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Supplement of

Variations of the 630.0 nm airglow emission with meridional neutral wind and neutral temperature around midnight

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Supplement

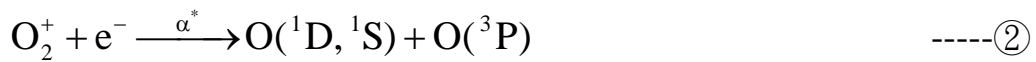
I. Chemical process

$$\text{Photo-Chemical Reaction: } \frac{\partial n}{\partial t} + \bar{\nabla} \cdot (n\bar{v}) = P - L$$

n: density,

P: production rate

L: Loss rate



Where r and α^* are rate coefficients of Reactions $\textcircled{1}$ and $\textcircled{2}$ respectively.

Consider the P and L of O_2^+ : $P_{\text{O}_2^+} = r[\text{O}_2][\text{O}^+]$, $L_{\text{O}_2^+} = \alpha^*[\text{O}_2^+][e^-]$

$$\text{Steady State: } \frac{d[\text{O}_2^+]}{dt} = 0 = P_{\text{O}_2^+} - L_{\text{O}_2^+} = r[\text{O}_2][\text{O}^+] - \alpha^*[\text{O}_2^+][e^-]$$

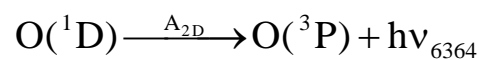
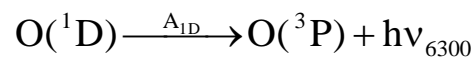
$$\Rightarrow [\text{O}_2^+] = \frac{r[\text{O}_2][\text{O}^+]}{\alpha^*[e^-]} \quad \text{-----} \textcircled{3}$$

$$\text{From } \textcircled{2} \Rightarrow P_{\text{O}(^1\text{D})} = \mu_{\text{D}} \alpha^*[\text{O}_2^+][e^-] \quad \text{-----} \textcircled{4}$$

μ_{D} is the quantum yield

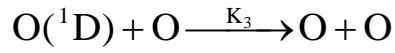
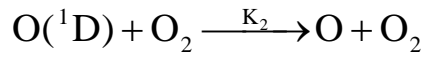
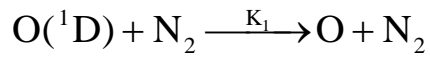
$$\text{Substitute } \textcircled{3} \text{ into } \textcircled{4} \Rightarrow P_{\text{O}(^1\text{D})} = \mu_{\text{D}} r[\text{O}_2][\text{O}^+]$$

Triple state but just 2 red lines because J=2 to J=0 is not allow (from selection rule of quantum mechanism).



If $\text{O}(^1\text{D})$ undergoes collisions with neutral particles, it will lose energy,

named Quenching Reaction.



$$\Rightarrow L_{\text{O}(^1\text{D})} = \{\text{K}_1[\text{N}_2] + \text{K}_2[\text{O}_2] + \text{K}_3[\text{O}] + \text{A}_{1\text{D}} + \text{A}_{2\text{D}}\}[\text{O}(^1\text{D})]$$

$$\text{Steady state: } \frac{d[\text{O}(^1\text{D})]}{dt} = 0 = P_{\text{O}(^1\text{D})} - L_{\text{O}(^1\text{D})}$$

$$\Rightarrow \mu_{\text{D}} r[\text{O}_2][\text{O}^+] = \{\text{K}_1[\text{N}_2] + \text{K}_2[\text{O}_2] + \text{K}_3[\text{O}] + \text{A}_{1\text{D}} + \text{A}_{2\text{D}}\}[\text{O}(^1\text{D})]$$

$$\Rightarrow [\text{O}(^1\text{D})] = \frac{\mu_{\text{D}} r[\text{O}_2][\text{O}^+]}{\text{K}_1[\text{N}_2] + \text{K}_2[\text{O}_2] + \text{K}_3[\text{O}] + \text{A}_{1\text{D}} + \text{A}_{2\text{D}}}$$

Volume Emission Rate of 630.0nm:

$$I_{6300} \equiv [h\nu_{6300}] = \text{A}_{1\text{D}}[\text{O}(^1\text{D})]$$

$$I_{6300} = \frac{\text{A}_{1\text{D}} \mu_{\text{D}} r[\text{O}_2][\text{O}^+]}{\text{K}_1[\text{N}_2] + \text{K}_2[\text{O}_2] + \text{K}_3[\text{O}] + \text{A}_{1\text{D}} + \text{A}_{2\text{D}}}$$