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Modelling of Optically Thick Cometary Comae

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Abstract

We have built a radiative transfer model for optically thick molecular emission spectra to better understand the near nucleus regions of comets' comae. We use Coupled Escape Probability, a new accurate method of radiative transfer, which we have improved to be used in asymmetric spherical situations.

We have implemented our model for CO, CO2, and H2O, species of particular interest in Deep Impact/EPOXI observations of Tempel 1 and Hartley 2. [2, 3]

1. Introduction

Recent in-situ observations of comets such as those by the Deep Impact and EPOXI missions have obtained spectra of the innermost regions of comets' comae with high spectral resolution and unprecedented spatial resolution. Upcoming missions to comets will also have such observations. These observations necessitate a better understanding of regions of the coma that may be optically thick and the effects of high optical depth on spectra observed in the innermost coma. We have built a complex tailor-made radiative transfer model to better understand these spectra.

2. Our Radiative Transfer Model

2.1 Coupled Escape Probability

Coupled Escape Probability is a New Method for Radiative Transfer Solutions devloped by Elitzur & Asensio Ramos. [1] In the CEP method a plane parallel atmosphere is divided into vertical "zones". Each zone's distribution of fractional populations in molecular energy levels is determined using statistical equilibrium. All the zones are coupled through “Net Radiative Bracket” terms resembling escape probability expressions, which encapsulate the self-radiation due to scattering and absorption between zones. This enables a self-consistent solution for the line radiation produced even in optically thick cases.

2.2 Asymmetric Spherical CEP

We have adapted the CEP method for use in asymmetric spherical situations, such as a comet's coma. (Yun, et al. [4] previously developed a spherical adaptation, but only for spherically symmetric situations.)

Our model includes a directional external source of radiation (solar illumination, in the case of cometary comae.) It also includes varying conditions within the spherical coma, to model morphological features such as jets.

3. Model Results

Our model can produce spectra and brightness maps for different wavenumbers (or bands) as necessary. We will present various model results with varying parameters and comparisons with actual data. [2, 3]

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References

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