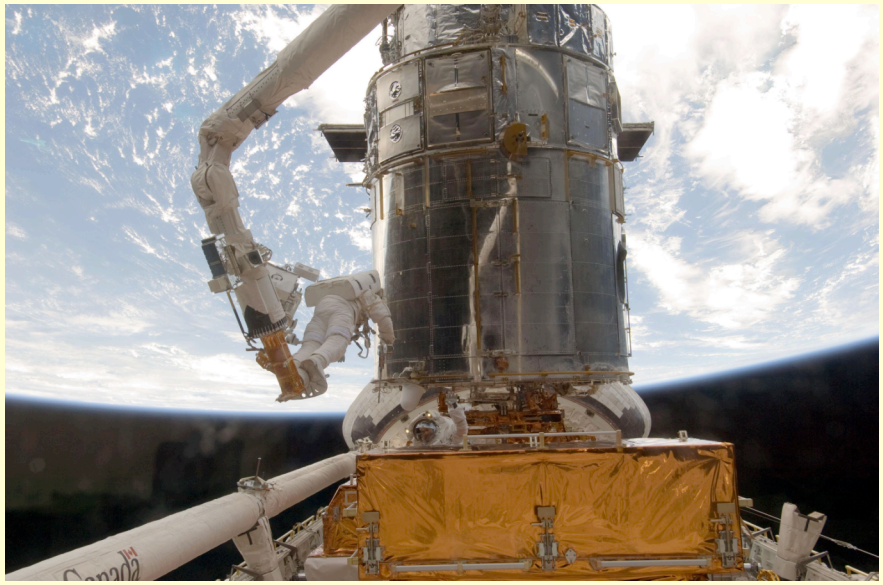
Cosmic Origins Spectrograph
Hubble Space Telescope

Early Science Results from the Cosmic Origins Spectrograph



Cynthia S. Froning
University of Colorado

October 12, 2010

Cosmic Origins Spectrograph
Hubble Space Telescope

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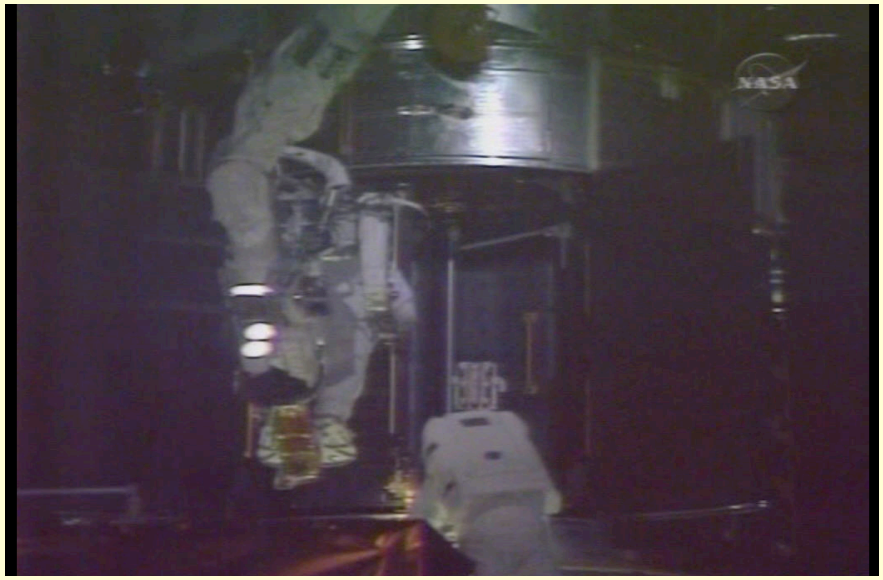

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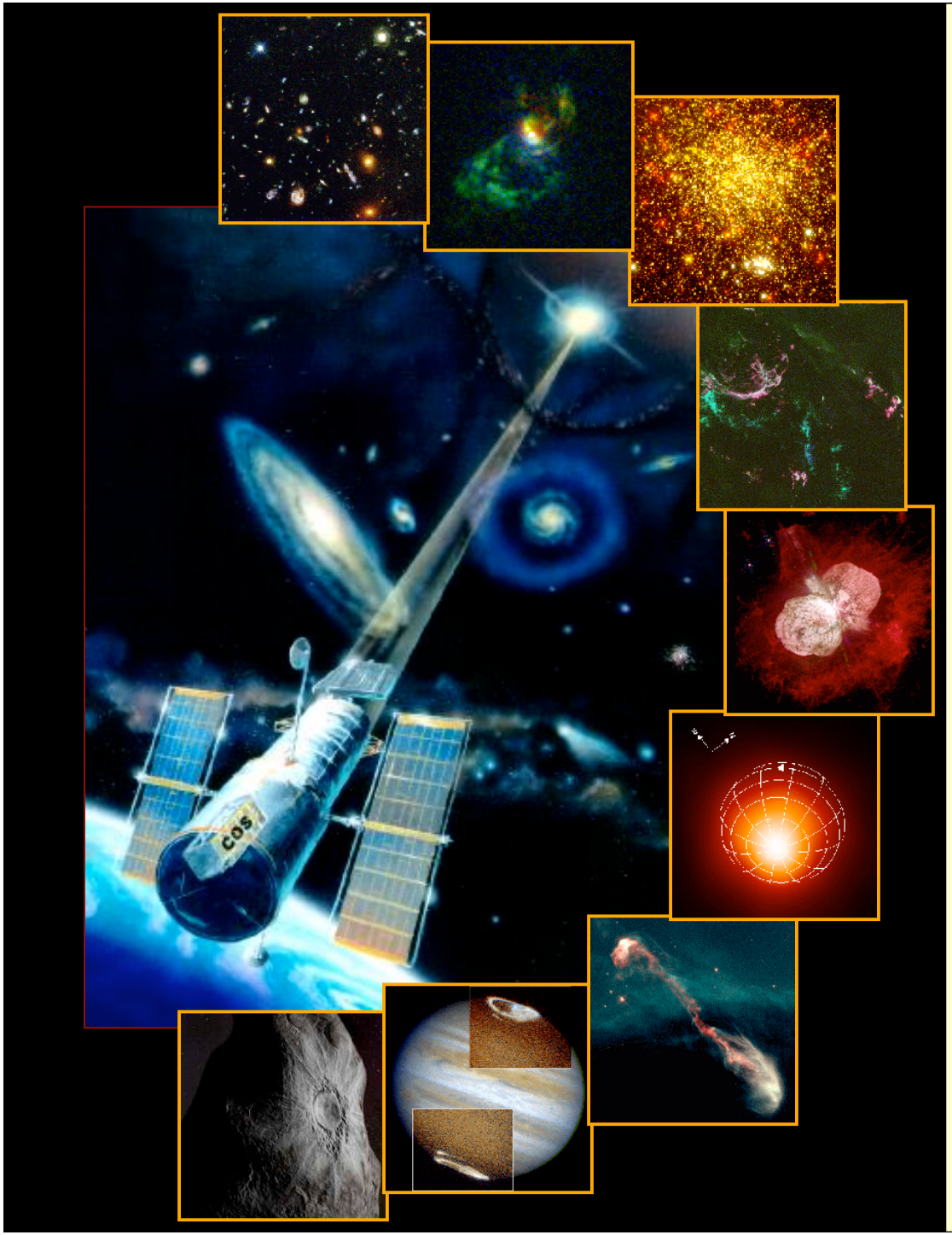
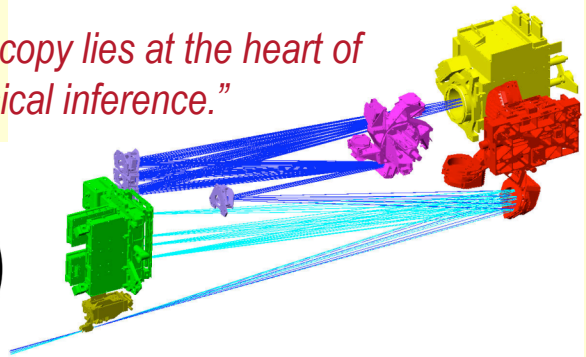


COS Science Themes

- What is the large-scale structure of matter in the Universe?
- How did galaxies form out of the intergalactic medium?
- How were the chemical elements for life created in massive stars and supernovae?
- How do stars and planetary systems form from dust grains in molecular clouds in the Milky Way?
- What are planetary atmospheres and comets in our Solar System (and beyond) made of?

"Spectroscopy lies at the heart of astrophysical inference."



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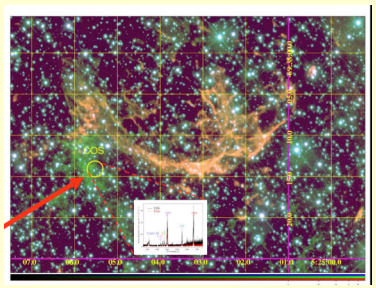
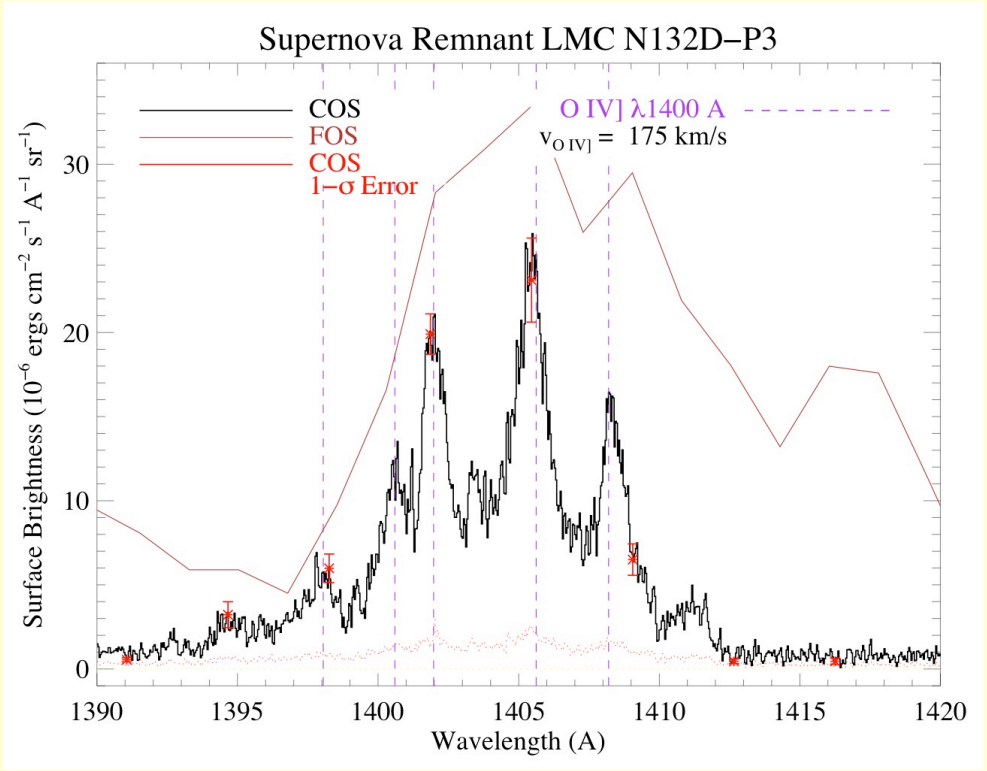


COS will observe a rich variety of targets from our solar system to the high(ish)-redshift universe.

Cycle 17/18 Observations

- ~25% of prime GO orbits in each cycle
- Four large programs (43 galaxy halos, 44 dwarf galaxy halos, 9 WHIM sightlines, 26 T Tauri stars)
- 555 GTO orbits (not all will be executed by the end of Cycle 18)
- Solar system & exoplanet atmospheres, WD debris disks, starbursts, stellar atmospheres and disks, ISM abundances, AGN & galaxy feedback, IGM and Galactic halo mapping, HeII G-P, etc.



France et al. 2009, ApJL, 707, L27

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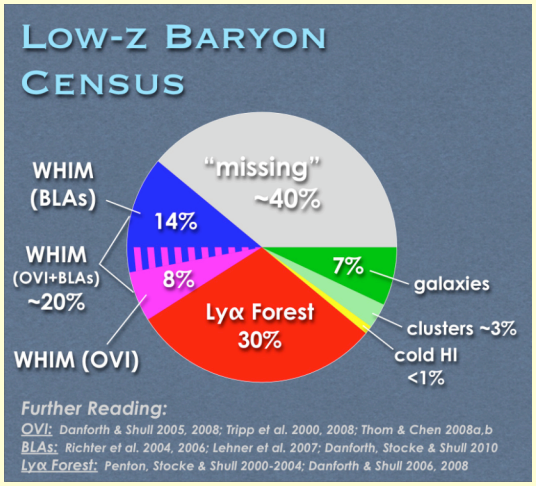
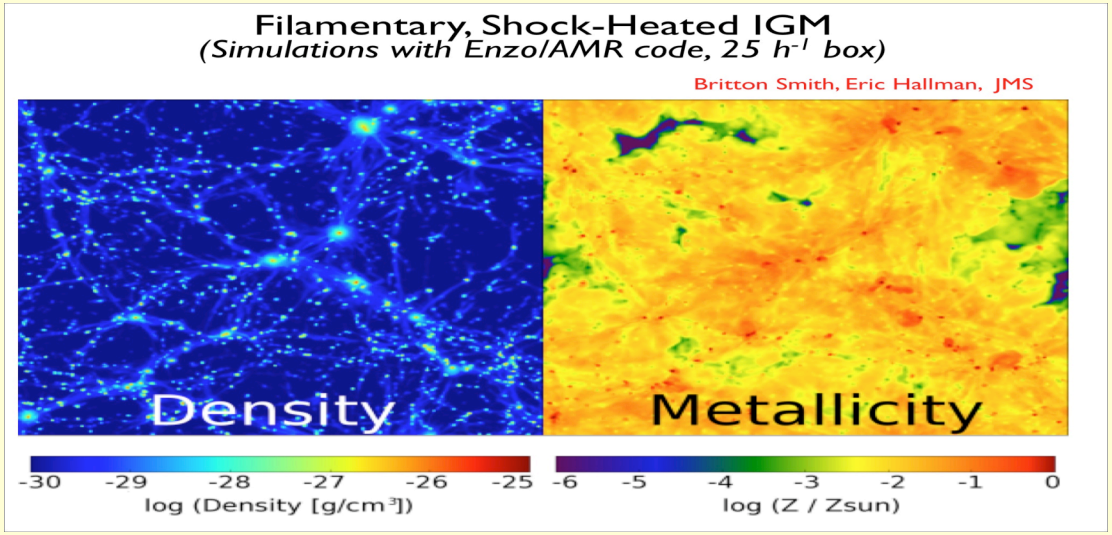
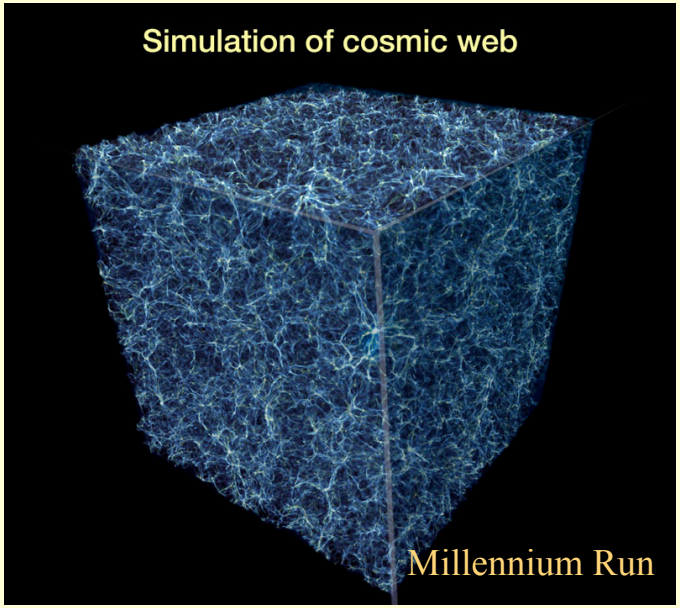
The Intergalactic Medium in the Modern Universe

Outstanding Questions in Modern Cosmology

- Missing baryons in the local universe
- Large scale structure
- Galaxy formation and evolution
- Feedback: galaxy-IGM interactions







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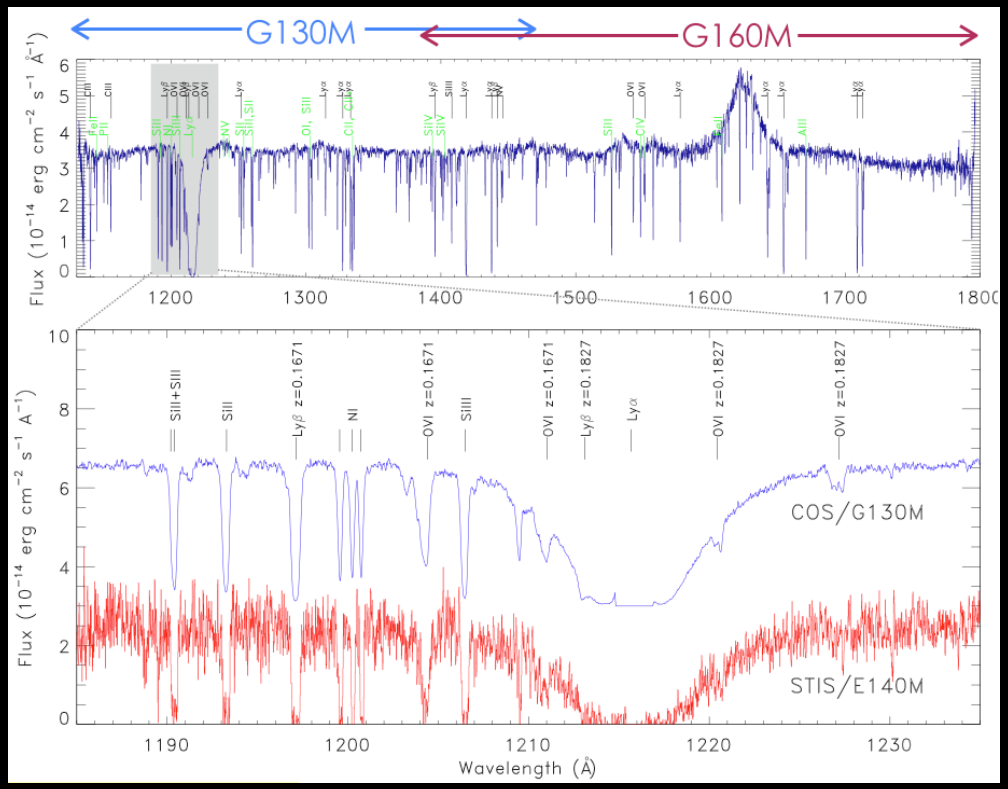
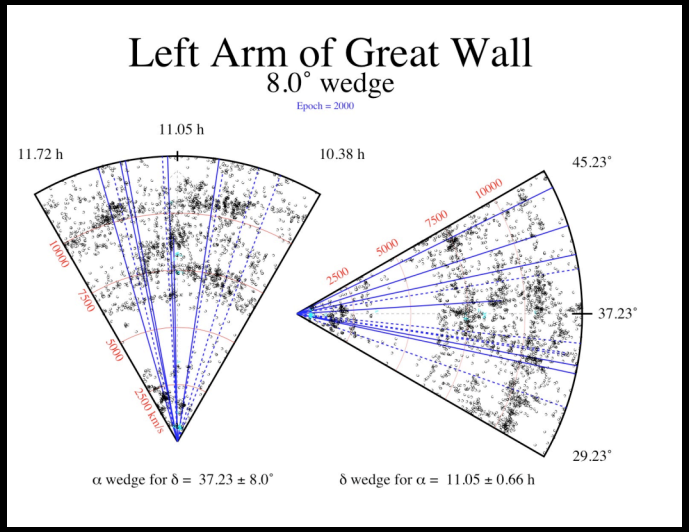


The Power of COS for IGM Studies

PKS0405

- 10-30x more sensitive than STIS; up to 100x more efficient for faint targets
  - ⇒Survey capabilities
  - ⇒Spatial mapping
  - ⇒Metals, diffuse IGM
- COS "will enable study of Lyα absorbers at overdensities comparable to that detectable at high z." (Davé et al. 2010)



To date (mid-July):

- 87 IGM sightlines observed, 300+ hrs (GO, GTO, ERO)
- Total Lyα pathlength Δz = 22.93
- COS has already **10x** the pathlength and **15x** the number of absorbers of previous GHRS+STIS studies!

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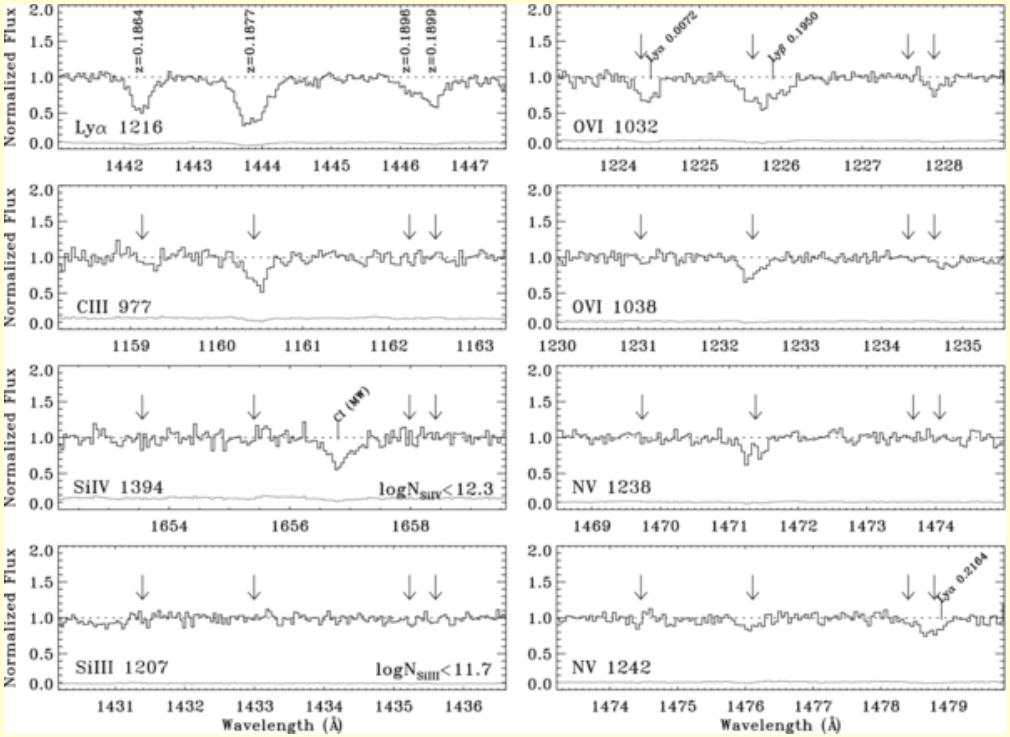
1ES 1553+113

- BL Lac object, no emission lines, redshift unknown
- $F_\lambda \approx$ 1.5e-14 ergs/cm^2/s/Å; S/N = 20 in 5 orbits
- Lyα+OVI absorber at z=0.395 $\Rightarrow$ $z_{AGN} \geq 0.4$
  $\Rightarrow$ great X-ray target for OVII, OVIII searches
- 41 intervening Lα systems; 13 higher Ly lines; 6 metal-ion systems
- New triple Lyα + metal ion system at z=0.188
- $\Delta v \approx$1200 km/s, nearby massive galaxies; plausible large-scale cosmic filament



Danforth et al. 2010, ApJ, 720, 976

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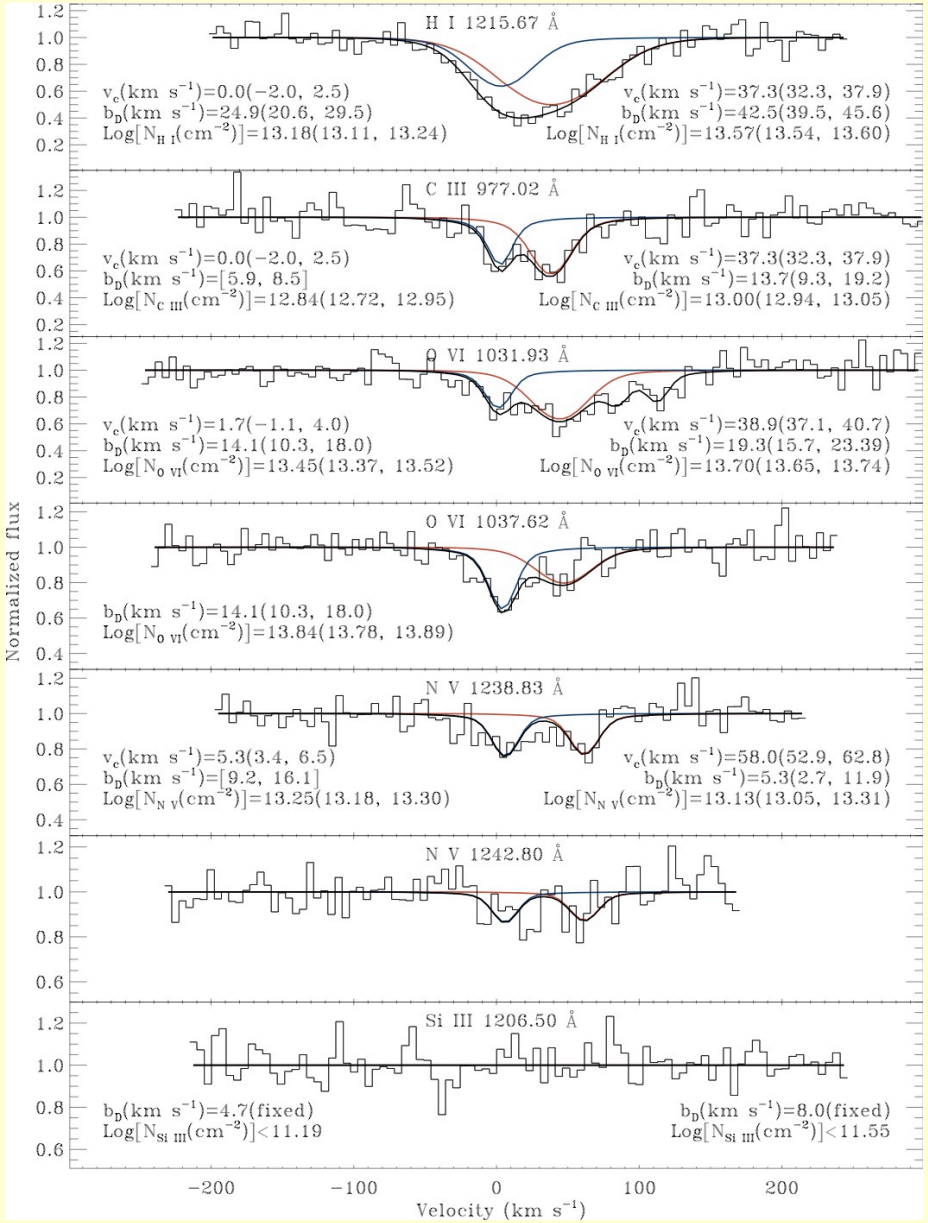
1ES 1553+113

- Detections in HI, OVI, NV, CIII (but not SiIII/IV: density, temperature, metallicity constraints, ionization fraction
  - ⇒ Multiphase gas (OVI and NV from WHIM, HI and CIII from cooler, photoionized gas)
  - ⇒ Model fits: cooler, lower ionization fraction, higher metallicity



Yao et al. 2010, submitted

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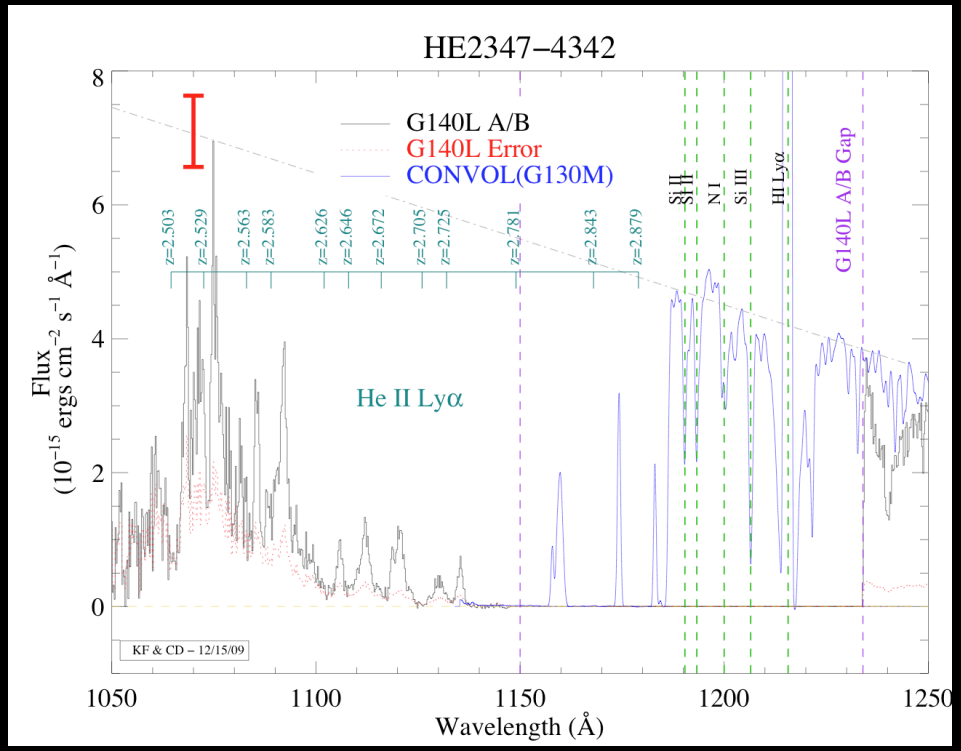
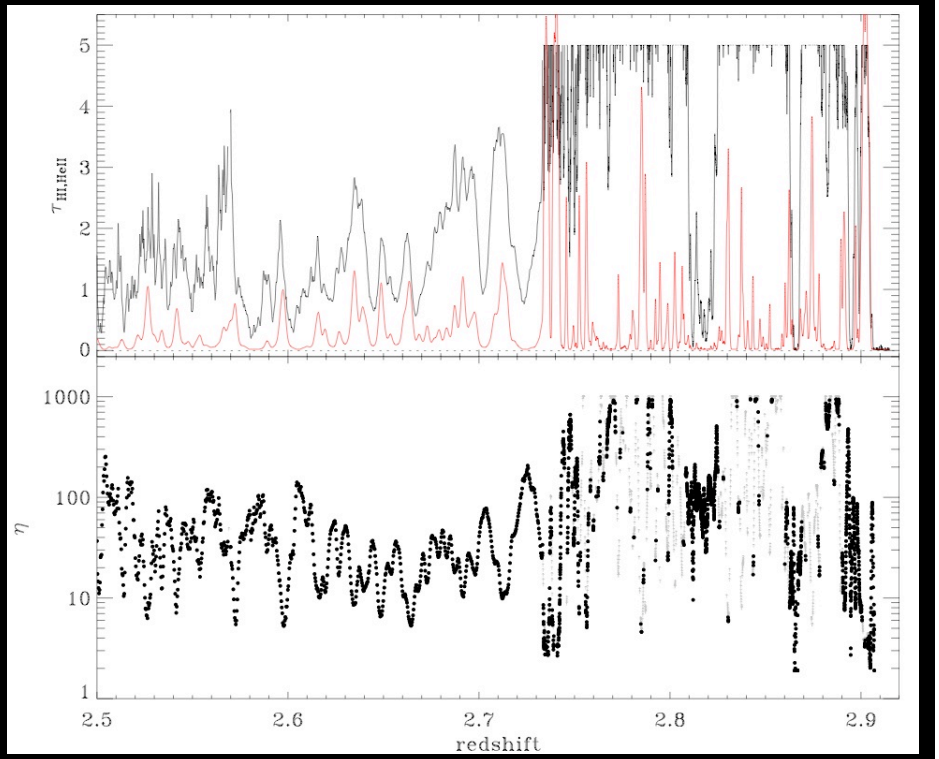
Hubble Space Telescope



- He II Gunn-Peterson targets
- HE 2347-4342, z=2.885
- Compare to HI Lyα forest to constrain UV/X radiation field, ionizing sources; track into HI "voids"



- Slow reionization to z≤2.7; variations in HeII/HI τ over 4–10 Mpc comoving scales
- Shull et al. 2010, ApJ, accepted
- Upcoming: 5 targets, 17 target snapshot
- See C. Danforth presentation

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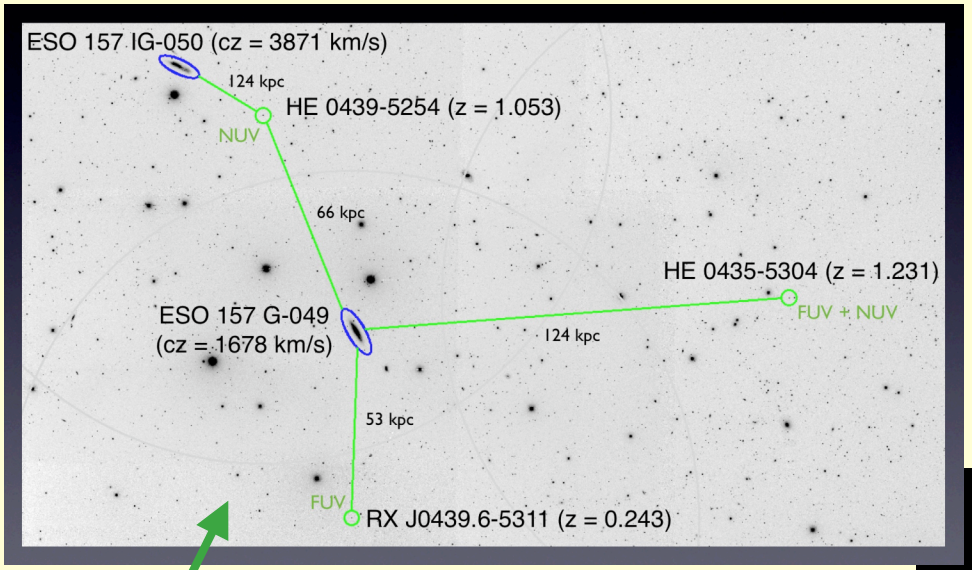
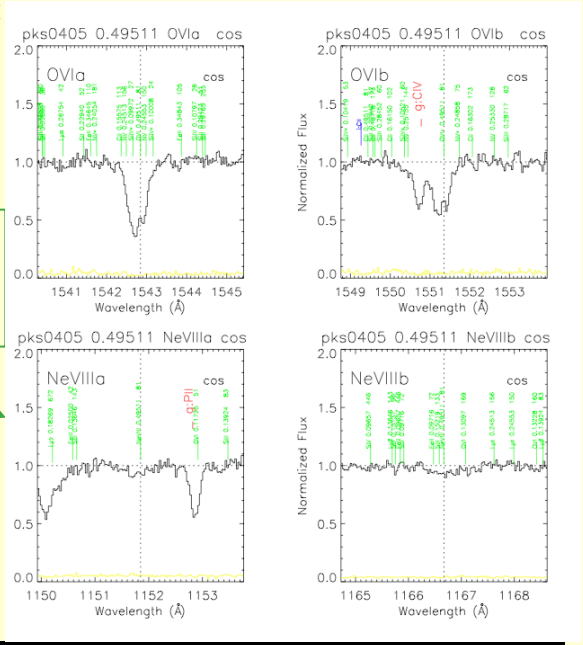


Three probes of a single galaxy halo

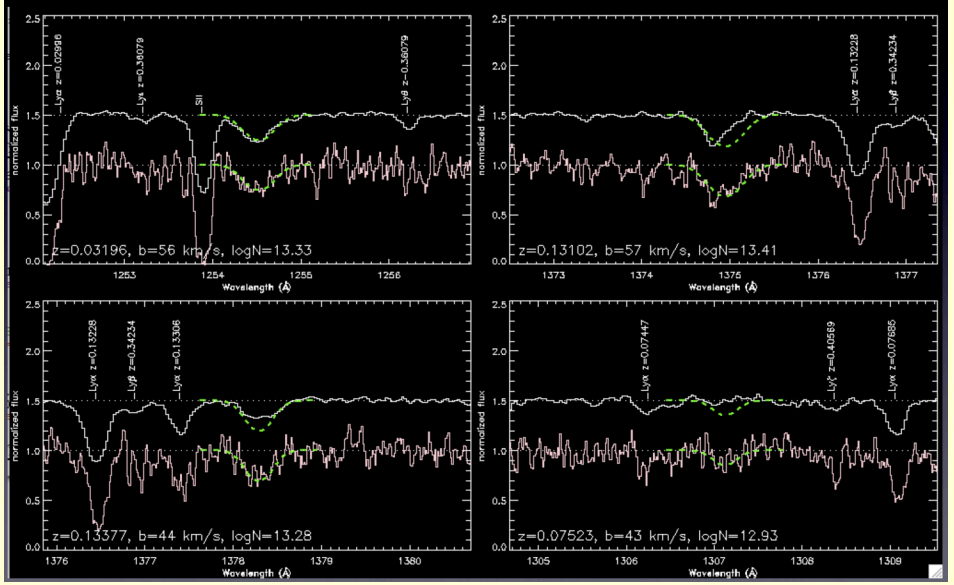
Ne VIII in PKS0405-123



BLAs as WHIM tracers

Science: Broad Lyα Absorbers

- b_{HI} > 40 km/s → T>10^5 K → potential WHIM tracer



And much, much more…

See presentations by Tumlinson, Stocke, Lehner, Thom, Tripp, Savage, Danforth, Penton, etc.

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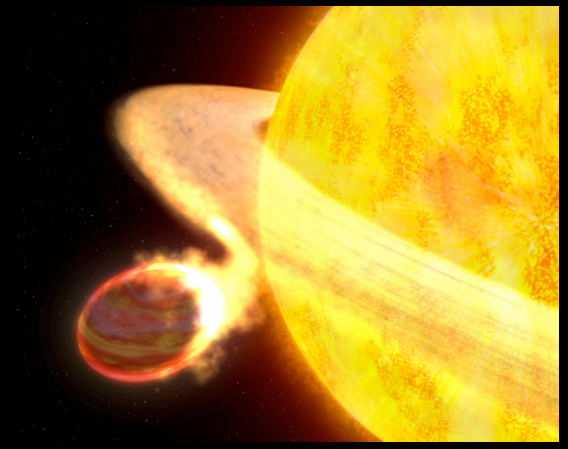
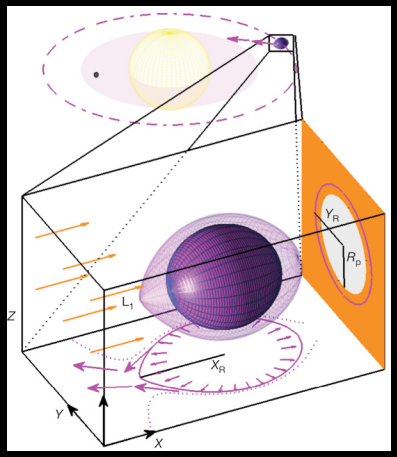
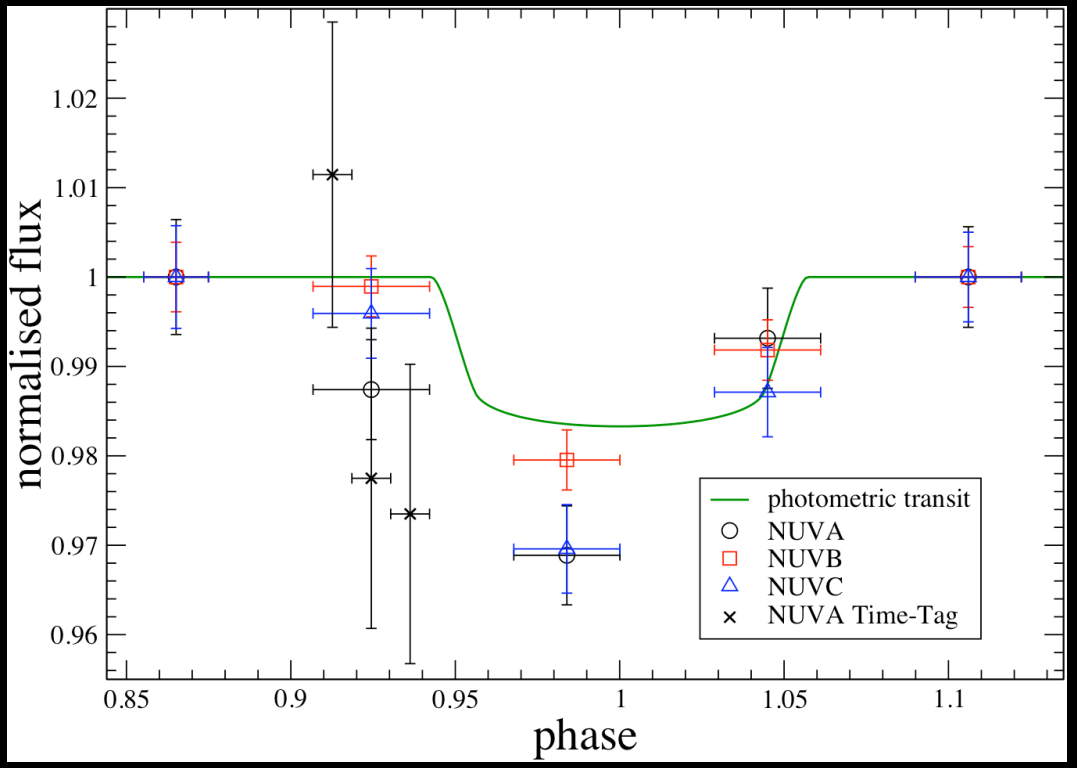
Transiting Exoplanet Wasp-12

- Hottest transiting exoplanet, closest to parent star: 1.5 M_J; 1 day P_{orb}
- GO program (PI: Haswell): test "blow-off" hypothesis using NUV spectroscopy
- Transit in MgII, Mn I, Sc II, etc. deeper than in continuum-dominated region
- Inferred radii ≈2.6 M_J, larger than planetary Roche lobe ⇒ exosphere
- Early ingress in metals could be disk around planet, consistent with model predictions of tidal stripping in Wasp-12 (Li et al. 2010)

Fossati et al. 2010, ApJL, 714, L222







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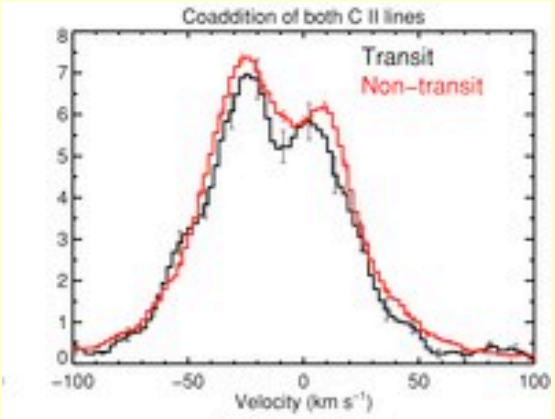
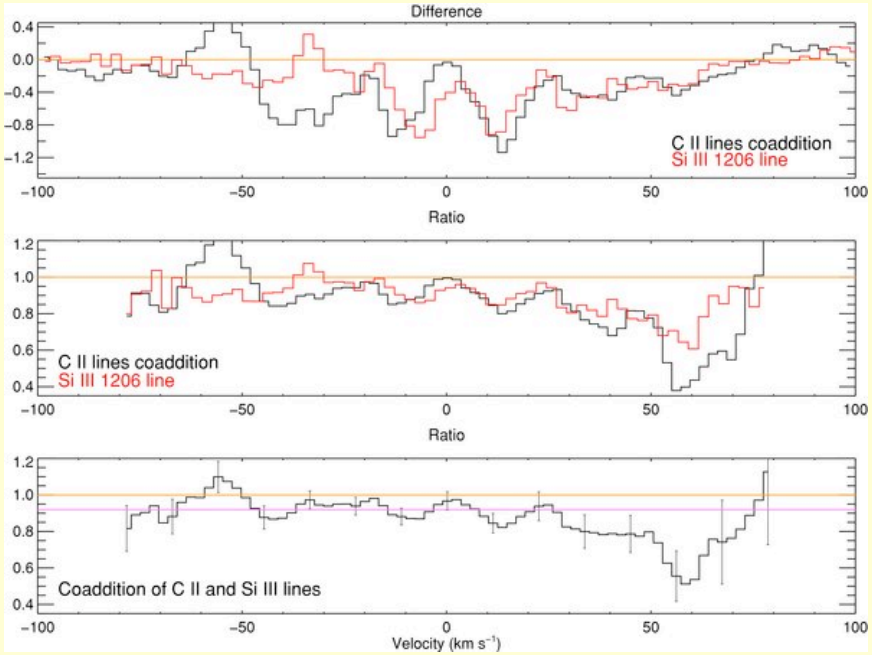
HD209458B

- FUV spectroscopy of transit, behind star, quadrature positions
- Transit detection (~8%) in CII, Si III
- Velocity-resolved transit seen from -50 to 50 km/s with probable substructure
- Mass loss rate 8×10^{10} g/s (thermal absorption only)
- Non-detection of auroral H_2 from the planet constrains H column density between star and planet; weak planetary magnetic field
- See Linsky presentation





Linsky et al. 2010, ApJ, 717, 1291
France et al. 2010, ApJ, 712, 1277

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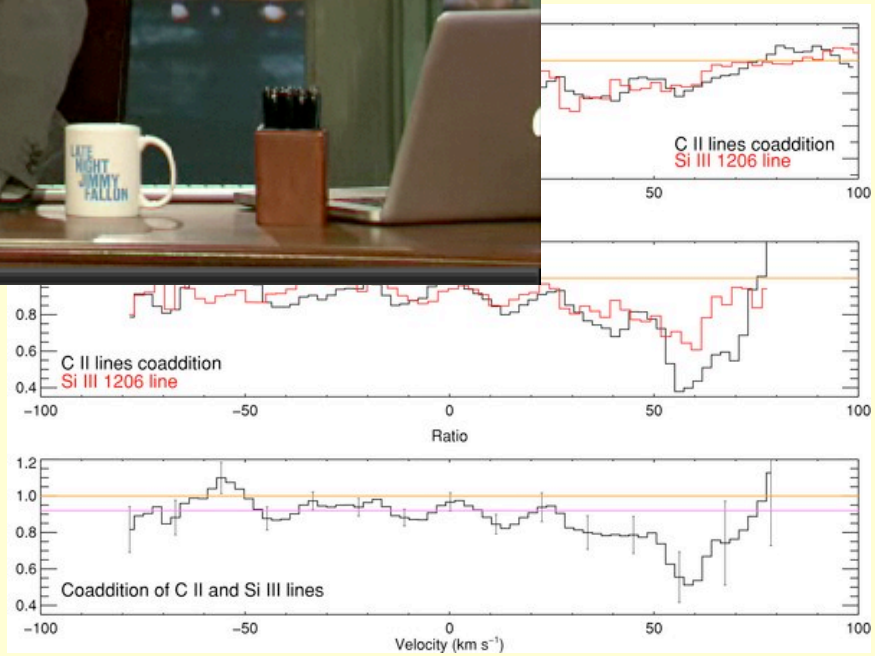

Linsky et al. 2010, ApJ, 717, 1291
France et al. 2010, ApJ, 712, 1277

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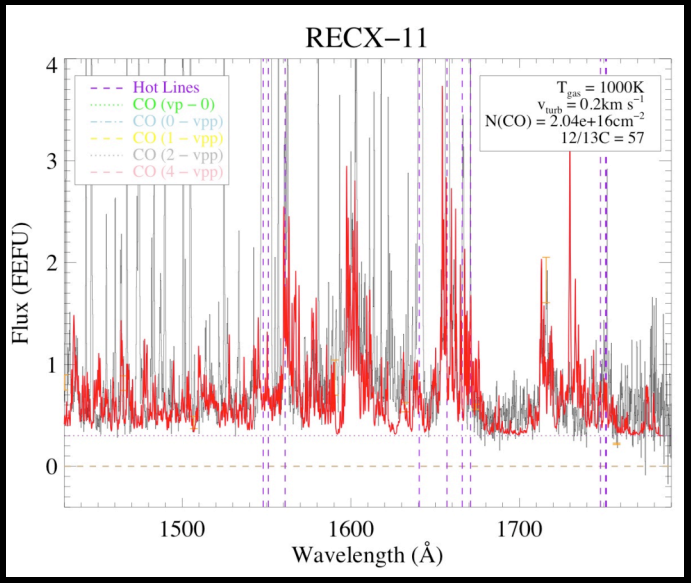
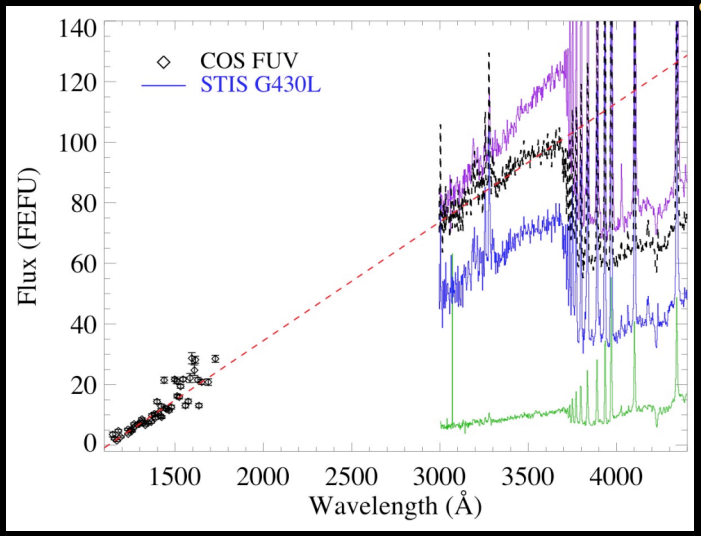
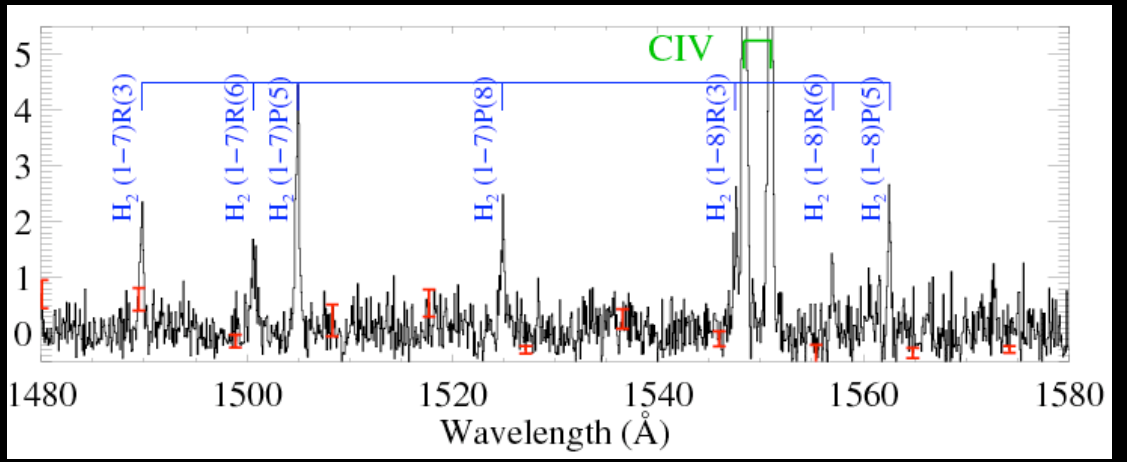
Protoplanetary Disk Spectra

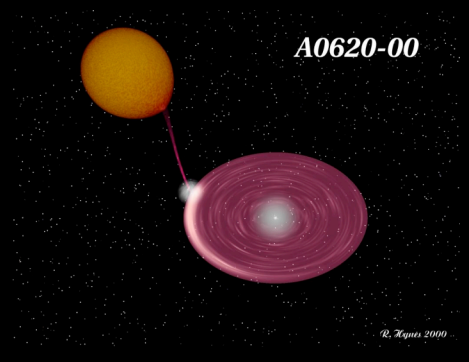


- RECX-11: Significant CO band emission contribution to "continuum" in planet-forming region; not just e$^-$ impact H_2 or hot accretion column
- Brown dwarf accretor 2M1207: Low mass analog to T Tauri stars; resolved H_2 line profile gives location of emission at dust sublimation radius/inner edge of the accretion disk
- Continuum FUV radiation field increases inner disk illumination (from M2 to "effective" A), affecting molecular chemistry in the protoplanetary disk at the epoch when planet formation is occurring
- See France poster, Herczeg talk (Friday)





France et al. 2010, ApJ, 715, 596



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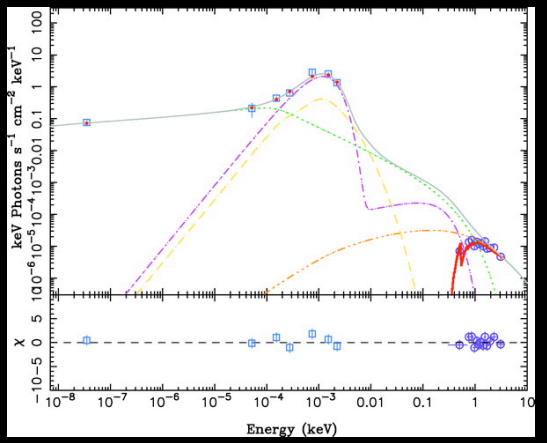
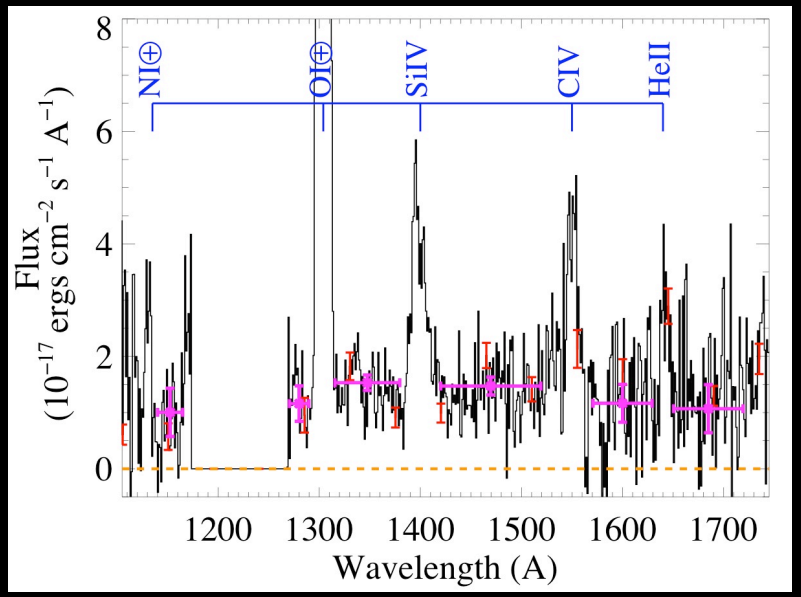
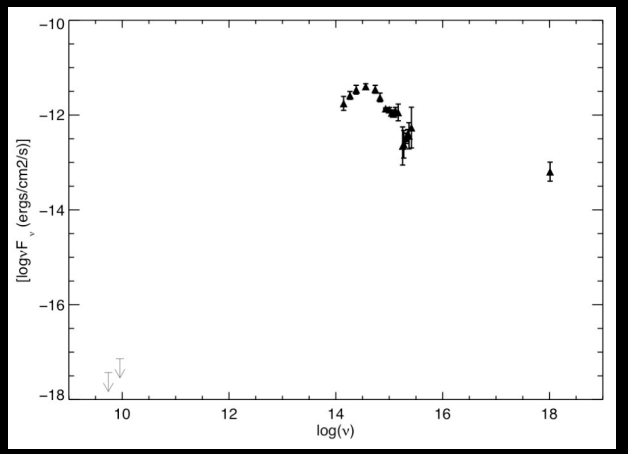
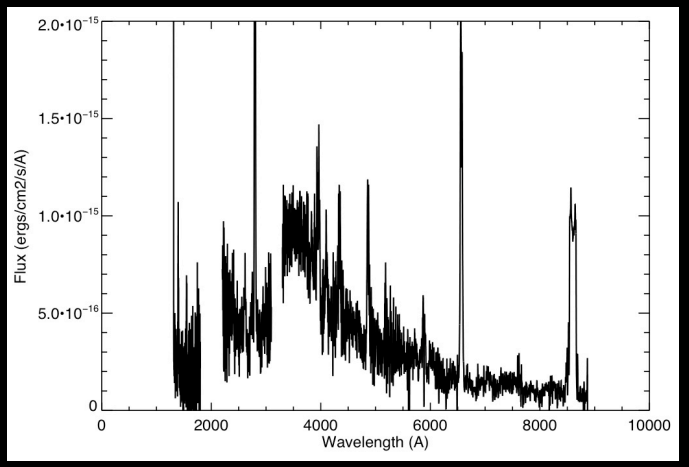




- FUV spectrum of quiescent black hole X-ray binary, A0620-00
- Continuum detection at 1.5e-17 ergs/cm^2/s/Å!



- CNO processing in evolved companion: constraints on age, evolution
- Structure, energetics of disk chromosphere
- Broadband X-ray, UV, optical/NIR, and radio SED to compare to models (ADAF, jets)



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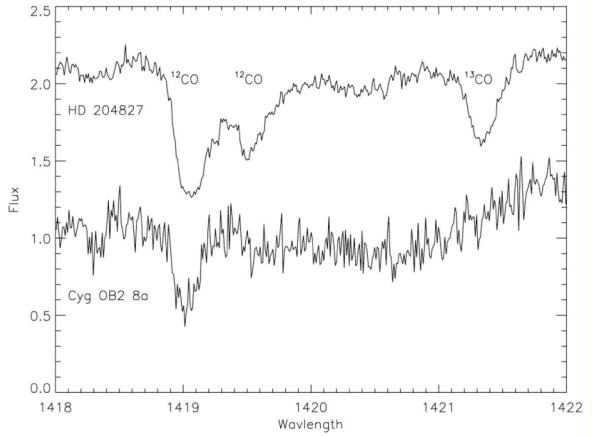
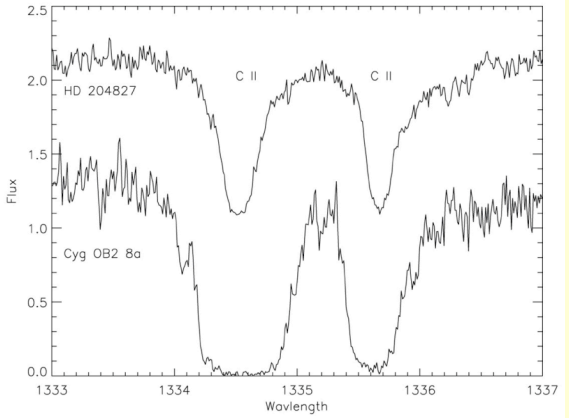
Translucent Clouds

- Observations of sightlines in the cold ISM
- Goal: first UV spectra of true translucent clouds, chemistry and physical conditions
- Study atomic to molecular hydrogen ratios, depletions, and molecular abundances in diffuse vs. translucent clouds
- Cyg OB2 8a: highest HI column density observed so far (21.95)
- HD204827 spectroscopic binary: use to search for neutral PAHs
- Snow et al. 2010, ApJL, 720, L190

CO Comparison



C II Comparison



	Cyg OB2 8a	HD 204827	Translucent Clouds (Burgh et al. 2010)
CO/H_2	8.6×10^{-7}	1.4×10^{-5}	$> 10^{-6}$
CO/C I	0.02-1.5	0.2	> 1.0
f_{H2}	0.17	0.67	> 0.4
N_{CN}	12.36	13.74	-

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For More Information

- See talks this week by Green, Tumlinson, Lehner, Thom, Stocke, Heap, Aloisi
- Posters by Barstow, Beasley, Beland, Burgh, Danforth, France, Kriss, Lennon, Linsky, Osterman, Penton, Snow, Wofford, etc.
- Attend the Friday splinter session: invited talks by Tripp, Herczeg, science presentations, discussion of on-orbit performance, calibration, etc.