HIGH VIBRATIONAL LEVELS AND POTENTIAL ENERGY CURVES FOR THE O_2 $b^1\Sigma_g^+$, $a^1\Delta_g$, AND $X^3\Sigma_g^-$ STATES DERIVED FROM ATMOSPHERIC NIGHTGLOW EMISSIONS

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The Earth's atmosphere has long been a source of spectroscopic information on molecular oxygen. The 10-m Keck telescope and HIRES spectrograph provide an unprecedented combination of sensitivity, dynamic range, and resolution that enables quantitative spectroscopy using weak, strongly forbidden atmospheric emissions.

We report analyses of emissions from 400 to 850 nm, from the $A^3\Sigma_u^+$, $c^1\Sigma_u^-$, $A'^3\Delta_u$, and $b^1\Sigma_g^+$ states to the ground $X^3\Sigma_g^-$ state (Herzberg I, II, III and Atmospheric Bands), as well as emissions from $A'^3\Delta_u$ to $a^1\Delta_g$ (Chamberlain Bands). The ranges of quantitatively known vibrational levels in $b^1\Sigma_g^+$ and $a^1\Delta_g$ are extended to v' = 15 and 12, from previous values of 3 and 6, respectively. Uncertainties in vibrational levels v" = 5-8 in the ground $X^3\Sigma_g^-$ state are also removed.

In the 400-600 nm region, nightglow emissions by the Herzberg states, $A^3\Sigma_u^+$, $A'^3\Delta_u$, and $c^1\Sigma_u^-$, have spectral magnitudes and densities comparable to the solar Fraunhofer absorption lines in the background Zodiacal Light (sunlight scattered by interplanetary dust). Lacking the sensitivity (1 Rayleigh/nm) and resolution (0.01 to 0.02 nm) of Keck/HIRES, atmospheric molecular oxygen emissions from this spectral region were previously unassignable from ground-based observations.