The Many Important Roles that IUE Played in Developing UV Spectroscopy: Lessons for the Future

Jeffrey L. Linsky - University of Colorado, Boulder Colorado
Al Holm - Retired, STScI
Joy Nichols – CfA. Cambridge Massachusetts

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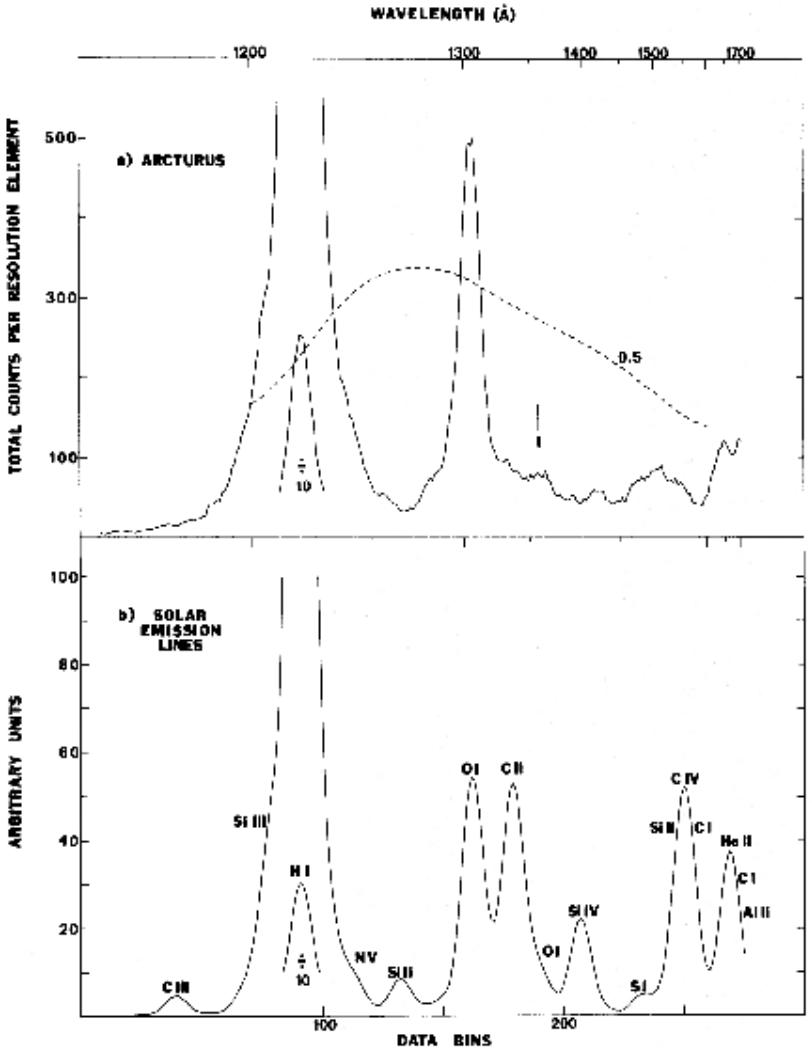
Outline

- UV spectroscopy prior to IUE (1940s to 1977) - Discoveries despite limitations.
- IUE era (1978 to 1996): New observational capabilities and new discoveries. What worked well for IUE should be a part of future missions.
- Post-IUE era: The observational techniques developed by IUE and the experienced personnel who worked on IUE are needed in future UV spectroscopy missions.
- MIND THE GAP splinter session at the 243rd AAS meeting in New Orleans will solicit and discuss community input into near-term science drivers for UV spectroscopy and spectropolarimetry and technology developments for the GAP era. Submit abstracts by Oct 31.

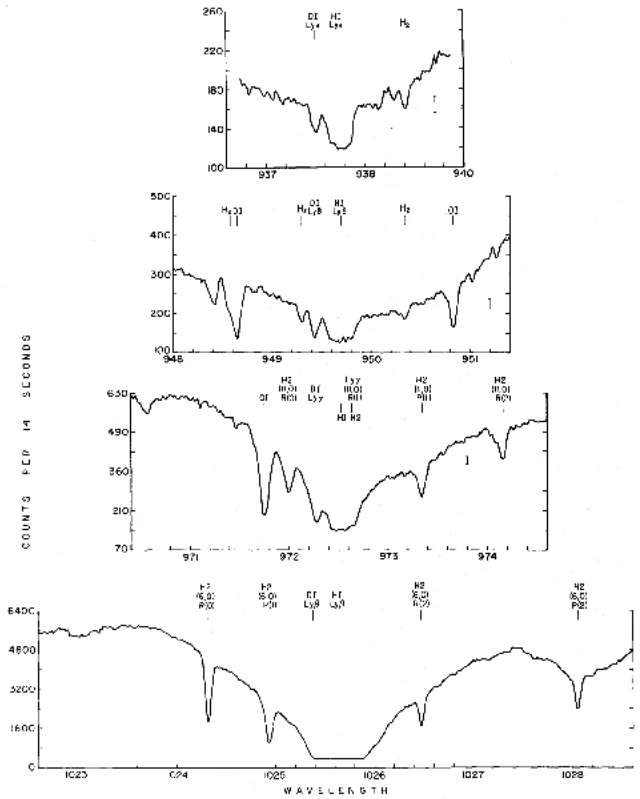
Prior to IUE there were UV spectrographs on rockets and balloons with new discoveries

- Post-WW2 Tousey first used captured V2 rockets to obtain UV spectra of the Sun.
- Spectrometers on rockets (Morton, Carruthers, Hopkins group, etc.) obtained far-UV spectra of O stars, ISM, and cool stars.
- FUV rocket spectrum of Arcturus (Weinstein et al. 1977).
- Kondo used spectrometers on balloons to obtain near-UV Mg II (2800Å) stellar spectra.

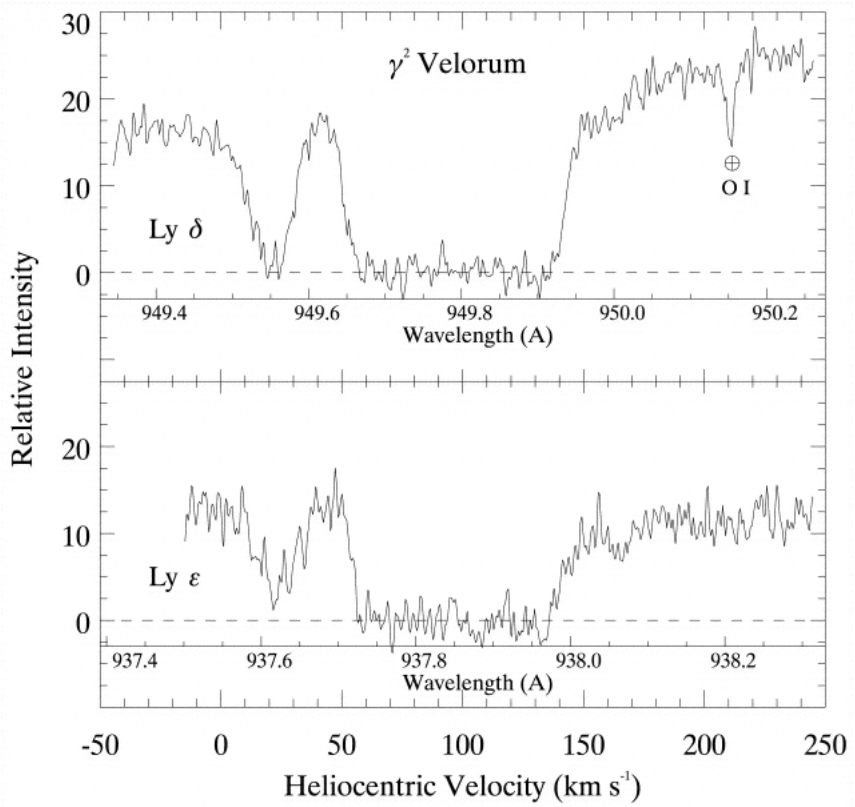


Copernicus (OAO-C) spectra: Will HWO and other missions be able to observe at 912-120 nm?

γ Cas (B0.5 IVp)

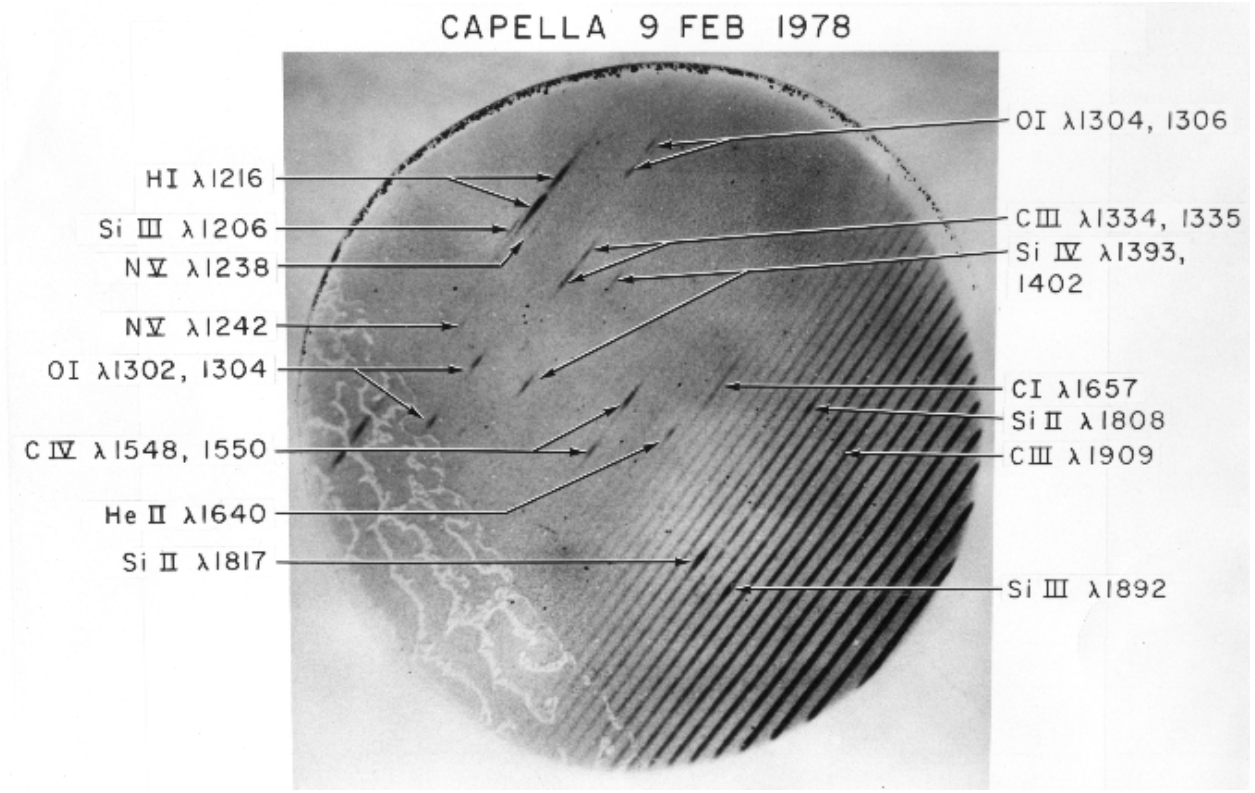


γ^2 Vel(WC8+O7.5 III)



What was new with IUE spectra – implications for the future

- Broad spectra range in 2 bands (FUV 1200-2300Å, NUV 2000-3200Å).
- Modest spectral resolution R=12,000 and low resolution. Inadequate for many scientific topics.
- Improved sensitivity (45 cm telescope).
- Studies of targets of opportunity (supernovae, novae, CVs, etc.). Extremely productive scientifically.
- Coordinated observations (e.g., X-ray, optical, IR). Extremely important.
- More than 1400 publications on a wide variety of astronomical targets.

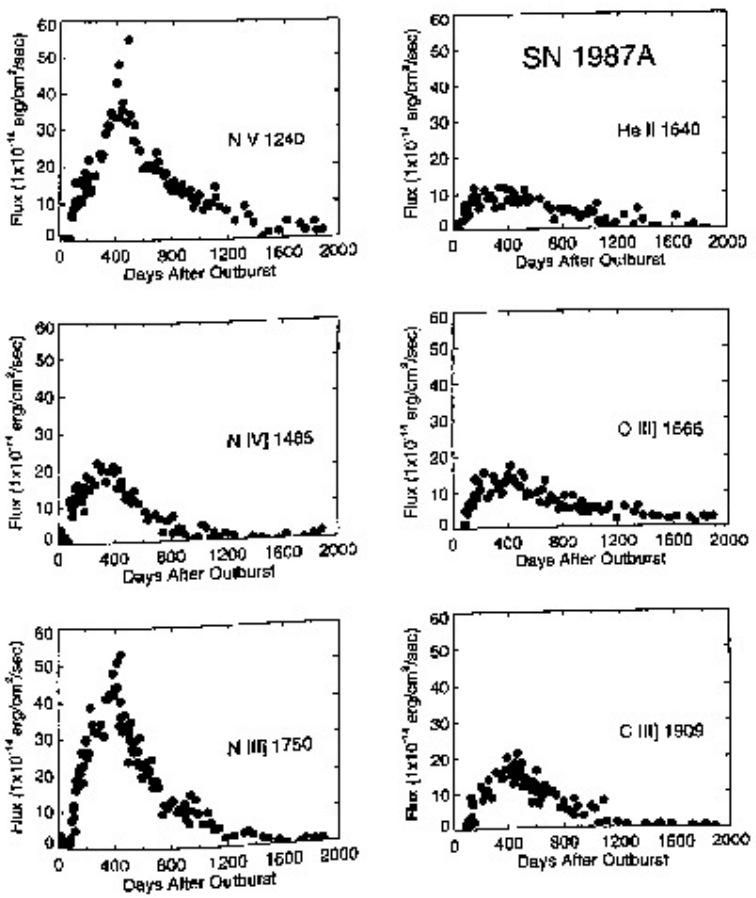


What was new with IUE Operations

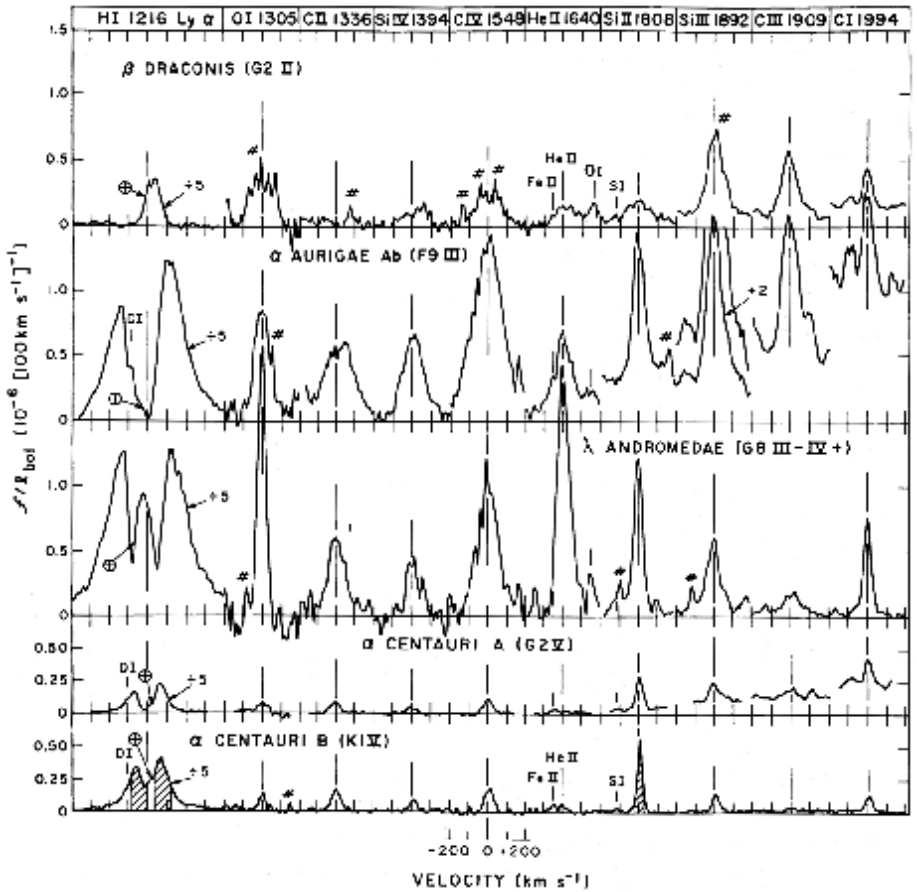
- Pure guest observer mission brought in many observers with programs selected by merit.
- Ability to modify the observing program in real time because the observer could see a spectrum soon after it was obtained. (Jeff Linsky and Fred Espanak).
- Ability to study many targets in a class, among classes, and time-dependent phenomena lasting decades (e.g., variability, flares, novae, cycles, rotation, etc.) with long-term observing programs.

Two examples of IUE spectra

SN 1987A (Sonneborn et al. (1994)



Cool star comparisons (Brown et al.)

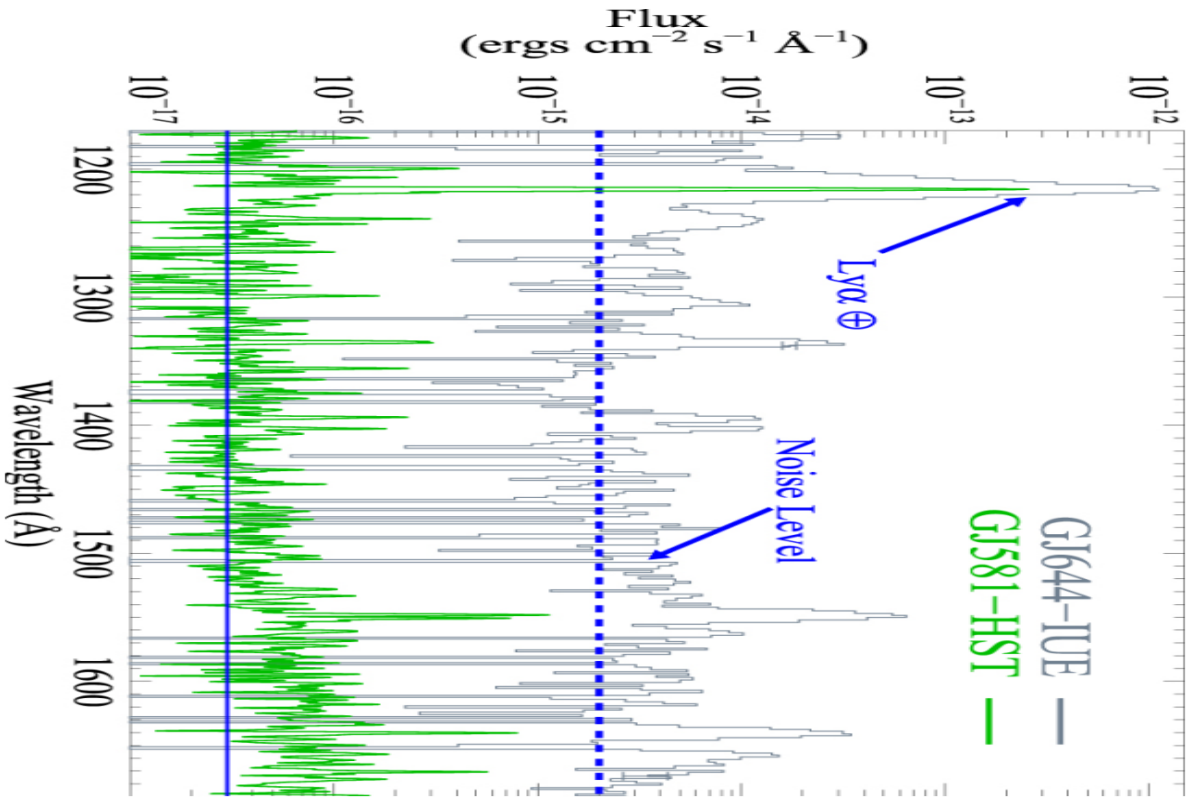


Personnel contributions to future missions

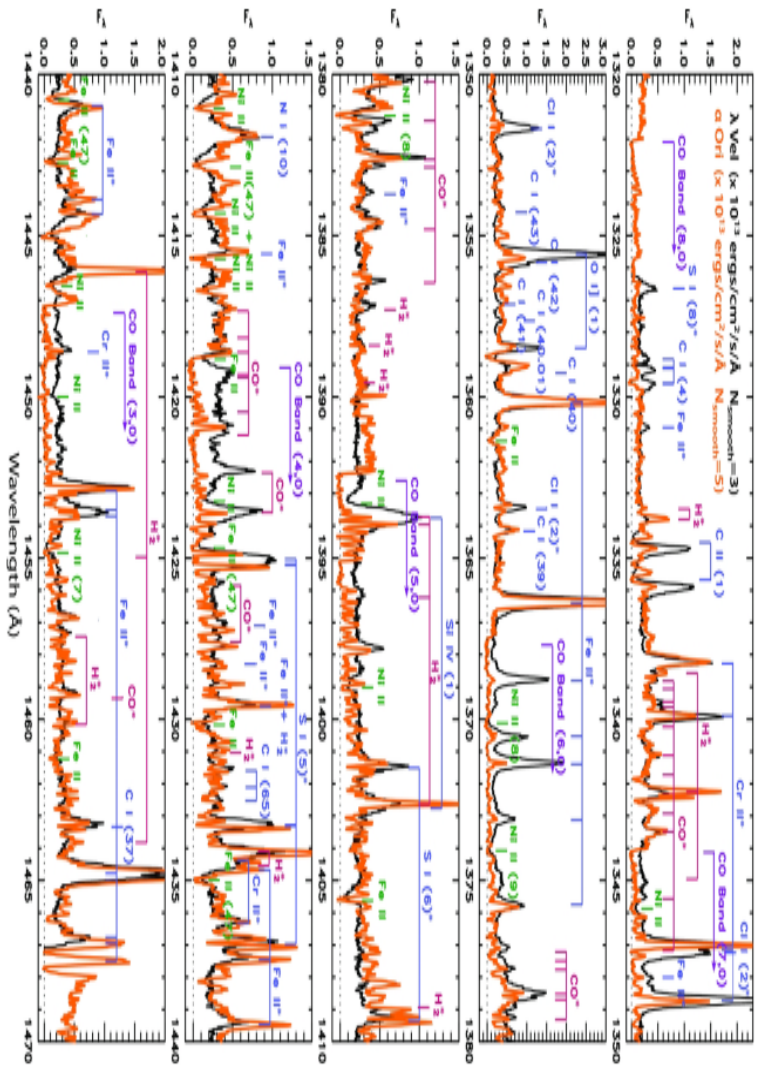
- Many people trained on IUE became leaders of new missions (e.g., FUSE, HST/GHRS, HST/STIS, HST/COS). Will this happen for HWO given the ≈15 year time gap after HST?
- Most people on GHRS Science Team (pictured) used IUE.
- IUE observers became expert HST observers.

Limitations of IUE – implications for the future

- HST/COS has 100 times lower noise level due to larger aperture, low noise detectors, more efficient optics. Intercomparison of data with past missions will provide a better understanding of real instrumental signal and noise (France et al. 2016).
- IUE was limited in studies of faint stars (e.g., M dwarfs) and galaxies. Going deeper is always rewarded.
- The scientific output of IUE benefitted greatly from real time changes in observing programs to optimize science. Will future large missions have this capability?
- Inadequate spectral resolution limited IUE studies of the ISM. Will HWO have the needed resolution R≥100,000?



HST/COS point source spectra of Alpha Cen A,B (Ayres et al. 2015) and Lambda Vel (K4 Ib) (Carpenter et al. 2014)



After HST?

- The lifetime of HST and its spectrographs is limited, perhaps 5 years.
- Habitable Worlds Observatory will not be in orbit until the mid-2040s, but it needs precursor observations and expertise in science and data operations to operate efficiently.
- After HST there will be 15-20 years with no high-resolution (R≥100,000) UV spectroscopy. Moderate resolution UV spectroscopy can be done with modern 1m class missions, and low resolution UV spectroscopy can be done with small missions.
- MIND THE GAP splinter session at the 243rd AAS meeting in New Orleans (January 2024). We solicit and will discuss community input into near-term science drivers for UV spectroscopy and spectropolarimety and technology developments for the GAP era. Submit abstracts to mindthegap.wikidot.com (by Oct 31).
- Students and early career astrophysicists are the researchers who will use future UV missions are especially invited to participate.

Limitations of the the pre-IUE UV spectra

- Limited sensitivity due to limited observing time (rocket spectra), spectral scanning (Copernicus), small aperture, low resolution.
- Despite low spectral resolution in FUV (Wisconsin Experiment Package on OAO-2 observed strong stellar and interstellar lines, interstellar dust, and time variations of emission from Comet Bennett 1970).
- Limited spectral range in FUV or NUV.
- Limited opportunities for coordinated observations with other wavelength regions (e.g., X-ray).
- Very limited opportunities for time domain observing sequences to study variability.
- Very limited opportunities to study many members of a class.
- Small community of observers and data analyzers.