## Probing He II reionization with GALEX-selected quasar sightlines in the HST/COS era

#### Gábor Worseck (UCO/Lick)

#### &

J. X. Prochaska (UCO/Lick), L. Wisotzki (AIP), M. McQuinn (UCB), A. Dall'Aglio (AIP), J. F. Hennawi (MPIA), C. Fechner (UP), P. Richter (UP), P. Madau (UCSC), S. Gallerani (INAF), J. M. O'Meara (St. Michaels), R. A. Simcoe (MIT), D. Reimers (Hamburg)

#### Cosmological Reionization

Harish-Chandra Research Institute, February 16–20 2010





- Our survey for new He II sightlines
- 4 Conclusions and Outlook

### Why do we care about intergalactic helium?

- 2nd most abundant element created in the Big Bang
- IGM of hydrogen and helium photoionized by UV background
- He II  $\rightarrow$  He III requires  $h\nu > 54.4$  eV photons
  - He II/H I traces SED of UV radiation field
  - late helium reionization epoch at z ~ 3 (QSOs required)
- IGM at z ~ 3 much better probed than at z ~ 6
- but: He II difficult to observe
  - He II Ly $\alpha$  at  $\lambda_{\text{rest}} = 303.78$  Å only observable from space at z > 2
  - far-UV emission of most quasars extinguished by H I Lyman limit systems

### Status prior to HST SM4

- extensive "blind" surveys for UV emission of high-z quasars
- only 5 sightlines studied at R > 800 (HST/STIS, FUSE)
- main features: GP trough at z > 3, patchy He II absorption at 2.7 < z < 3, forest at z < 2.7</li>



#### $GALEX \longrightarrow We are not lacking photons, but resolution!$

- GALEX: first UV extragalactic all-sky survey at  $m_{\rm AB} \lesssim 21$
- Syphers et al. (2009): GALEX UV pre-selection
  - $\longrightarrow$  22/53 z > 3.1 targets detected in He II (R  $\sim$  200)
- SM4 restored UV spectroscopic capabilities of HST
- BUT: several faint QSOs ( $m_{\rm FUV} \gtrsim 22.5$ ), expensive follow-up



### Our GALEX UV color selection technique

- two GALEX bands: NUV (1750-2200Å) and FUV (1350-1750Å)
- NUV flux alone is not sufficient (low-z Lyman limits)
- significant FUV flux required (at least for  $z \leq 3.5$  targets)



### GALEX finds all known needles in the haystack



G. Worseck (UCO/Lick)

Probing HeII reionization with GALEX-selected guasar sightlines in the HST/COS era

7/13

#### Blue GALEX colors $\longrightarrow$ high He II detection rate



### Our successful Cycle 17 He II survey

- HST/COS FUV spectroscopy of 8 FUV-bright QSOs (21 orbits)
- UV-bright QSOs: simultaneous efficient confirmation and follow-up
- 2 QSOs observed so far: both sightlines transparent
- first clear detection of cosmic variance in He II absorption: GP trough vs. voids at z ~ 2.9



## Comparison H I & He II $\longrightarrow$ UVB spectral shape

- HI: complementary optical program (Keck/HIRES & VLT/UVES)
- η=He II/H I ∝ Γ<sub>H I</sub> / Γ<sub>He II</sub>
- procedure: fit H I forest & find  $\eta$  matching unresolved He II absorption
- UVB shape fluctuates,  $\eta \gg 100$  indicates low  $\Gamma_{\text{He II}}$ 
  - $\longrightarrow$  large He II fraction, either soft galaxies contribute to UVB or QSO radiation strongly filtered



### Comparison to simulations: Understanding the physics

- 3D rad. transfer simulations predict large variance in HeII spectra
- extended HeII reionization due to patchy QSO distribution
- our COS spectra assess variance in He II absorption
- The astronomer's desire: more data, high-z targets, high S/N



McQuinn et al. 2009

### Comparison to simulations: Understanding the physics

- 3D rad. transfer simulations predict large variance in HeII spectra
- extended HeII reionization due to patchy QSO distribution
- our COS spectra assess variance in He II absorption
- The astronomer's desire: more data, high-z targets, high S/N



McQuinn et al. 2009

## GALEX: There's hope at z < 4!



G. Worseck (UCO/Lick)

Probing He II reionization with GALEX-selected guasar sightlines in the HST/COS era

12/13

## Outlook: Understanding He II reionization via He II absorption spectra

- Efficient He II target selection via GALEX photometry
  - Blue GALEX colors indicate transparent sightlines
  - ~ 100 z > 2.7 targets in GALEX GR4
- Promising results with COS in Cycle 17
  - 2/8 targets observed so far, 100% success, science-ready data
  - variance in He II absorption at  $z \sim 2.9$
  - Future: correlate voids and foreground quasars
- Joint analysis of He II and H I forests
  - spectral shape of UV radiation field at z ~ 3
  - evolution of the UV background approaching He II reionization
  - constrain ionizing source population at z ~ 3

# Goal: A definitive HST/COS He II Legacy Sample

## Outlook: Understanding He II reionization via He II absorption spectra

- Efficient He II target selection via GALEX photometry
  - Blue GALEX colors indicate transparent sightlines
  - ~ 100 z > 2.7 targets in GALEX GR4
- Promising results with COS in Cycle 17
  - 2/8 targets observed so far, 100% success, science-ready data
  - variance in He II absorption at  $z \sim 2.9$
  - Future: correlate voids and foreground quasars
- Joint analysis of He II and H I forests
  - spectral shape of UV radiation field at z ~ 3
  - evolution of the UV background approaching He II reionization
  - constrain ionizing source population at z ~ 3

# Goal: A definitive HST/COS He II Legacy Sample