COMPOSITION OF THE ORION NEBULA

Using the Hubble Space Telescope Faint Object Spectrograph

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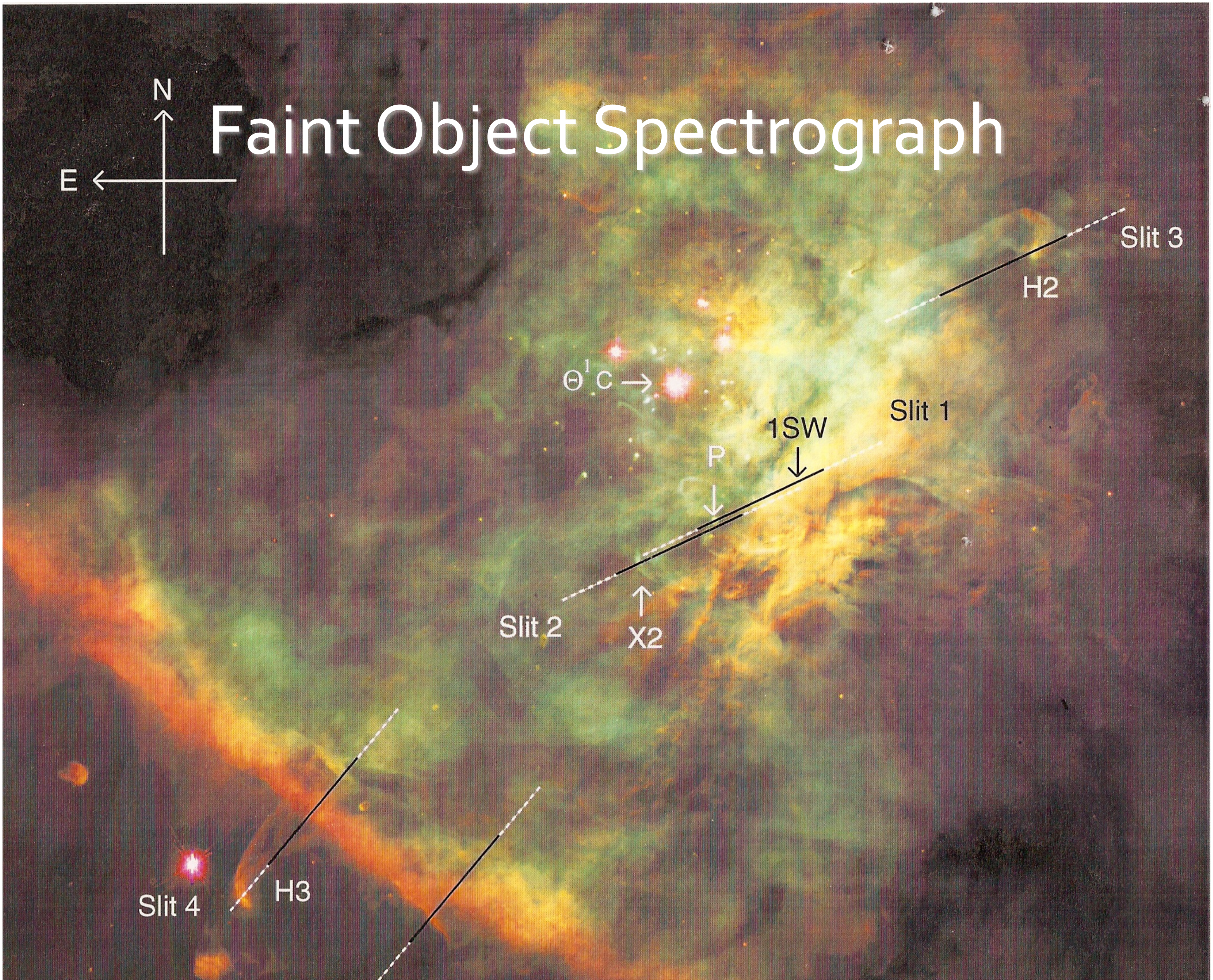
Motivation

- Analyze elemental abundances in the Orion Nebula with HST FOS data
- Ability to analyze data from UV and visible regions with the **same instrument** observing the **same position** in the nebula
- UV data enables determination of carbon abundances

HII regions

- Clouds of ionized gas
- Regions of recent star formation
- Orion Nebula is the closest H II region (1344 light years)

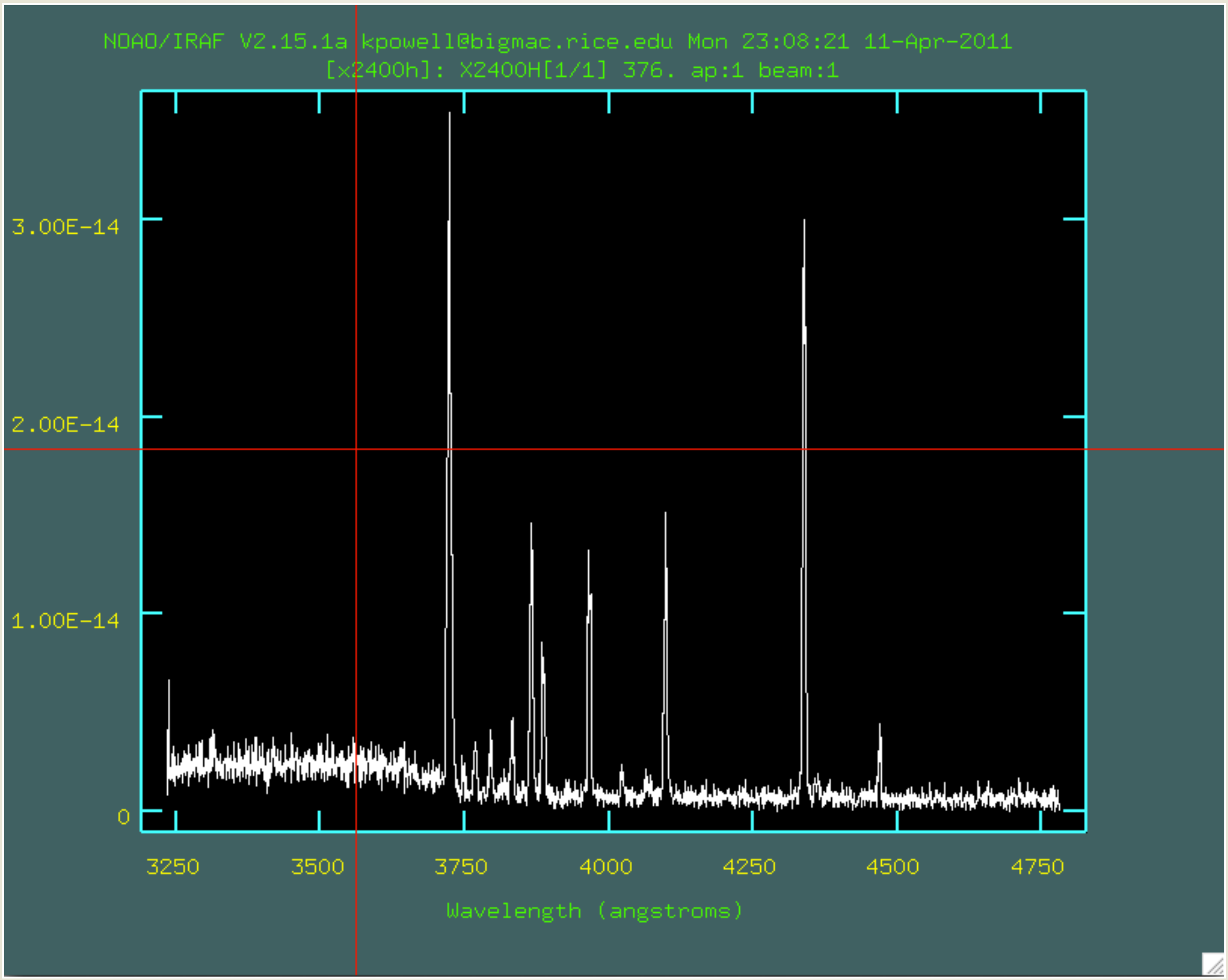
Faint Object Spectrograph



Collisionally excited lines

- “Forbidden” lines
  - Transitions produce lines not observed in the lab; very unlikely under normal conditions
  - Observed in low-density gases where atomic collisions are infrequent, like H II regions!
  - Notated by square brackets: O++ → [O III]
- Measure the intensities of these lines to learn about conditions in the nebula

Measuring Line Intensities



Reddening Correction

$$\frac{I(\lambda)}{I(H\beta)} = \frac{F(\lambda)}{F(H\beta)} 10^{c[f(\lambda) - f(H\beta)]}$$

reddening-corrected flux

measured flux

extinction correction parameter that varies with wavelength

$$c = \frac{\log_{10}(2.86) - \log(H\alpha/H\beta)}{-0.274}$$

Hα, Hβ : Balmer lines of hydrogen

nebular

- Package in Space Telescope Science Data Analysis System
- Shaw & Dufour (1995)
- Calculate temperatures, densities, and abundances in IRAF

Temperature and Density Calculations

- Strength of the forbidden lines is very sensitive to temperature
- Due to weak/noisy lines needed to determine temperature, values presented here are from the literature

$$T_e(OIII) = \frac{(4959 + 5007)}{4363}$$

$$T_e(NII) = \frac{(6548 + 6584)}{5755}$$

$$N_e(SII) = \frac{6716}{6731}$$

Abundance Calculations

Ionic abundances → Total elemental abundances

$O/H = (O^{+} + O^{++})/H^{+}$

$S/H = (S^{+} + S^{++})/H^{+}$

$N/H = (N^{+}/O^{+})*(O/H)$

$Ne/H = (Ne^{++}/O^{++})*(O/H)$

$C/H = (C^{++}/O^{++})*(O/H)$

-Where possible, sum the contribution from multiple excitation states

-Otherwise, take advantage of similar ionization potentials and use O/H correction factor

-log(X/H) + 12

Elemental Abundances

log(X/H) + 12

Object	C	N	O	Ne	S
Orion 1SW	8.66	7.88	8.46	7.76	6.98
Orion X2	8.44	7.65	8.51	7.64	6.95
Orion*	8.39	7.62	8.48	7.70	6.97
Solar*	8.59	7.92	8.69	8.08	7.32

*Stasinska, G. (2004) In *Cosmochemistry: The Melting Pot of the Elements,* Cambridge U. Press.

Conclusions

- Determined elemental abundances in the Orion Nebula from collisionally excited spectral lines
- Found consistent abundances with FOS spectra
  - Oxygen consistent with literature
  - Carbon within reasonable limits
- Not able to determine temperatures precisely enough with HST FOS