COLLISION CROSS SECTIONS BETWEEN SOME ROVIBRATIONAL STATES OF AMMONIA GAS PERTURBED BY HYDROGEN

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ABSTRACT

We have studied lines mixing induced by collisions in the \( \nu_A \) IR band of ammonia colliding by hydrogen. We have observed a narrowing effect in the inversion doublets. The line-shapes were analysed using an adapted form of Broquier et al. (4). Comparison between our measurements and a semiclassical calculations shows a good agreement.

Ammonia molecules are abundant in interstellar clouds. Townes et al (1) were the first to demonstrate that excitation through collisions with molecular hydrogen leads to the mechanism for the various line intensities. Models taking into account these mechanisms tried to explain these intensities but needed very accurate state to state transfer rates for collisions. It is not easy to calculate the cross sections in case of inelastic transitions which are induced by collisions because we have to know the anisotropic part of the intermolecular potential (which reflects the angular momentum transfer). Therefore the experimental rotational energy transfer values (given by the linewidths study and by time resolved infrared infrared double resonance) prove to be essential to improve the knowledge of interaction potential.
In a previous paper (Broquier et al. (2)) we have studied the absorption lines profiles in the infrared region (6-7 μm) by means of a diode laser spectrometer and FT spectrometer in ammonia diluted in He and H₂(para) at room temperature. We determined the pressure broadening cross sections and the intradoublet inelastic rates (due to molecular inversion). In addition we compared our results to values obtained by a semi classical approach developed in Billing calculations (3). These calculations undertaken on another system have shown that the cross relaxation term is very sensitive to the quality of the representation of the anisotropic part of the intermolecular potential (2). This paper brings new results concerning NH₃-H₂ (normal). This work was recorded on a commercial Fourier transform spectrometer, Brucker model IFS 113V equipped with HgCdTe detector with CaF₂ window (resolution about 0.03 cm⁻¹). The method used in this work have been described in detail elsewhere (4). The studies lead us to two complementary results according to the experimental conditions.

Isolated lines:

From the pressure broadening coefficient $\xi$, we have deduced the $\sigma_{PB}$ pressure broadening (PB) cross section, which is proportional to $\xi$. Formally the PB cross section can be expressed as half the sum of the total inelastic cross section of the upper and lower levels of the transition to which an elastic contribution must be added.

Overlapping lines or interference effect:

When the pressure involves the overlapping of the two components of the inversion doublet, we observe a non lorentzian profile. Then we can treat the problem with a four level system (4) (as usually done in molecular physics). The resulting profile depends on the splitting of the components, on the PB coefficient ($\xi$) and on the intradoublet inelastic coefficient ($\epsilon$). This last term produces the narrowing of the line which is a characteristic of destructive interferences.