High Temperature Line lists of Carbon Monoxide from Microwave discharge spectroscopy

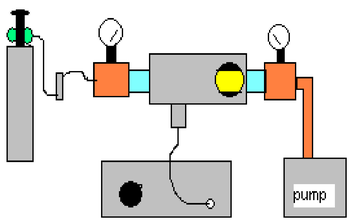
Farnood REZAIE,C.Ghosh, P. Figueiredo, J. Arnold and R.E. Peale
Department of Physics,University of Central Florida,Orlando,Florida 32816,USA

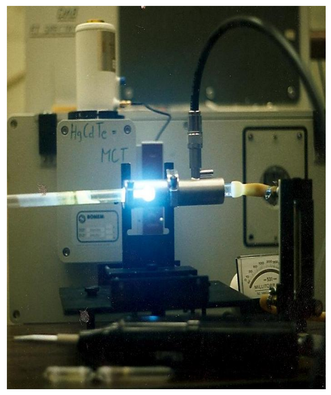
Introduction

In gas giant exoplanets that orbit close to their parent stars, known as hot Jupiters, carbon is thought to be sequestered primarily in carbon monoxide and methane. The relative CO and CH4 abundances inform us about temperature and pressure conditions and also about mixing by global winds driven by intense but asymmetric heating for these tidally-locked bodies. Emission spectra collected during secondary eclipses, as the hot Jupiter passes behind its parent star, in principle allows a determination of the CO:CH4 concentration ratio. Since Hot Jupiters exist at temperatures of order 1000 K, accurate model atmospheres require high temperature line lists for relevant molecules, for which existing data bases are apparently incomplete. Here we present high temperature emission spectra of CO. The spectra were obtained using a microwave discharge apparatus where the source of CO was carbon dioxide that dissociates under microwave heating.

Experimental set up

-BOMEM DA8 FTIR as a Spectrometer
-InSb detector at 77K
-KBr Beam splitter
The pressure inside the discharge tube was of order 1 Torr and the microwave power applied to the cavity was ~70 W. Emission exited the discharge tube via a ZnSe window and entered through a NaCl window the emission port of the evacuated Fourier spectrometer.





Intensities in Rotation-vibration spectra

-Number of molecules in rotational level J of the initial vibrational state at temperature T:

$$N_J \propto (2J+1)e^{-BJ(J+1)hc/KT}$$

Using $B_{CO} = 1.93cm^{-1}$ and knowing $J_{\max} = 17$ for V(1->0) vibration
So, Rotational temperature is in order of 1600-1700K

$$J_{\max} = \sqrt{\frac{KT}{2Bhc}} - 0.5 \Rightarrow T \cong 1650K$$

Translational temperature and Broadening effect

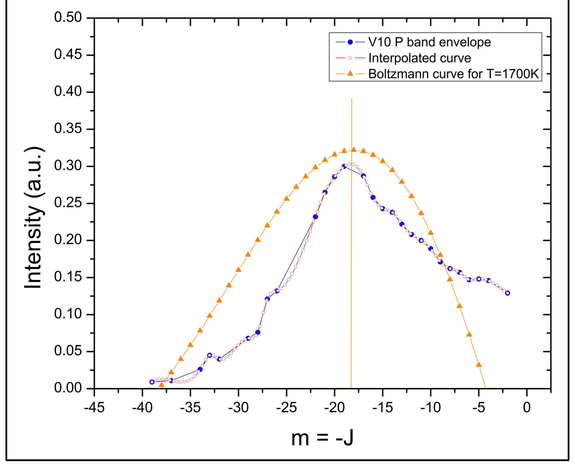
From the width of and line shape of v(1→0) transition it is possible to estimate the translational temperature:

$$I \propto e^{\left[-c^2\left(\nu-\nu_0 / \nu_0 v_p\right)^2\right]}$$

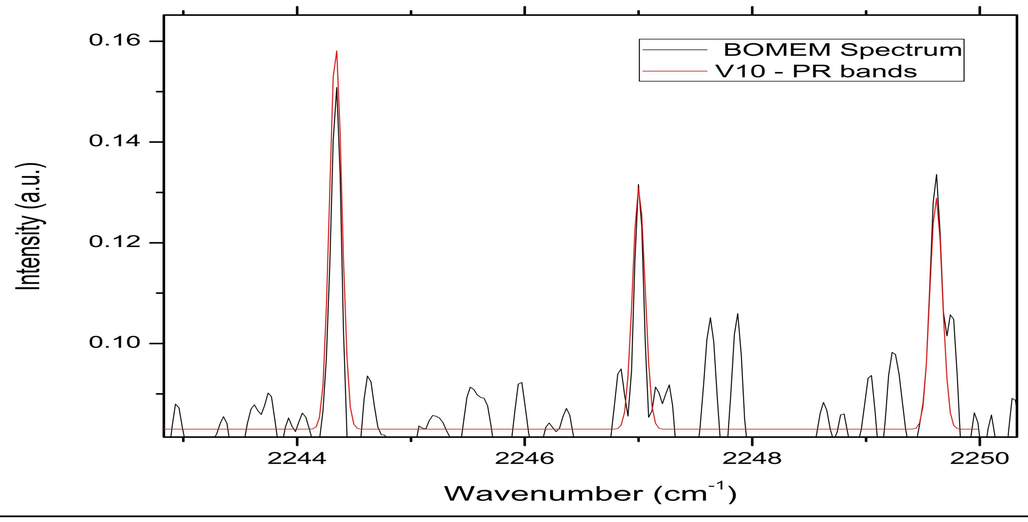
in which I is intensity and dominant broadening effect will be Doppler broadening.
Knowing the thermal velocity of molecules from $v_p = \sqrt{\frac{2KT}{M}}$
And knowing B_{CO}=1.93 cm^{-1} and $M_{CO}=28M_{proton}$
We find the translational temperature of CO molecules: →T=300K

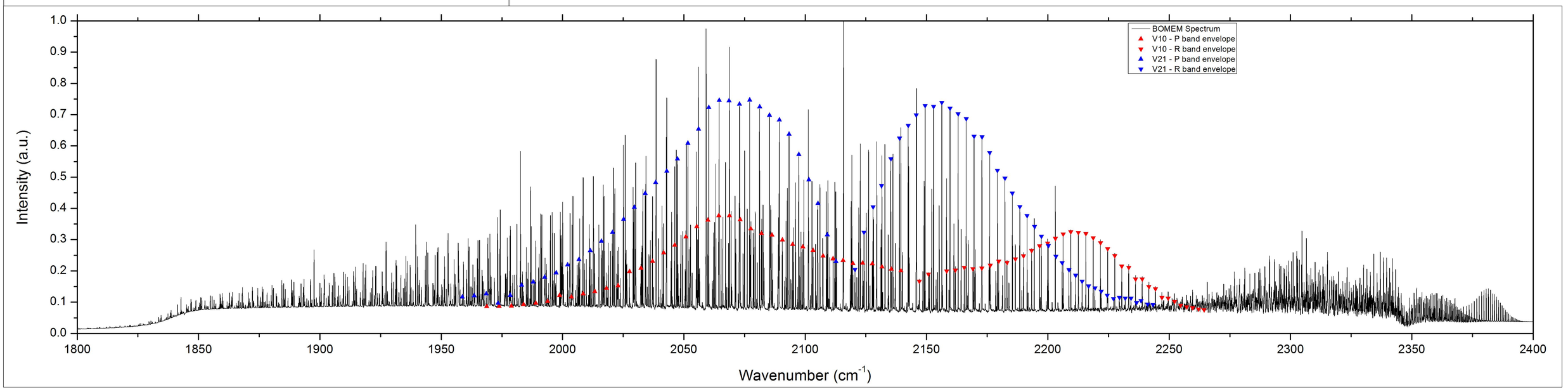
Estimating temperature using P-band of V10

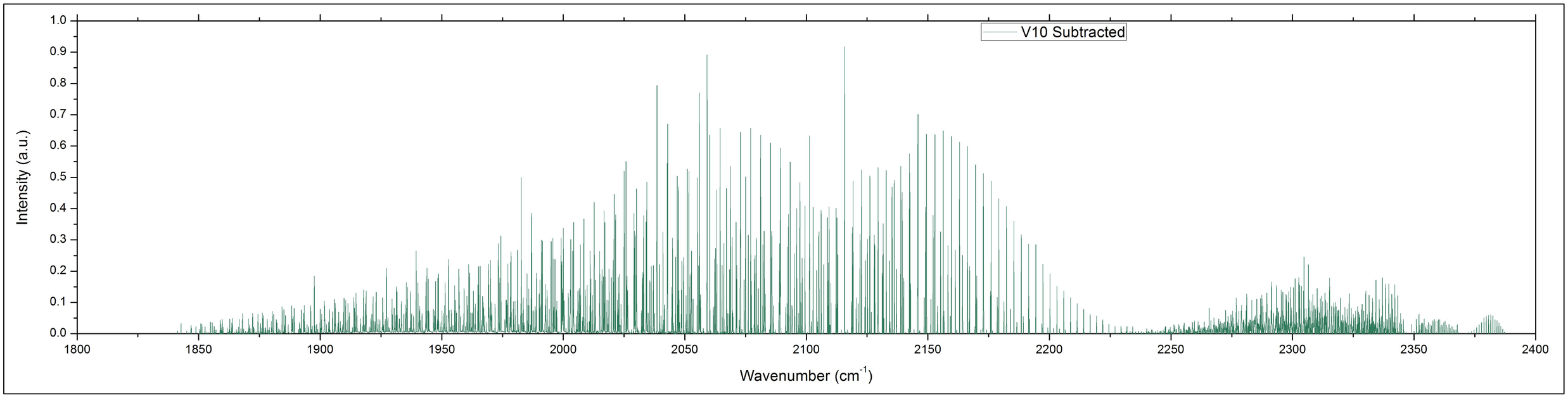
Boltzmann distribution and empirical data have been plotted together



Synthetic spectrum of V10 and empirical data are shown for R30,R31,R32







Contact : farnood_rezaie@knights.ucf.edu Web:www.physics.cos.ucf.edu