Lecture 14

December 8, 2011

Lab 7 – Spectroscopy of the Orion Nebula

News

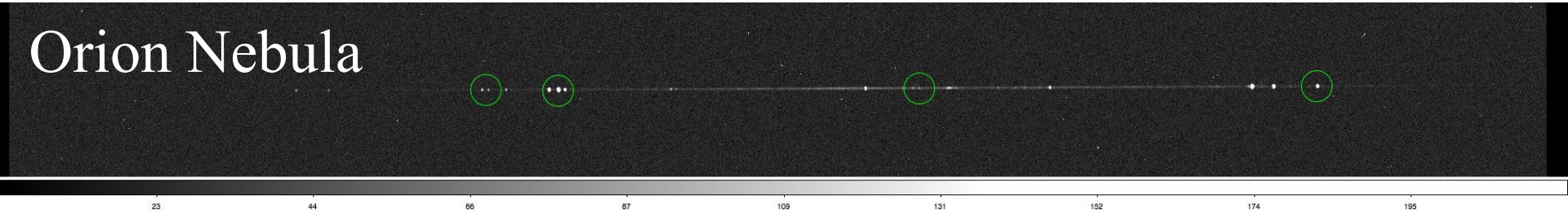
- Rutgers Astronomical Society
  - Observing with the Faraday Christmas Lectures.
    - Friday, Saturday, and Sunday 6-10 PM
    - The 8-inch telescopes will be set up on the Engineering Quad (follow the red lights from the Physics Lecture Hall).
- Lab 7 – Nebular Spectroscopy
  - Due: Thursday, December 8 (accepted without penalty through the last day of class)

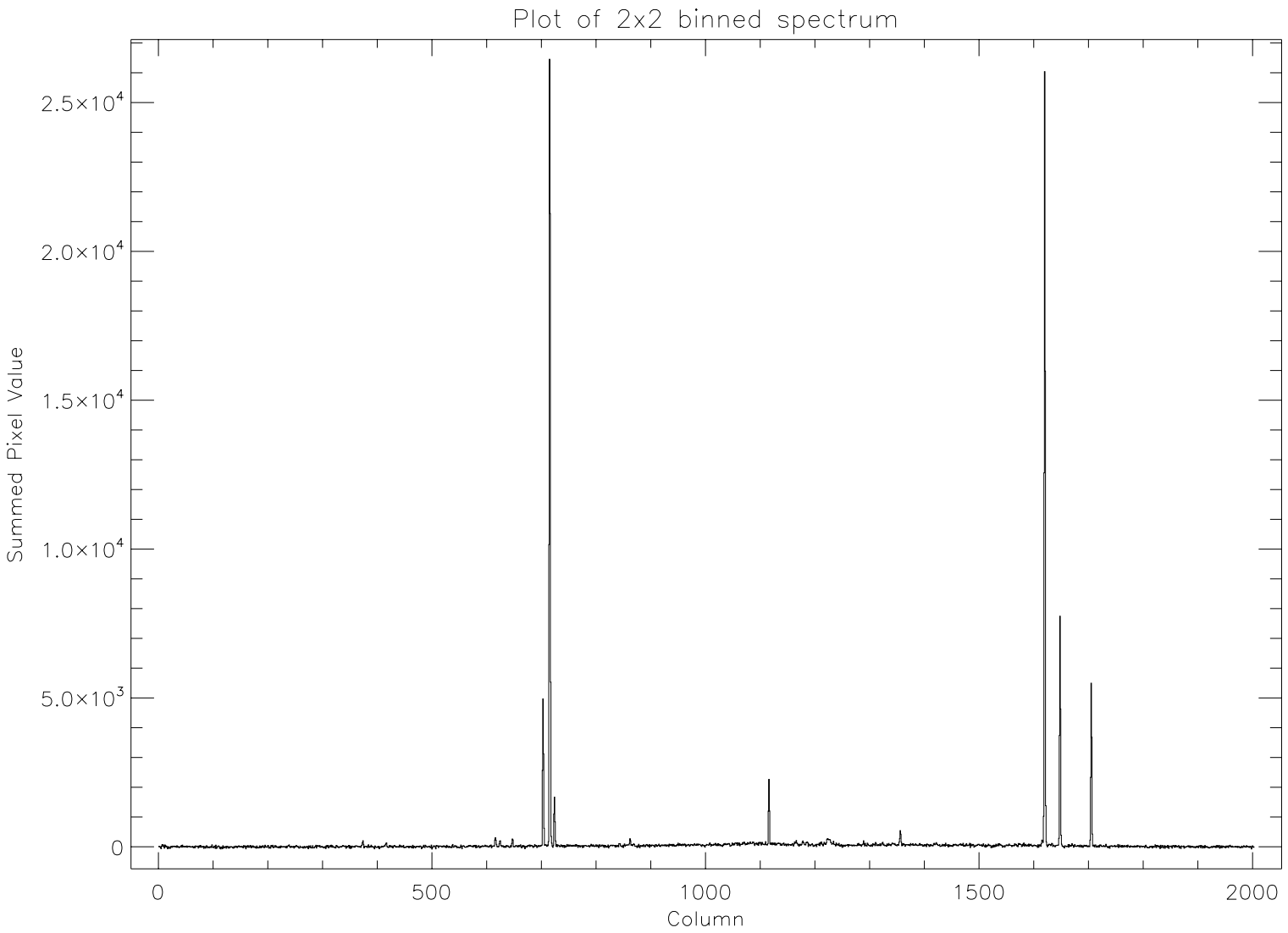
Spectroscopy of the Orion Nebula

- Spectroscopy is a very powerful tool for determining physical properties of astronomical objects.
  - Temperature, density, composition, …

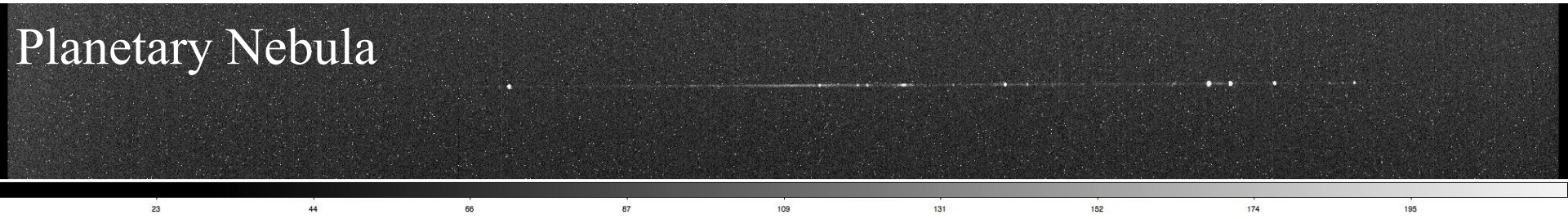
- Orion Nebula (M42)
  - Nearest site of active star formation. (~430 pc)
  - A dense cloud of (mostly) hydrogen gas illuminated and ionized by (ultraviolet) light emitted by partially embedded hot, young (newly-formed) stars.

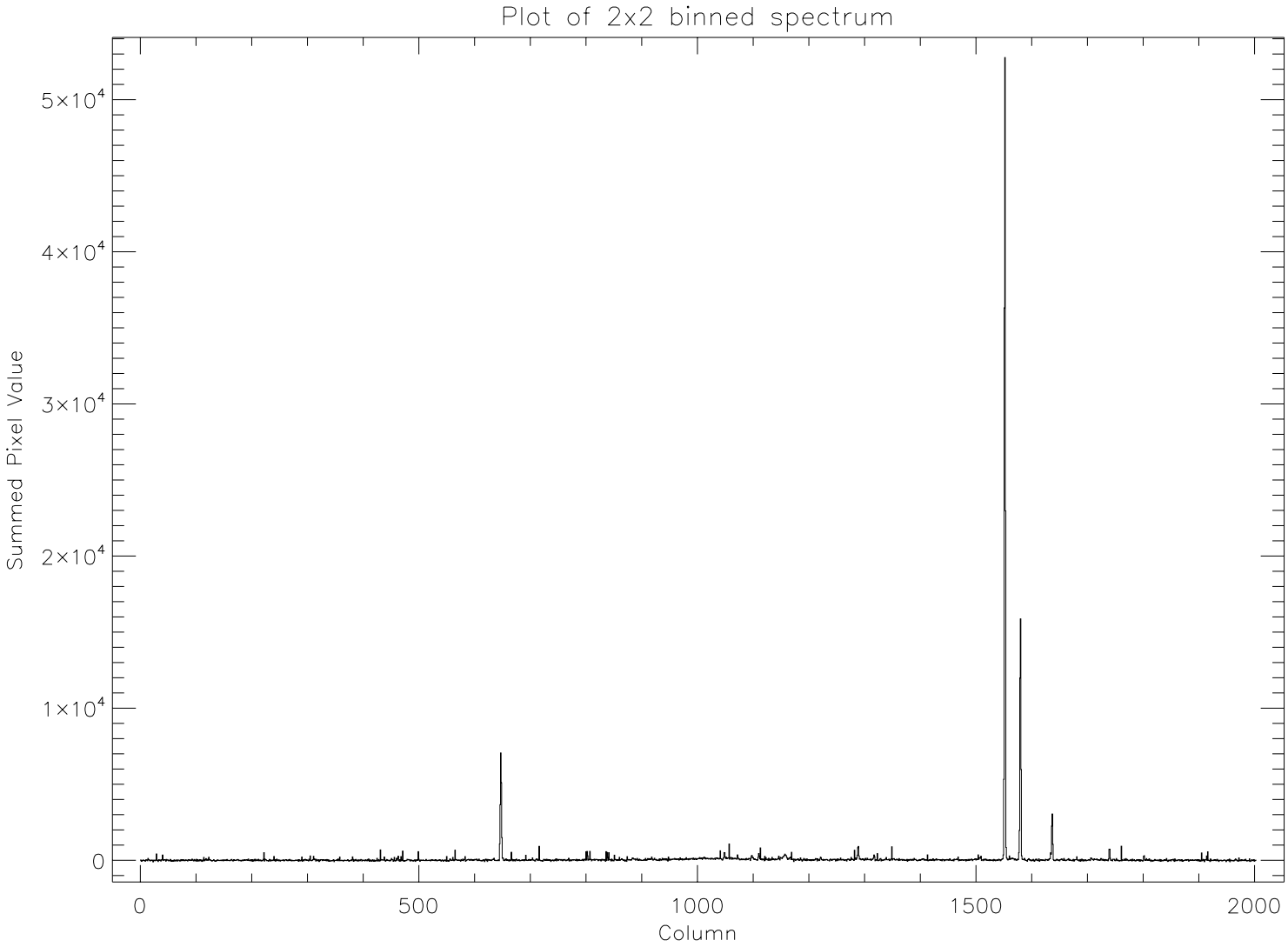
Orion Nebula

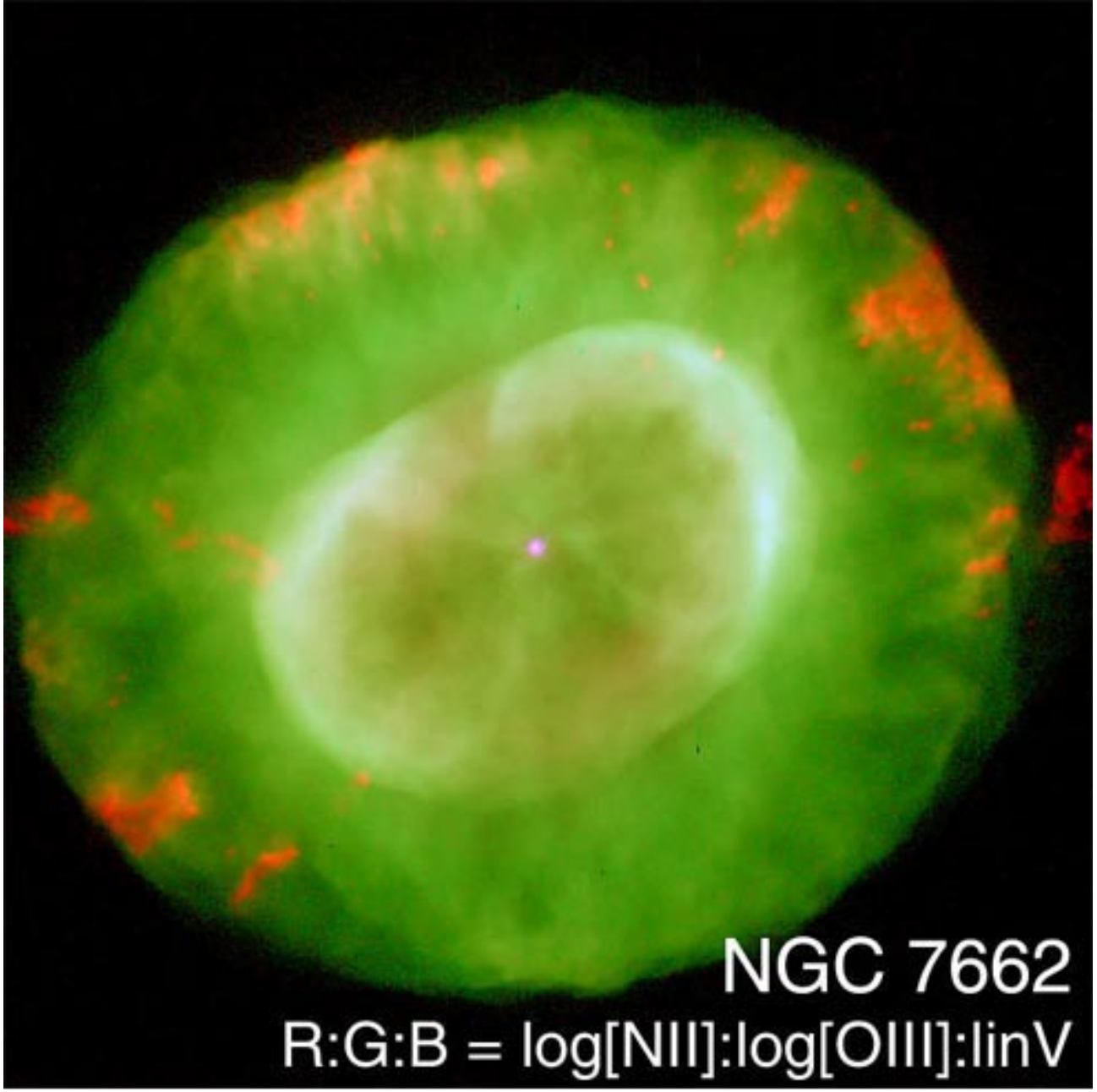




Planetary Nebula







NGC 7662 G106.5-17.6 23 25 54.00 +42 32 06.0, R:G:B = log[NII]: log[OIII]: linear V
HST/WFPC2/PC1 N is NOT up. credit: Hajian et al (unpublished)
HST archives, GO 7501/8390/8773

Not much nitrogen in NGC7662 = Blue snowball nebula?

Ionized Hydrogen (HII) Regions

- $HI + \gamma_{uv} \rightarrow HII + e^-$ (ionization)
- Emission mechanisms:
  - Recombination: $HII + e^- \rightarrow HI + \gamma$'s (Balmer series)
  - Collisional excitation + radiative de-excitation: $X + e^- \rightarrow X^* + e^- \rightarrow X + \gamma + e^-$ (emission lines)
  - Free-free emission (continuum radio emission)

- Physical conditions:
  - $T \approx 10^3 - 10^4$ K
  - $n_e \approx$ 100's – 1000's cm^{-3} (depending on the nebula)

Temperature Measurements

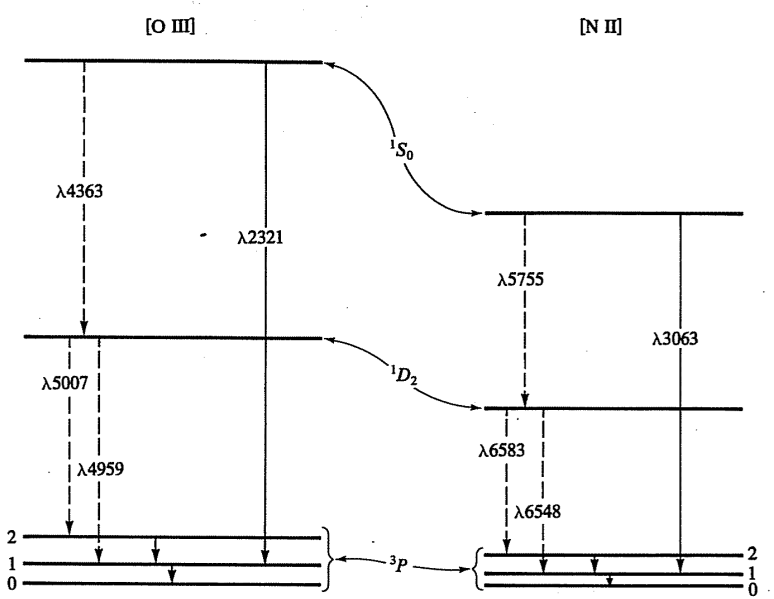


FIGURE 3.1
Energy-level diagram for lowest terms of [O III], all from ground $2p^2$ configuration, and for [N II], of the same isoelectronic sequence. Splitting of the ground ^3P term has been exaggerated for clarity. Emission lines in the optical region are indicated by dashed lines, and by solid lines in the infrared and ultraviolet. Only the strongest transitions are indicated.

Method: measure the ratio of the strength of the emission lines arising from transitions out of two excited states of a single ion.

As the plasma temperature increases, the fraction of electrons with enough energy to excite the higher energy level increases. The electrons have a Boltzmann energy distribution: E-propto-exp(-E/kT).

In the simplest (low-density) picture, every collisional excitation is followed by a radiative de-excitation.