Detectability of Prolate Symmetric-Top Molecules in Diffuse Clouds by a "Hot-Axis Effect"

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The aim of this study is to detect prolate symmetric-top molecules in diffuse clouds by observations of absorption lines by a "hot-axis effect." Molecules in low excitation temperatures in diffuse clouds can be detected by only absorption. A prolate symmetric-top molecule, such as CH_3CN and CH_3CCH, has a special advantage to detect absorption lines. The *K* rotation (rotation around the red dotted lines in Figure 1) is excited by collisions in a high kinetic (collisional) temperate and is not cooled by radiation. On the other hand, the *J* rotation is cooled well by radiation due to a permanent dipole moment and the low radiative temperature as shown in Figure 1. As a result, the special advantage is that the $J = K$ rotational levels have population concentrations as shown in Figure 2. We call the population concentrations a "hot-axis effect." Absorption lines of the $J + 1 \leftarrow J$ $(= K)$ and $\Delta K = 0$ transitions indicated by the red arrows in Figure 2 can be strong. To calculate the population concentrations, both of radiation and collisions should be considered simultaneously. In the case of a linear molecule the equation for rotational distribution by radiation and collisions was derived by Oka *et al*. [1]. Recently Araki *et al*. derived the equation in the case of a symmetric-top molecule having the hot-axis effect [2]. Using the equation the population concentrations of CH_3CN and CH_3CCH were calculated and the intensities of absorption lines were estimated. Therefore it is suggested that the absorption lines enhanced by the hot-axis effect can be the powerful probe of the molecules in diffuse clouds.

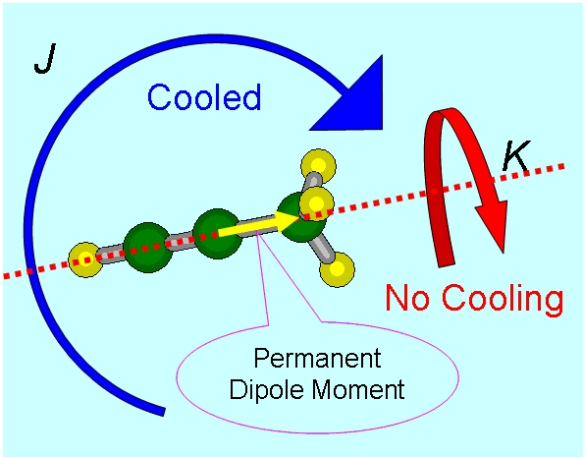

Figure 1: Hot-axis effect for a prolate symmetric top molecule. The red dotted line is the hot axis.

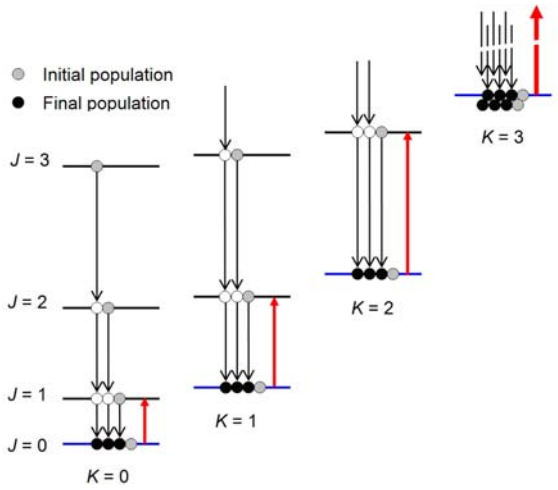

Figure 2: Population concentrations at the $J = K$ levels for a prolate symmetric top molecule. The emissions are drawn by the black arrows. The $J = K$ levels are descried by the blue bars and the strong absorptions are by the red arrows.

References

[1] Oka *et al*., 2013, ApJ, **773**, 42.
[2] Araki *et al*., 2014, AJ, in press.