HST SPECTROSCOPY OF THE ORION NEBULA

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Abstract.
From our recent Faint Object Spectrograph (FOS) observations of the Orion Nebula obtained with the Hubble Space Telescope, we present preliminary results that address the nitrogen abundance. The list of detected lines and their identifications included the first measurement of the N II] 2142 Å line in an H II region. This measurement in conjunction with [O II] 2471 Å permits a new assessment of the important N/O ratio in Orion. Unfortunately, the measurements of the N III] 1747-54 Å multiplet and the O III] 1660-66 Å multiplet have poor signal-to-noise, precluding another independent derivation of N/O.

1. Observations

Several bright regions at varying distances from θ^1 Ori C were observed during 1993 August with HST/FOS at 5–15 Å resolution. For three positions, we have total wavelength coverage from 1650–6800 Å. Additionally,

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at the three positions, we observed at $3250 < \lambda < 6800$ Å through the upper member of the 1.0″ pair of apertures (beam switching). The second member of the paired square aperture provided us with a position located 3″ from each of our primary positions with little added exposure time. This allows us to investigate small-scale variations in ionization and physical conditions in the same part of the nebula.

For the purpose of providing a preliminary list of spectral lines measured, we derive an average of the spectra taken in the three lower apertures at our positions 1, 2, and 3 – 29″, 19″, and 42″ from θ^1 Ori C. We have presented elsewhere a table listing measurements from this composite spectrum – with the measured wavelength, the vacuum rest wavelength and preliminary line identification, our measured flux in the 1″×1″ aperture (erg cm^{-2} s^{-1}), the equivalent width (Å), and the FWHM (Å) (Rubin *et al.* 1994). Because this FOS observing configuration (the 1.0″ pair of apertures) did not have proper calibration observations made until July 1994, the analysis and results presented here are subject to revision. Our Cycle 3 observations included a GHRS spectrum with the large science aperture at Position 1. This G270M exposure covered the region 2310–2360 Å and provided the first detection of Si II] 2335.3 Å emission in an HII region (Walter *et al.* 1994).

2. Discussion

We detected the N II] 2142 Å line(s) in the spectra at position 3 low only. The measurement of this line in Orion is the first in an H II region. Previously it has been seen in RR Tel (Penston *et al.* 1983), nova CrA 1981 (Williams *et al.* 1985), and the η Car S condensation (Davidson *et al.* 1986). There are two lines that arise from $^5S_2$ with lower levels $^3P_2$ (2143.45 Å) and $^3P_1$ (2139.68 Å) – in sum referred to as 2142 Å. The red component is expected to be more than twice as strong as the blue one. Preliminary analysis indicates that position 3 low has the highest T_e as measured by the combined [N II] and [O III] temperatures, which may be significant in explaining why the N II] 2142 Å line is strongest at this position. Further analysis of T_e and temperature fluctuations in the N^+ zone using this line in conjunction with the 5755 and 6584 Å lines, arising at the immediate lower levels, is underway. The measurement of N II] 2142 Å in conjunction with [O II] 2471 Å provides another measurement of the N^+/O^+ abundance ratio that is less sensitive to uncertainties in knowledge of the T_e value/distribution and to uncertainty in differential extinction compared with the more traditional optical method (see below).

Here we simply take the approach of retrofitting our two independent models of Orion (Baldwin *et al.* 1991; Rubin *et al.* 1991) to predict the

N II] 2140–43 Å line and compare with the preliminary fluxes at position 3 low. For our retrofits at this time, in order to narrow the differences in input parameters, we arbitrarily used the Rubin *et al.* ionizing spectrum for θ^1 Ori C and abundance set (whether meritorious or not). We use the same updated effective collision strengths and A-values to solve the N^+ energy level populations. Calamai & Johnson (1991) have laboratory A-values for the 2140–43 Å line. Recently calculated collision strengths affecting all 6 lowest-lying levels are from Stafford *et al.* (1994), although there is another contemporaneous set by Lennon & Burke (1994) that has somewhat different values. For our separate models, we then prorate input nitrogen abundance to force the predicted line ratio to match the extinction-corrected observed N II]2142/[O II]2471 ratio, yielding $(N/O)_{uv}$. The same is done for the [N II]6584/[O II]3727 ratio, which provides $(N/O)_{opt}$ and the observed [N III]57μm/[O III]52μm ratio, yielding $(N/O)_{ir}$. Extinction is corrected for by using $A(\lambda)$ (magn.) $= 2.5\ C(H\beta)\ [1 + f(\lambda)]$, where $C(H\beta) = 0.64$ for our Orion position and $f(\lambda)$ is from Bohlin & Savage (1981) in the UV and from Costero & Peimbert (1970) in the optical. The effect of differential extinction is to increase the observed ratio I(2142)/I(2471) by a factor of 1.20, which is less than for I(3727)/I(6584). For the $(N/O)_{ir}$ determinations, we match to I(57)/I(52) = 0.13 (Rubin *et al.* 1991) at a position which might be typical to our HST locations.

The retrofit of the Baldwin *et al.* model gives $(N/O)_{uv} = 0.109$, $(N/O)_{opt} = 0.0840$, and $(N/O)_{ir} = 0.213$, while the retrofit of the Rubin *et al.* model gives respectively, 0.0843, 0.128, and 0.176. There is much that remains to be done, awaiting final calibration of our FOS spectra, in terms of reconciling these spectral region differences and model differences. This preliminary analysis is to demonstrate the expanded opportunity HST data permit in regards to just one important "unsolved problem" – deriving N/O.

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