A case study on the possible altitude-dependent effects of collisions on sodium airglow emission

S. Sarkhel, R. Sekar, D. Chakrabarty, and S. Sridharan

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1. Introduction

The emission of airglow from the neutral Na atoms in the terrestrial mesosphere has been known for many years, and Chapman [1939] first suggested that mesospheric ozone plays an important role for this emission. The following chemical scheme was proposed by Chapman [1939] to explain the origin of the Na airglow:

\[ \text{Na} + \text{O}_3 \rightarrow \text{NaO} + \text{O}_2, \]  
\[ \text{NaO} + \text{O} \rightarrow \text{Na}^* (2P) + \text{O}_2, \]  
\[ \text{Na}^* (2P) \rightarrow \text{Na}^* (2S) + h\nu(589.0, 589.6 \text{ nm}). \]

In the preceding scheme, \( k_1 \) and \( k_2 \) are the temperature-dependent reaction rate constants for reactions (1) and (2), respectively, and \( \alpha \) is the branching ratio for reaction (2). The Chapman mechanism explicitly suggested the roles of mesospheric ozone and mesospheric temperature and correctly indicated the formation of an intermediate species, NaO. Multitechnique observations in recent times [e.g., Clemesha et al., 1978, 1979, 1993; Takahashi et al., 1996] directly or indirectly confirmed the veracity of the Chapman mechanism. However, it was realized [e.g., Clemesha et al., 1995; Hecht et al., 2000] that the branching ratio \( \alpha \) involved in reaction (2) of the Chapman mechanism may vary substantially depending on mesospheric conditions. Clemesha et al. [1995], based on rocket-borne photometry and lidar measurements, found the derived \( \alpha \) to lie between 0.05 to 0.2, whereas Hecht et al. [2000], using onboard photometers and ground-based Na lidar as well as an airglow imager, found that the value of \( \alpha \) lies between 0.02 and 0.04. The factor(s) that is (are) responsible for the variations in \( \alpha \) is an important issue to be settled as variable \( \alpha \) also means variations in the yield of Na airglow emission.

Recently, Slanger et al. [2005] proposed that the original Chapman mechanism needs to be modified to accommodate this aspect of variable \( \alpha \). The modified Chapman mechanism needs to be modified to...