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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

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

n: density,
P: production rate

L: Loss rate

$$O_2+O^+\xrightarrow{r}O_2^++O \qquad \text{-----①}$$

$$O_2^++e^-\xrightarrow{\alpha^*}O(^1D,{}^1S)+O(^3P) \qquad \text{-----②}$$

Where r and α^* are rate coefficients of Reactions ① and ② respectively.

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

Steady State: $\frac{d[O_2^+]}{dt}=0=P_{O_2^+}-L_{O_2^+}=r[O_2][O^+]-\alpha^*[O_2^+][e^-]$

$$\Rightarrow [O_2^+]=\frac{r[O_2][O^+]}{\alpha^*[e^-]} \qquad \text{-----③}$$

From ② $\Rightarrow P_{O(^1D)}=\mu_D\alpha^*[O_2^+][e^-]$ -----④

μ_D is the quantum yield

Substitute ③ into ④ $\Rightarrow P_{O(^1D)}=\mu_D\, r[O_2][O^+]$

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

$$O(^1D)\xrightarrow{A_{1D}}O(^3P)+h\nu_{6300}$$

$$O(^1D)\xrightarrow{A_{2D}}O(^3P)+h\nu_{6364}$$

If $O(^1D)$ undergoes collisions with neutral particles, it will lose energy, named Quenching Reaction.

$$O(^1D) + N_2 \xrightarrow{K_1} O + N_2$$

$$O(^1D) + O_2 \xrightarrow{K_2} O + O_2$$

$$O(^1D) + O \xrightarrow{K_3} O + O$$

$$\Rightarrow L_{O(^1D)} = \{K_1[N_2] + K_2[O_2] + K_3[O] + A_{1D} + A_{2D}\}[O(^1D)]$$

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

$$\Rightarrow \mu_D\, r[O_2][O^+] = \{K_1[N_2] + K_2[O_2] + K_3[O] + A_{1D} + A_{2D}\}[O(^1D)]$$

$$\Rightarrow [O(^1D)] = \frac{\mu_D\, r[O_2][O^+]}{K_1[N_2] + K_2[O_2] + K_3[O] + A_{1D} + A_{2D}}$$

Volume Emission Rate of 630.0nm:

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

$$I_{6300} = \frac{A_{1D}\,\mu_{1D}\, r[O_2][O^+]}{K_1[N_2] + K_2[O_2] + K_3[O] + A_{1D} + A_{2D}}$$