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Search for molecules in cool cosmic objects

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1. Introduction

In cool cosmic objects, kinetic temperature is few tens of Kelvin, or even less. Information about physical conditions prevailing in these objects can be received only through molecular rotational lines. In some of these objects, kinetic temperature may not be sufficient to excite the molecules to higher rotational levels in sufficient quantity required for generation of their emission spectra. These molecules may, however, be identified through their absorption lines, as the lower energy levels always have some population, and the molecule can absorb radiations coming from the background sources. In case no background sources are present, cosmic microwave background (CMB) corresponding to a kinetic temperature of 2.7 K is always present.

Absorption against the CMB is an unusual phenomenon. However, it has been observed in a large number of cosmic objects. Up to now only two lines have been found in absorption against the CMB. Transition $1_{10} - 1_{11}$ of formaldehyde (H_2CO) at 4.83 GHz and the transition $2_{20} - 2_{11}$ of cyclopropenylidene (C_3H_2) at 21.59 GHz have been found in absorption against the CMB (see references in Chandra & Kegel 2001). Observation of an interstellar line in absorption against the CMB, obviously, implies that the excitation temperature of the line is less than 2.7 K.

2. Mechanism for our proposal and recent results

Mechanism for anomalous absorption of $2_{20} - 2_{21}$ transition (Figure 1) in a-type asymmetric top molecules may be understood in the following manner. The level 2_{21} de-excites through a weak radiative transition $2_{21} \rightarrow 2_{02}$, whereas the level 2_{20} de-excites through a strong radiative transition $2_{20} \rightarrow 1_{01}$. Consequently, the molecules stay for a rather long time in the level 2_{21}, and wait for absorption of a frequency, corresponding to the transition $2_{20} - 2_{21}$, coming from the background sources. Upper levels (above $J = 2$ levels) of the system are populated through the collisional excitations from the ground rotational level 0_{00}. These upper levels cascade down to the $J = 2$ levels through radiative transitions. In cosmic objects having low densities,

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the transition $2_{20} - 2_{21}$ may obviously show absorption, even against the CMB. Similar mechanism is applicable for absorption of $2_{20} - 2_{11}$ transition (Figure 1) in b-type asymmetric top molecules, even against the CMB.

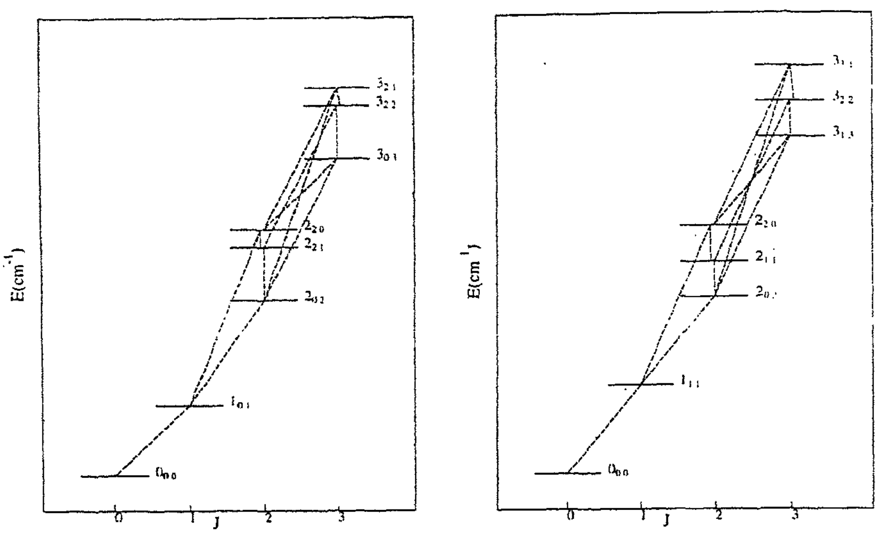

Figure 1. Rotational energy levels (up to J = 3) in *a*-type and *b*-type asymmetric top molecules along with the allowed radiative transitions. Energies of the levels are not to scale.

Motivated by the observation of anomalous absorption of $2_{20} - 2_{11}$ transition in C_3H_2, we performed detailed NLTE radiative transfer calculations for two *b*-type (C_3H_2 and C_2H_4O) and one *a*-type (C_3H_4) asymmetric top molecules. Our calculations show that in low density and low temperature regions, the transition $2_{20} - 2_{11}$ of C_3H_2 and C_2H_4O, and the transition $2_{20} - 2_{21}$ of C_3H_4 show anomalous absorption, even against the CMB (Chandra & Kegel 2001). We (Sharma & Chandra 2001) have suggested for identification of C_3H_4 through the transition $2_{20} - 2_{21}$ at 3.67218 GHz in cosmic objects having low density and low kinetic temperature.

This shows that searching for the lines in absorption may be used as a technique for identification of asymmetric top molecules in tool cosmic objects.

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