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Model of molecular non-LTE emission in exoplanetary atmospheres

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Abstract

The observations by transit spectroscopy of exoplanetary atmospheres give the first insight into the atmospheric physics of these objects [1,2] Observations of anomalous emission in the near infrared have challenged interpretation of exoplanetary spectra [1]. A model of non-LTE emission is presented to support the interpretation of K and L band excess emission

1. Introduction

Transit spectra from HD189733b have been extracted at a spectral resolution of about 170 in K and L band, and show an excess emission at spectral positions compatible with methane emission [3].

2. Model

The model is adapted from giant planets fluorescence radiative transfer model used for Jupiter and Saturn [4]. The proximity of the star and the high temperatures give a larger enhancement in fluorescence (non-LTE) emissions. Nevertheless, pure radiative processes do not retrieve the excess emission, in LTE (thermal and stellar reflected flux) as well as in purely radiative non-LTE regime [5]. The interpretation of these anomalous emissions is therefore a signature of out of equilibrium processes that are investigated in this study.

3. Results

Despite the limited information available from the low resolution spectra, some conclusions can be obtained from the model. The identification of the emission bands with methane emission in both K and L bands give additional constrained on the model. The excess emission can be reproduced by a non-thermal reservoir of vibrational energy in the exoplanet atmosphere. A plausible source could be vibrational energy in H_2, which can be pumped in vibrational levels from various sources, including particle precipitations from stellar wind activity. Such a mechanism has been identified on giant planets [6]. It can be shown that a modest increase of the vibrational temperature of H_2 could enhance the non-LTE emission in methane through resonant processes between H_2(1-0) and CH_4 (octad band complex at 2.3μm). Joint K and L band observations allow us to constrain quantitatively the emission

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