Cosmic Origins Spectrograph
Hubble Space Telescope

Scientific Observations with the Cosmic Origins Spectrograph

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Outline

I. Observing with COS
II. COS Science Themes
Observing with COS
Overview

- COS is an ultraviolet (1150 – 3200 Å) spectrograph designed to maximize sensitivity for point or point-like source observations at low (R~2000) and moderate (R~20,000) spectral resolutions
- FUV (1150 – 2050 Å) sensitivities exceed comparable STIS modes by 10 to 20; NUV (1700 – 3200 Å) by 2
- COS and STIS will provide a powerful, complementary UV spectroscopy capability for HST
COS Sensitivities

- Limiting magnitude for S/N=10 in 3600 sec (R=10,000)
- FUV gains >10 in sensitivity, 70 in observing speed
- COS gains: faint targets (discovery), observing times (survey)
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COS FUV Channel

• Two detector segments, similar in look and feel to FUSE detectors, but at much higher effective area, lower (effectively zero) background, scattered light
• In medium resolution modes, a single exposure covers a 300 Å bandpass at R = 20,000 – 24,000
• Points to consider when planning observations:
  – Binned-up G130M and G160M have higher throughputs than G140L and may be preferred for most observations
  – Full instrument performance (resolution, wavelength calibration, throughput) is achieved for point sources within 0.5" of aperture center
  – The BOA aperture has degraded spectral resolution performance (R~12,000 for M modes); STIS may be better
  – Time-tagged (32 ms) data and tag-flash observing mode for most targets
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- One of two detector segments, 15384x1024 pixels per segment
- Note background (10 cts/sec/segment!)
- PtNe spectrum from thermal vacuum tests: 1304 – 1445 Å

COS FUV Channel

Science

Cal
COS NUV Channel

• MAMA detector similar to STIS (is in fact the STIS flight spare)
• In M modes, three spectral stripes cover 3x35 Å non-contiguous regions at R=16,000 – 24,000
• Points to consider when planning observations:
  – COS sensitivity about 2x STIS in NUV but wavelength coverage per exposure more limited; choice depends on science
  – Bright object protection limits target fluxes in PSA to global fluxes $\leq 2 \times 10^{-12}$ erg cm$^{-2}$ s$^{-1}$ Å$^{-1}$ (FUV) and $\leq 2 \times 10^{-11}$ erg cm$^{-2}$ s$^{-1}$ Å$^{-1}$ (NUV); O9V star; local count rate limits also apply
  – COS has a limited (2.5") imaging mode: broadband (1700 – 3200 Å), highly sensitive; 2 pixel FWHM at 0.024"/pixel
- NUV thermal vacuum data
- Note that calibration lamp lines are not in focus
- “Tag-flash” will be the standard mode for on-orbit time-tag observations
COS Science Themes
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.”
The Intergalactic Medium
• Available sight lines increased from a score to hundreds
• This facilitates broader surveys, spatial structure maps, probes into the most diffuse clouds and detection of weak metal lines

Quasar Absorption Lines trace the “Cosmic Web” of material between the galaxies

- Visualization concept from Schiminovich & Martin
- Numerical simulation from Cen & Ostriker (1998)
- Songaila et al. (1995) Keck spectrum adapted by Lindler & Heap
IGM Programs
- Baryon census of the diffuse IGM
- Large-scale structure probes
- Formation of galaxies, galaxy-IGM interactions, feedback
- Chemical evolution and transport
- HeII Gunn-Peterson
- Lyα emission in local starburst galaxies as cosmological templates
- AGN structure and outflows

Spatial mapping of the IGM
Available COS sightlines through the Great Wall; S/N=20 in <5 orbits (S. Penton).
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The Warm and Warm-Hot ISM
• Increased number of background targets for MW and extragalactic ISM observations
• Rich set of diagnostic lines; multiple species and ionization states
• Programs include:
  – Probes of Galactic corona and origins of highly ionized gas
  – Temperature and structure of the Local Bubble
  – Extragalactic SNRs; shock processes; metallicity effects
  – Extragalactic HII regions; near-field cosmology
  – Local environments of GRBs

The High Velocity H I + O VI Sky
The Cold ISM

- COS sensitivity extends probes of dense clouds up to $A_V > 7$
- First spectra of truly translucent clouds, regions where $C^+ \Rightarrow C$ and CO
- Extinction curves to trace dust formation, grain size as gas becomes neutral
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Snow & McCall 2006 ARAA, 44, 367
Stars
- Observations of faint targets, such as L and T dwarf chromospheres
- Trace magnetospheric activity as a function of age, metallicity
- Time-tagged (32 ms) observations of time-variable objects, such as interacting binaries, accretion disk systems
- Stellar winds and outflows in massive stars, pre-main sequence stars
- Spectroscopy of faint white dwarfs

STIS spectrum of L-dwarf (M = 0.03 M$_{\text{sun}}$) 2MASSW J1207334-393254 (Gizis et al. 2005).
Solar System and Extrasolar Planets

- Improved sensitivity allows for higher spectral (and time) resolution observations of extrasolar planet transits, determination of line widths, velocities, chemical composition of atmospheres
- Number of stellar occultation events for studies of planetary, cometary, and satellite atmospheres will increase by an order of magnitude and with finer resolution capabilities
- Observations of seasonal changes, spatial distributions, chemical composition of atmospheres in the solar system

COS Science team

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COS Guaranteed Time Observations

COS GTO program is a mix of programs, united by the theme of cosmic origins.

Phase I forms are available online:
http://www.stsci.edu/hst/proposing/docs/COS-GTO
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For more information:

STScI COS information:
http://www.stsci.edu/hst/cos

Colorado COS web site:
http://cos.colorado.edu/

GSFC HST site:
http://hubble.nasa.gov/index.php