Post-AGB stars, accreting white dwarfs, and the warm ISM of retired galaxies

Tyrone Woods

with Marat Gilfanov, Jonas Johansson,
Marc Sarzi, & Hai-Liang Chen

Ionized Gas in Retired Galaxies

Low-Ionization Emission Line Regions

- Warm ($T \approx 10^4$K) ISM in quiescent galaxies
- Extended, LINER-like emission
- Primary ionizing source is component of the stellar population (e.g. Sarzi+ 2010, Yan & Blanton 2012)
- Most likely candidate is post-AGB stars
  e.g. Binette+1994, Sarzi+2010, Yan & Blanton 2012, Singh+ 2013 (see next talk!)
- Other sources (e.g. LMXBs) shown to be subdominant.
  What about accreting white dwarfs?

Accreting White Dwarfs

- Spectra ~ blackbody in EUV (Rauch 2010), even if photosphere inflated (Woods & Gilfanov 2013)

$$T_{\rm eff} = \left(\frac{L_{nuc}}{4\pi R_{WD}^2 \sigma_{SB}} \right)^{\frac{1}{4}} \approx 5.3 \cdot 10^5 \ \dot{M}_{-7}^{1/4} \ R_{-2}^{-1/2} \ K$$

- Photosphere may be inflated, pushing most emission to the EUV (e.g. in accretion wind regime, Hachisu+ 2010)
- Photospheric T ≈ 10^5 – 10^6 K, L_{bol} ≈ 10^{38} erg/s

Accreting White Dwarfs

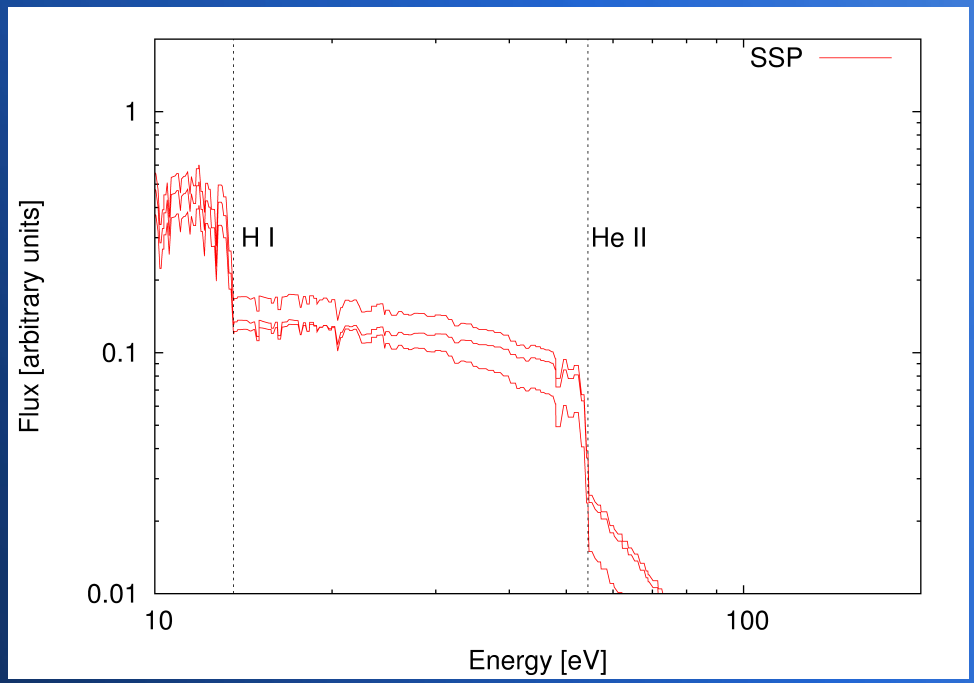
- Two ways to make an estimate the total luminosity of an accreting white dwarf population
  - Assume all SN Ia arise through “single degenerate channel” (as in Gilfanov & Bogdan 2010):

$$L_{\mathrm{tot,SNIa}} \approx N_{progenitors} \cdot L_{nuc} = \epsilon_{\mathrm{H}} \chi \Delta M_{\mathrm{Ia}} \dot{N}_{\mathrm{SNIa}}$$

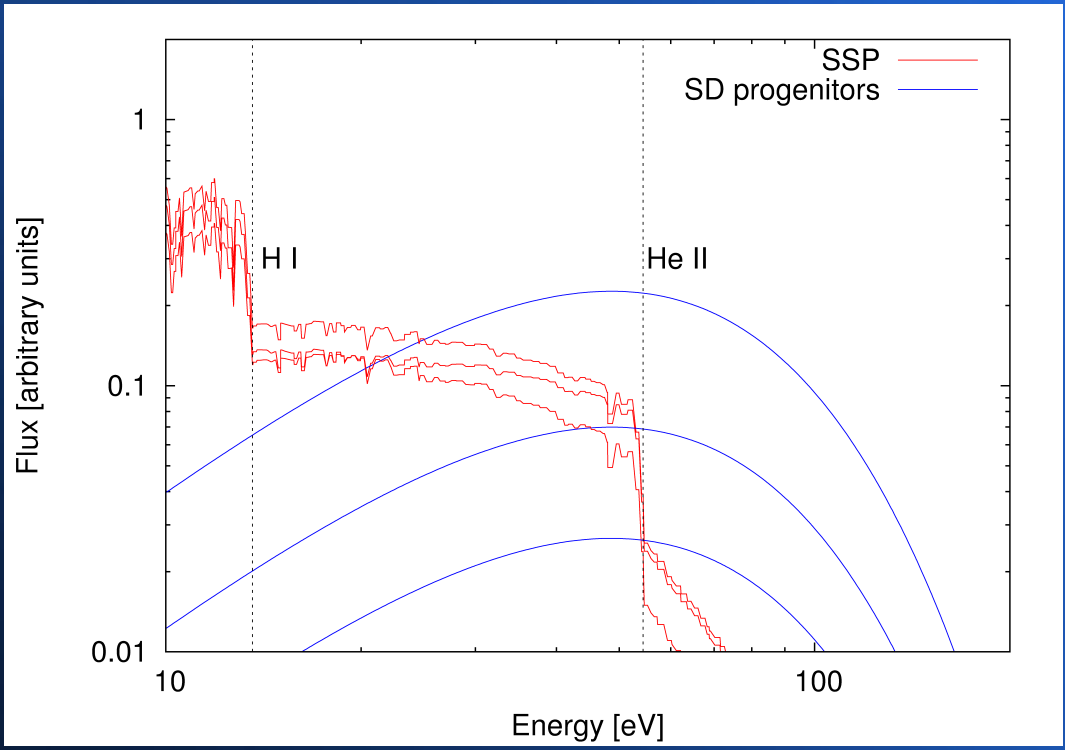
  - Detailed population synthesis calculations (e.g. Chen, Woods+ 2014)

Accreting White Dwarfs

- Simple stellar population (SSP) synthesis of Bruzual & Charlot (2003)
- Lines correspond to ages of 3 Gyr (upper line), 6 Gyr (middle line), and 10 Gyr (lower line)



Accreting White Dwarfs

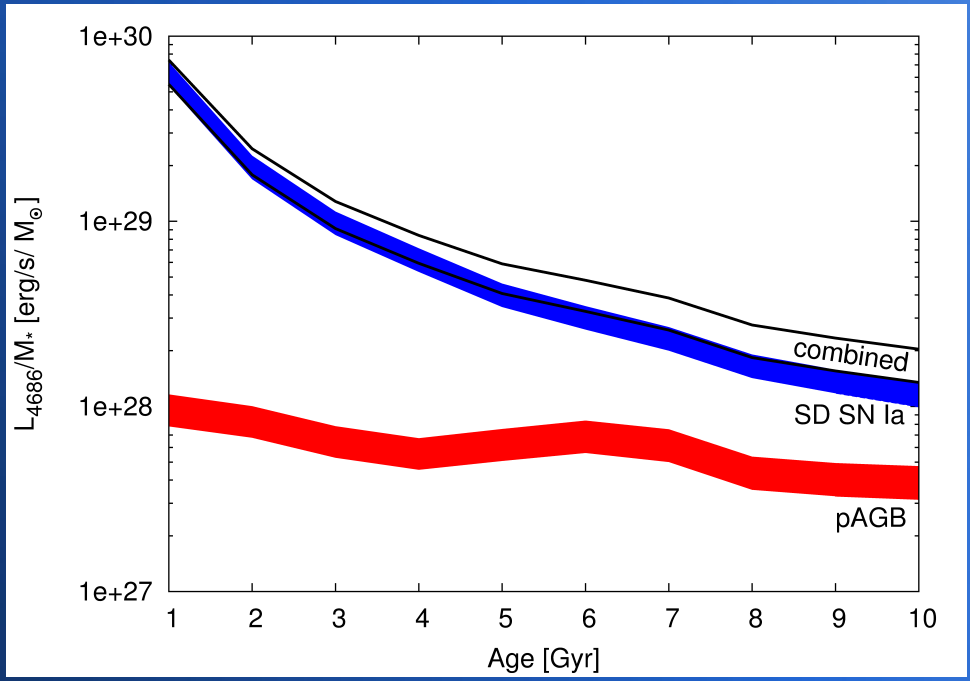


“Minimal contribution” single degenerate channel
($\Delta M \approx 0.3\ M_\odot$, $T \approx 2 \cdot 10^5 K$)

He II Recombination Lines

- He II 4686Å emission per unit stellar mass
  - Red: Bruzual & Charlot (2003)
  - Blue: SD SN Ia progenitors
  - Black: combined

Woods & Gilfanov (2013)



MAPPINGS III

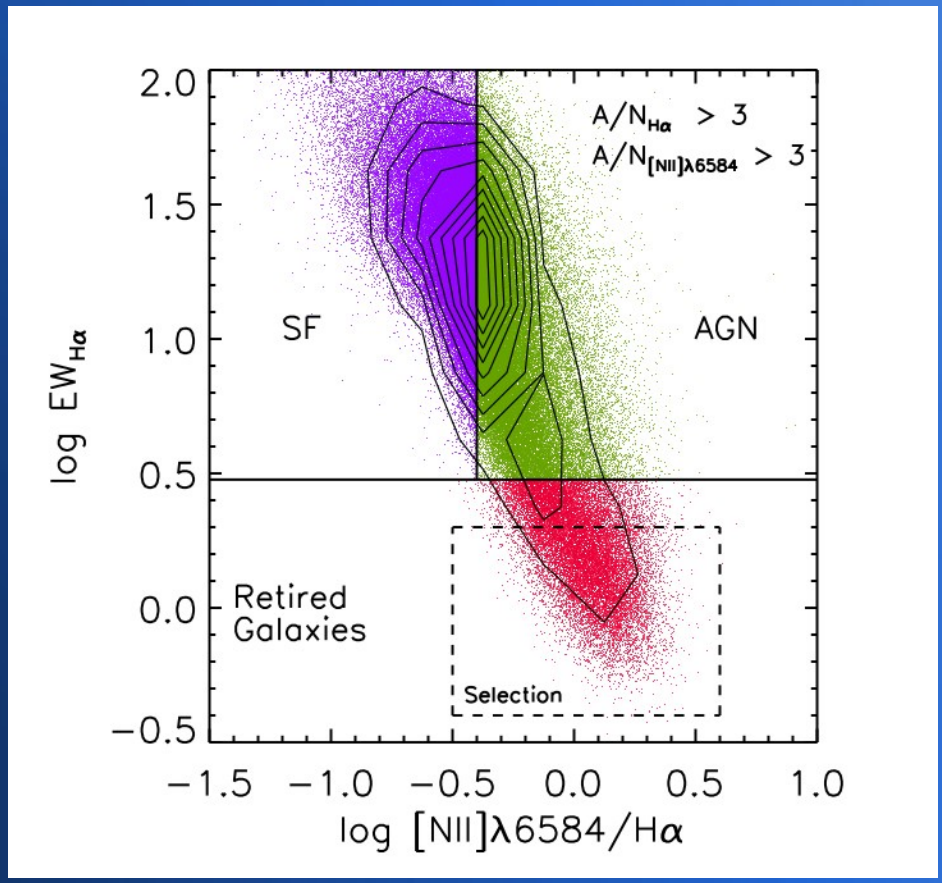
$$L_{4686} \approx 1.4 \cdot 10^{40}\ t_{Gyrs}^{-1.7}\ T_5^{-1}\ f_c\ \frac{\Delta M}{0.3 M_\odot}\ \frac{M(t)}{10^{10} M_\odot}\ \mathrm{erg/s}$$

Sample Selection

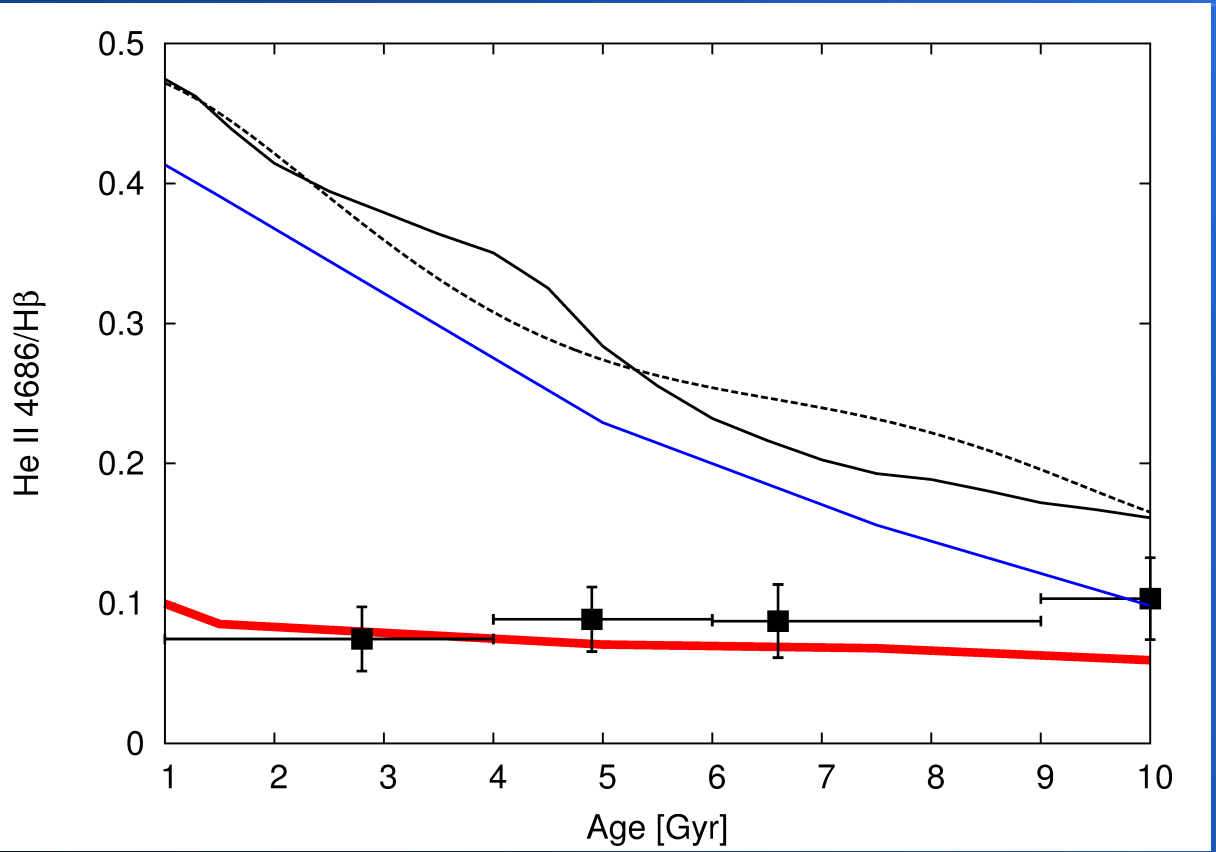
Johansson+ 2014

Choose only retired galaxies in the SDSS
(see Cid Fernandes+ 2011)

- 0.04 < z < 0.1
- A/N > 3 (Hα & [N II] 6584)
- log(EW[Hα]) < 0.3
- -0.5 < log[N II]/Hα < 0.6

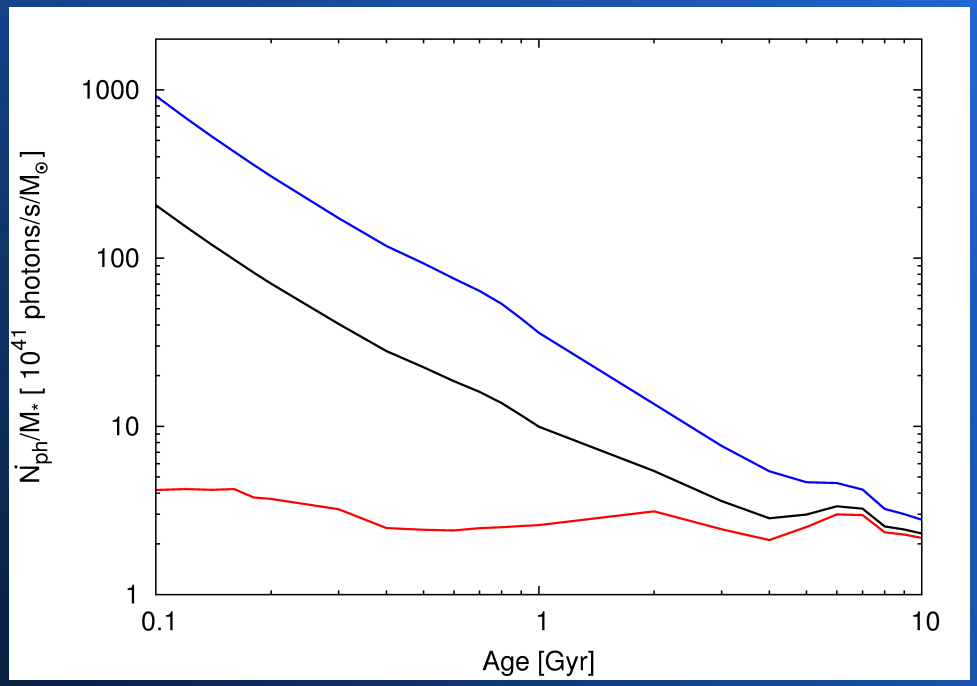


Results



Compare with predictions from SD channel (Johansson, Woods+ 2014) and population synthesis (Chen, Woods et al 2014)

Future Prospects



- In post-starburst galaxies, effect should be even stronger
- See Woods & Gilfanov (2014)

Conclusions

- Accreting white dwarfs must be subdominant photoionizing source, or else early-type galaxies (with warm ISM) would exhibit strong He II emission in their spectra, clear trend with mean stellar age. **This is not what we observe!**
- This tells us accreting, nuclear-burning white dwarfs can't be the progenitors of type Ia supernovae! Most likely candidate double white dwarfs.
- In post-starburst galaxies, EW of [O II] 3727, Hα would exceed observed values by ~1 – 2 orders of magnitude!
- Need to follow up with IFU spectroscopy