Atomic Oxygen Ion–Neutral Collision Frequency Models at Ionospheric Temperatures

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The collision between atomic oxygen and its first positive ion plays a major role in Earth's F region ionosphere. An accurate corresponding collision frequency model is necessary to quantitatively understand the ionosphere. However, the widely used classic Banks theoretical model typically provides a collision frequency that is 30% lower than the expectation from ionospheric observations. Accordingly, the classic collision frequency is often adjusted by multiplying it by a constant known as the Burnside factor. This correction-factor model adopted the classic model as its basis due to a misunderstanding that the classic model was based on a laboratory experiment; that is, the correction factor was originally meant to compensate for laboratory contamination.
In this study, a collision frequency model is constructed based on the laboratory experiment, and the resultant laboratory-based model is found to be consistent with ionospheric observations. In this construction, the impact of laboratory contamination is determined to be small (7%) and is mostly canceled by a misinterpretation regarding the conventional definitions of energy. Thus, the 30% difference is mainly caused by a theoretical error in the classic model itself. This error is energy-dependent and corrected by the later wide-energy theoretical model. Thus, the classic model cannot be corrected by a temperature-independent constant and should be replaced by the later model.

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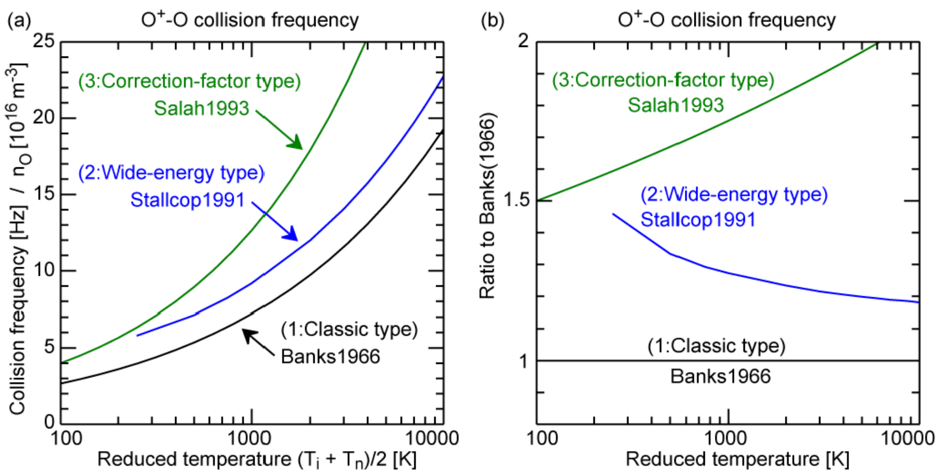

Figure 1. (a) Existing models of O^+-O momentum-transfer collision frequency. They are for the unit number density of atomic oxygen and are a function of the ion-neutral reduced temperature $(T_i+T_n)/2$. A representative model of each of the three types of models is shown: (1) classic high-energy theory type (Banks, 1966), (2) later wide-energy theory type (Stallcop et al., 1991), and (3) correction-factor type (Salah, 1993). (b) The ratio of (a) to the Banks model, known as the Burnside factor, for each of the representative models.