Studying Atomic Physics Using the Nighttime Atmosphere as a Laboratory

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Abstract

Many of the atomic transitions observed in low-ionization plasma astrophysical environments, such as planetary nebulae and H II regions, are also manifest in the terrestrial night airglow or nightglow. Ground-based observations of astrophysical objects inevitably capture the spectrum of the nightglow. The combination of the high resolution of these spectra, their associated high-sensitivity detectors, and the ability to calibrate these spectra to high precision in terms of wavelength and absolute intensity, have allowed the observation and measurement of weak permitted and optically-forbidden atomic transitions that are difficult to observe in the laboratory. We present here a summary of our recent work in this area, including a new determination of the wavelengths of the [O I] $^2D^o$–$^2P^o$ $\lambda\lambda$7320,7330 doublets that are used to characterize the velocity field of the Orion Nebula outflow. Also presented are experimental tests of the theoretical intensity ratios of [N I] $^4S^o$–$^2D^o$ $\lambda5198/\lambda5200$ and [O I] ^3P–^1D $\lambda6300/\lambda6364$, used as electron density and temperature diagnostics, and our observations of high-energy triplet and quintet Rydberg series neutral oxygen permitted lines, arising from electron radiative recombination, that allow calculations of effective recombination coefficients used for elemental abundance determination to be verified. Finally, we present our re-confirmation in these spectra of a discrepancy between the observed intensity ratio of [O I] $^1D_2$–$^1S_0$ $\lambda5577$ to [O I] $^3P_1$–$^1S_0$ $\lambda2972$, and the ratios predicted by *ab initio* theory calculations and laboratory experiment, in some cases differing by more than a factor of two.

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