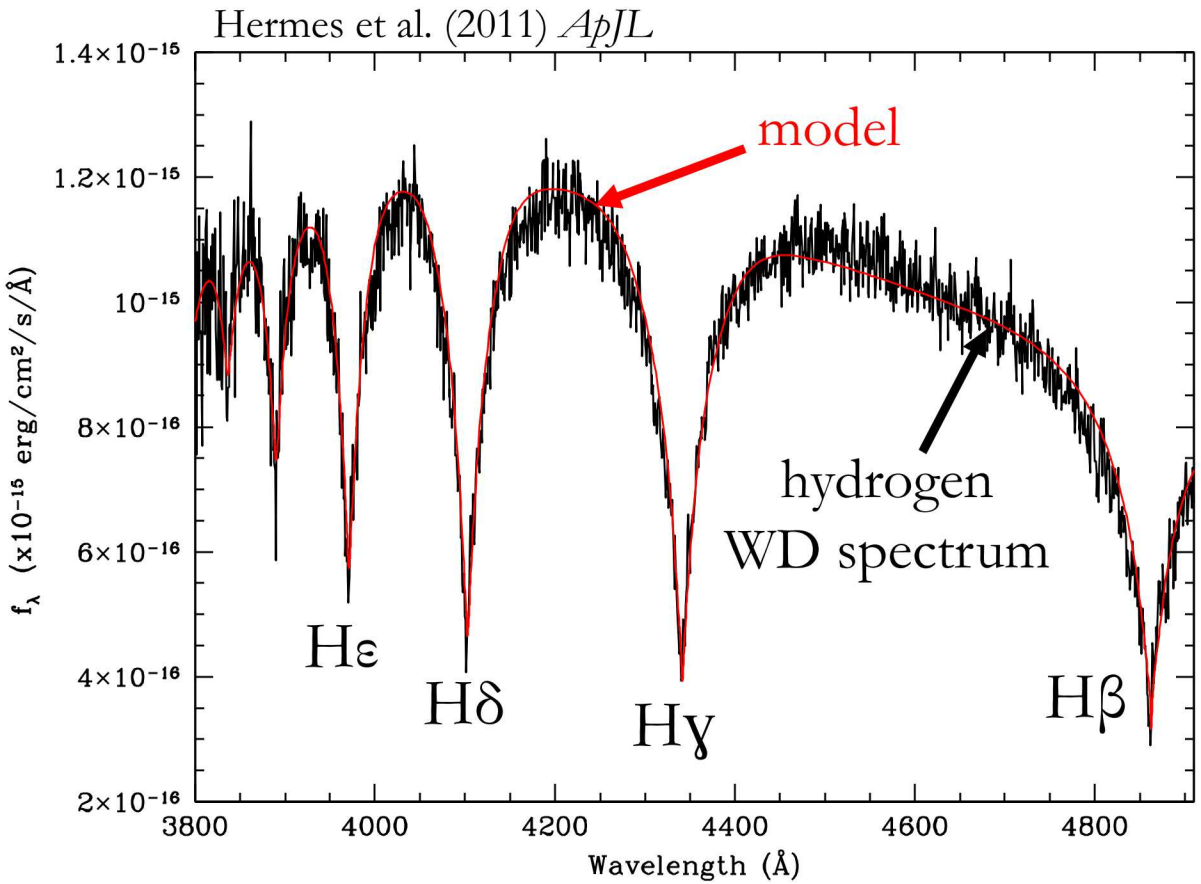
- Theoretical luminosity functions depend on WD masses

Hydrogen WD masses are critical for determining the age of the universe



- Theoretical luminosity functions depend on WD masses
- WDs constrain the age of Galaxy to:
  - 11.5 ± 0.7 Gyr

Most hydrogen WD masses are obtained by fitting emission-validated models to stellar absorption spectra

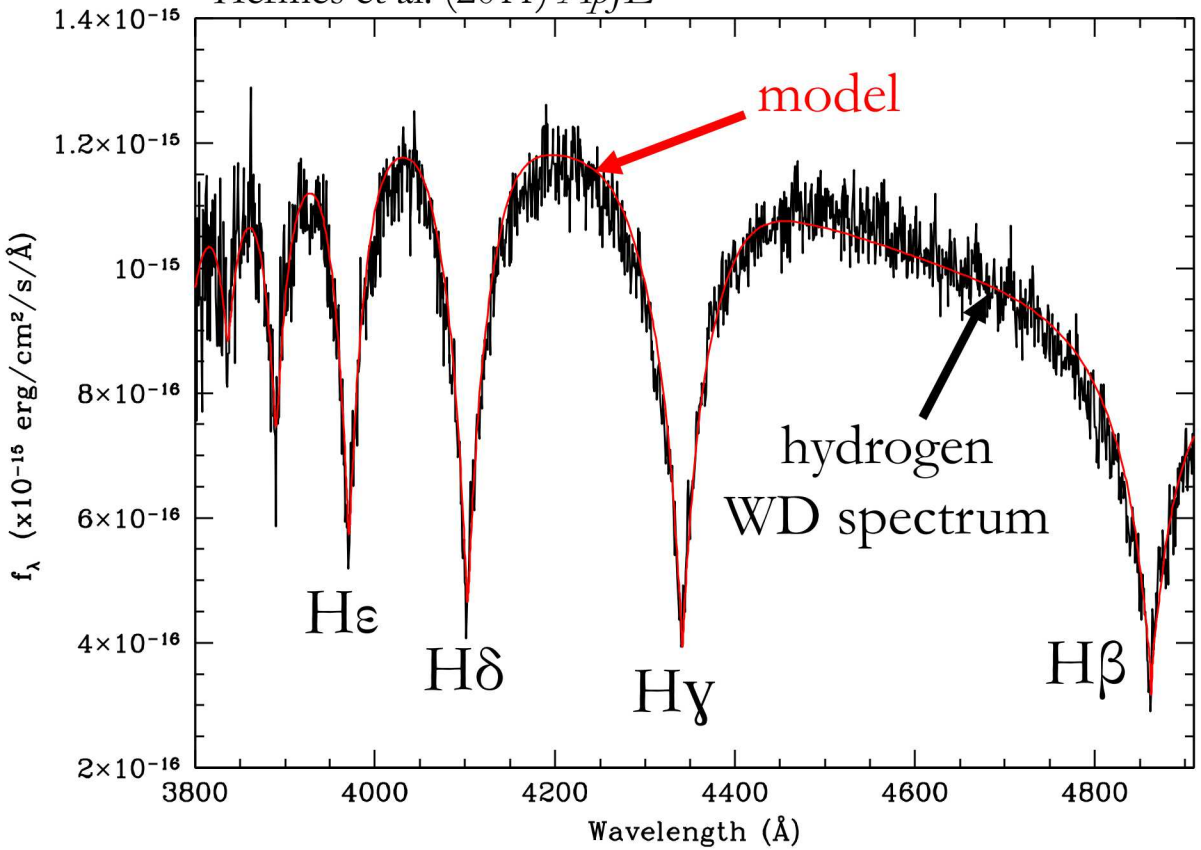


- Fits of model atmosphere (red) to an observed hydrogen WD spectrum (black).

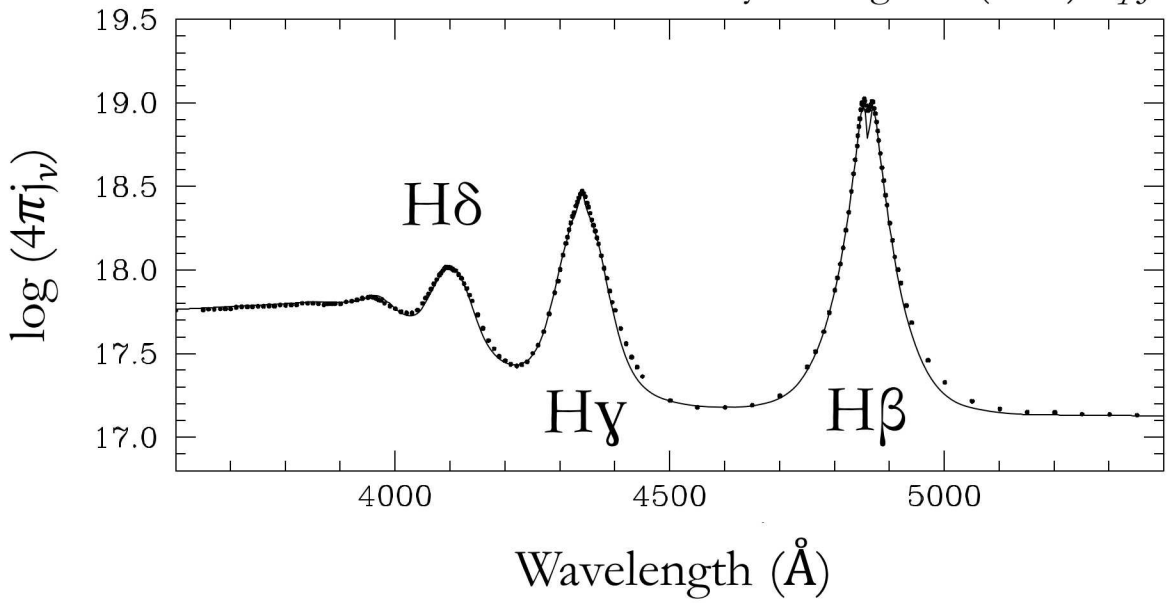
- The line widths are sensitive to atmospheric n_e values, which are directly related to the stellar log g and therefore also the stellar mass.

Most hydrogen WD masses are obtained by fitting emission-validated models to stellar absorption spectra

Hermes et al. (2011) *ApJL*

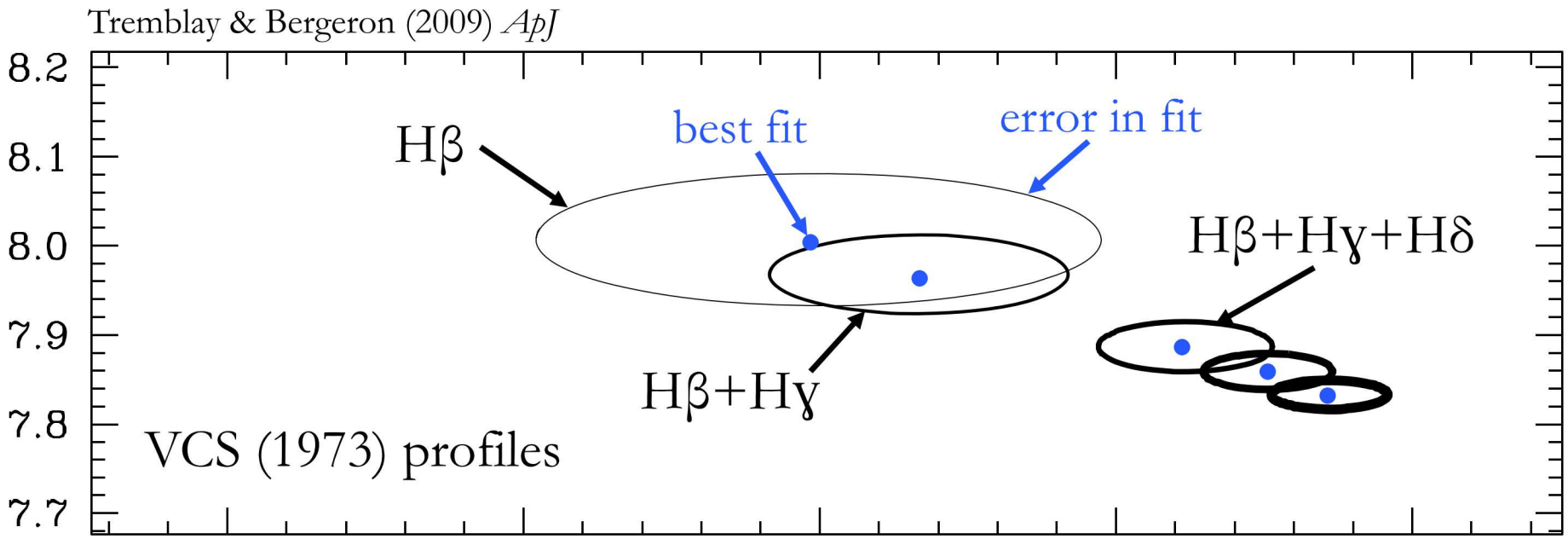


Tremblay & Bergeron (2009) *ApJ*



Emission-validated line-shapes
are crucial ingredients for spectroscopic models.

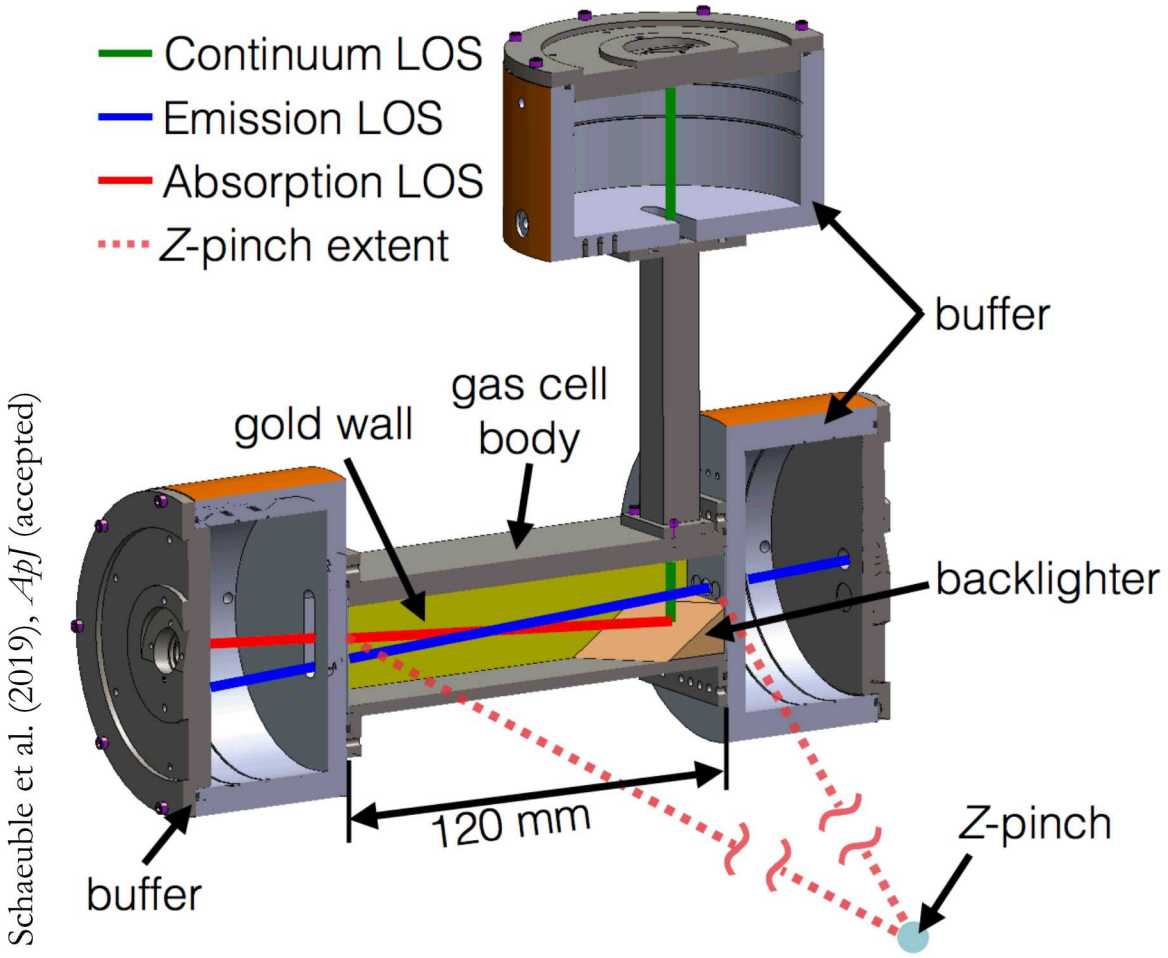
Masses inferred from different Balmer series members disagree



Higher principal quantum number Balmer series members result in ***lower*** stellar masses.

Since the line-shape models are verified in emission, does this imply that these models are inaccurate in absorption?

The White Dwarf Photosphere Experiment on the Z-machine

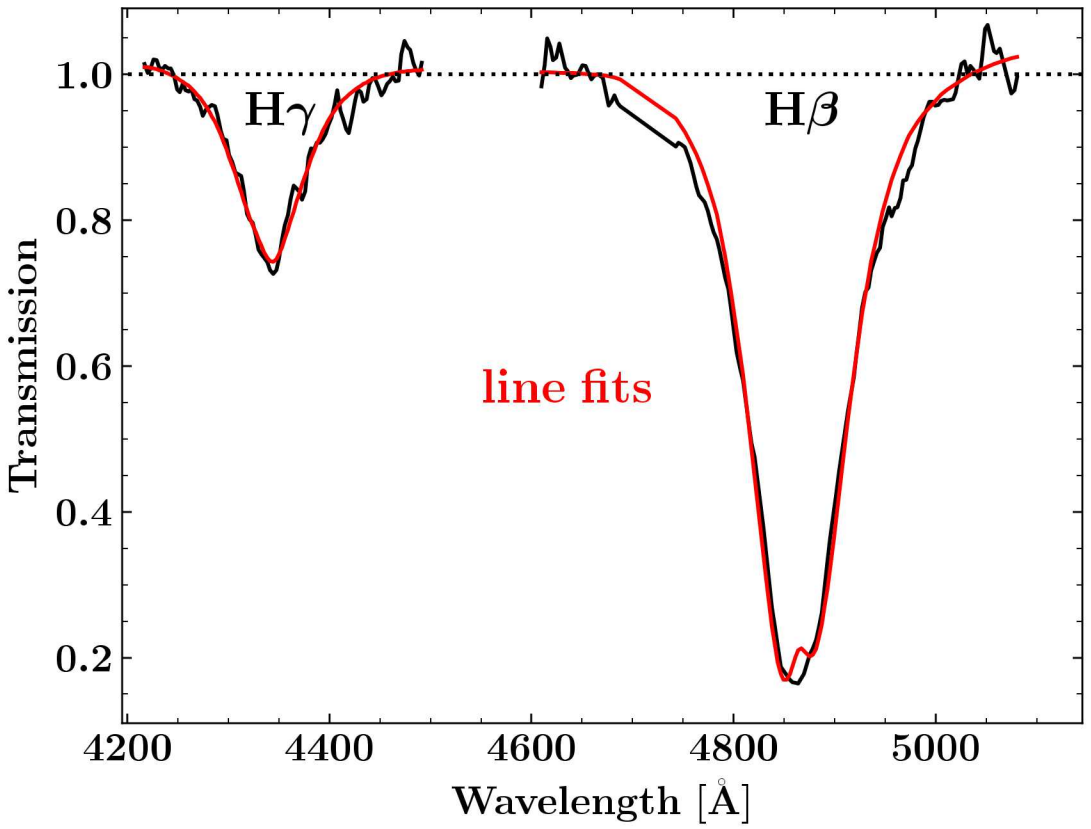


Schaeuble et al. (2019), *ApJ* (accepted)

- The White Dwarf Photosphere Experiment platform is ~324 mm away from the Z-pinch
- We observe the resulting spectrum using the absorption (red), emission (blue) and continuum line-of-sight (green). This experimental setup allows us to re-create WD absorption observations.

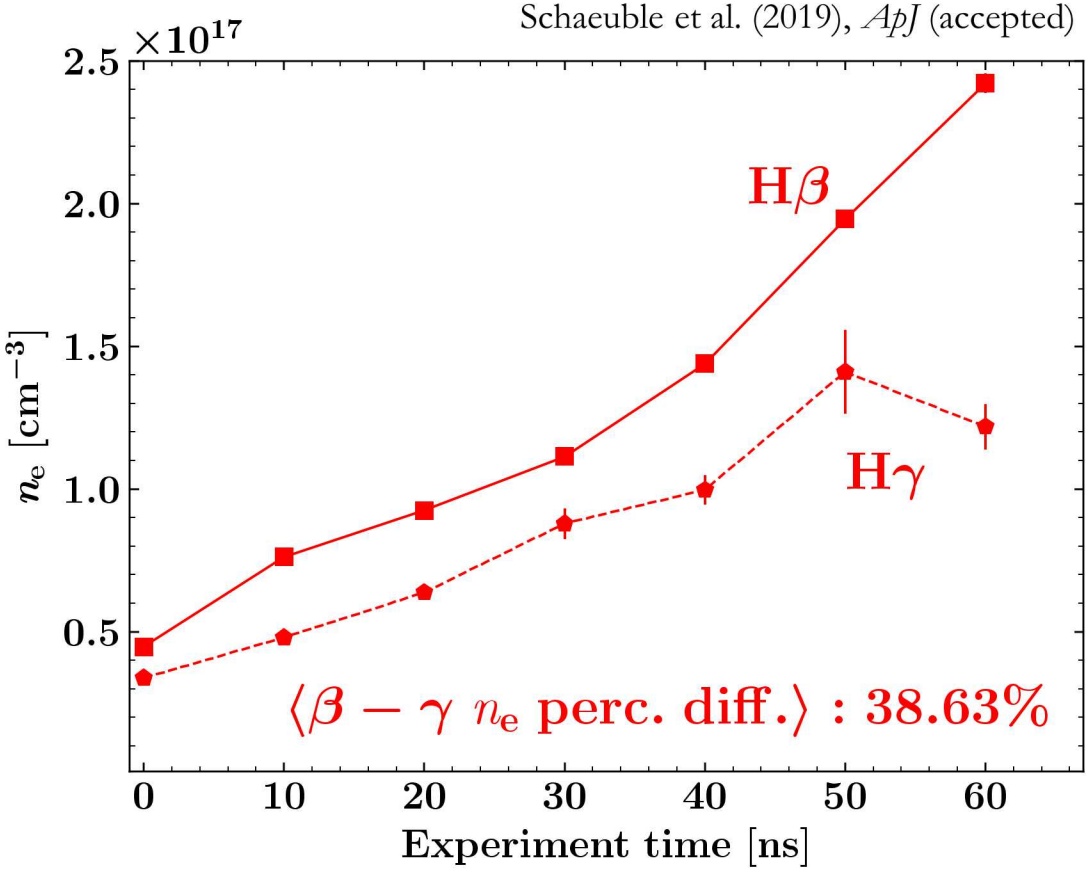
Analysis of the WDPE absorption spectra reveal trends similar to those observed in stellar spectra

Schaeuble et al. (2019), *ApJ* (accepted)



Line fits to absorption spectra.
These are used to extract n_e values.

Schaeuble et al. (2019), *ApJ* (accepted)



Hβ and Hγ n_e values differ by ~40%.

Experimental line-shapes are difficult to extract and their accuracy depends on many different parameters

We investigated the following effects:

- Extraction procedure of hydrogen line shapes from experimental data
- Influence of plasma gradients on Hβ and Hγ line-shapes

Data extraction and plasma physics effects are most likely not responsible for the observed n_e differences

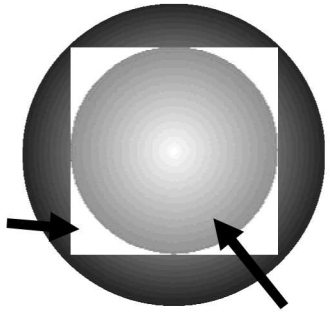
We investigated the following effects:

- ~~Extraction procedure of hydrogen line shapes from experimental data~~
- ~~Influence of plasma gradients on Hβ and Hγ line-shapes~~

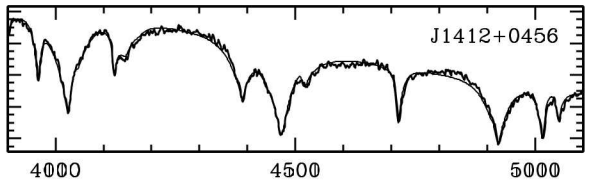
The experimentally determined Hβ-Hγ n_e disagreement, if real, could have significant implications for all of plasma and astrophysics!

Stellar evolution and the age of the universe can be constrained using White Dwarf (WD) stars

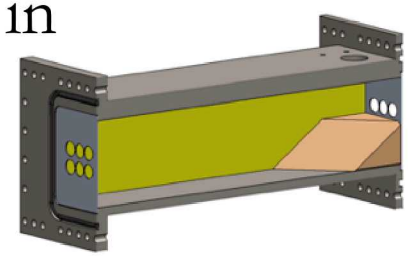
- Applying WD to astrophysical problems requires accurate stellar masses



- The main mass determination methods have deficiencies



- Z-machine experiments enable scrutiny of constituent atomic physics in WD mass determination methods



Z-machine data have highlighted deficiencies in the atomic data used for WD mass determination methods.