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PhD Thesis Abstract

High-Temperature Non-Equilibrium CO_2 Kinetic and Radiation Processes

Recent efforts by the world's Space agencies have put Mars as a prime target for Space exploration. Landing on Mars is however not an easy process. The main component of Mars atmosphere being CO_2 (<95%), there is a lot of uncertainties how the flow around a spacecraft entering the atmosphere behaves. Convective and radiative heating uncertainties are paramount in the design of the thermal protection system (TPS) of the spacecraft. To correctly predict convective or radiative heating experienced by spacecraft entering Mars, many recent works have been dedicated to the creation of simplified models for CO_2 for use in computer simulations. Although this is the utmost objective, there is a lack of a complete and physically consistent model that can be used as a reference for simplified models. The objective of this thesis is accordingly to contribute for the development of a reference high temperature state-to-state kinetic and radiation model for CO_2. Such a model will have to be physically consistent and also capable of reproducing experimental results obtained in other works.

To achieve a complete model, all vibrational modes of CO_2 must be defined first. This is a prerequisite for the computation of the physical problems we are most interested in: vibrational excitation leading up to dissociation and vibrational spontaneous emission. Vibrational excitation can be studied applying the Forced Harmonic Oscillator (FHO) model to compute the probabilities of a Vibrational-Translational energy transfer to occur. Vibrational radiative transitions can be included by computing vibrational Einstein coefficients which together with vibrational excitation and dissociation rates will provide a full description of a pure CO_2 gas in a non-equilibrium scenario.