

RELATIONSHIP BETWEEN GAS-PRESSURE SHIFTS AND STARK DISPLACEMENT OF CENTERS OF MOLECULAR LINES

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In this short paper we wish to point out a relationship, evidently heretofore unnoticed, between the experimental values of the gas-pressure shifts of molecular lines and the calculated values of the Stark displacements of the centers of these same lines. The experimental values of the shifts given below were obtained for a single-component gas at different times by Karyakin ([1, 2] and the OCS data) and Belov, Gersh-tein, and Maslovskii ([3] and data on the (1, 1) and (2, 2) transitions in ammonium in the $v_2 = 1$ state).

It turns out that the pressure shifts of the submillimeter rotational lines of linear N_2O and OCS molecules are very small (on the order of kHz/torr, at the limits of experimental accuracy). This correlates with the small Stark displacements of these lines, which result both from the small dipole moments and, primarily, from the large values of the rotational quantum number J in the submillimeter range (Stark displacement is proportional to J^{-2} [4]).

The measured line shifts for the lower rotational transitions $J = 0 \rightarrow 1$ of a molecule of "symmetrical top" type PH_3 in the ground and excited states ($v_2 = 1$) turn out to be equal, +0.56 MHz/torr, and, as regards the sign of the effect, this agrees with the Stark-effect displacement of the centers of these lines [4].

The lines considered above display a second-order Stark effect. We should note that the much stronger first-order Stark effect does not shift the line centers.

The measured shifts of the $J = 0 \rightarrow 1$ transitions of the $v_2 = 1$ state for $^{14}NH_3$ and $^{15}NH_3$ molecules are positive [2] ([2] measured not the absolute value of the shift but rather the ratio of the shift to the broadening, this being equal to +0.65); this also agrees with the sign of the Stark displacement of the line centers, determined in first approximation as the repulsion of a pair of adjacent levels (see [4] and the scheme in [2]).

The inversion transitions ($J = 1, K = 1$) and ($J = 2, K = 2$) of ammonium $^{14}NH_3$ in the $v_2 = 1$ state present an interesting case for comparison. Whereas the Stark displacement of the ($J = 2, K = 2$) is positive (like that of a pair of adjacent levels), the Stark displacement of ($J = 1, K = 1$) is negative as a result of the predominance of repulsion of the adjacent (as a result of random coincidence) upper level of this transition ($J = 1, K = 1, a$) and the lower level of the next transition ($J = 2, K = 1, s$). The corresponding scheme of the levels is given in [5]. According to this, the pressure frequency shift is positive (+1.5 MHz/torr) for the ($J = 2, K = 2$) transition and negative (-2.4 MHz/torr) for the ($J = 1, K = 1$) transition. These examples should be continued.

In addition to data which confirm the above relationships (a shift of +1 MHz/torr for the $J = 0 \rightarrow 1$ transition in CH_3Cl in [6]), there are data which seemingly contradict those presented in this paper. For example, the pressure shifts of the $J = 1 \rightarrow 2$ and $J = 2 \rightarrow 3$ lines for OCS as measured in [6-8] are negative and equal to -35 kHz/torr and -113 kHz/torr (data of [6]) and -(2-4) kHz/torr and -10(10) kHz/torr (data of [7, 8]). These discrepancies make evaluation of the results difficult; it is possible, however, that there is a small negative frequency shift that results from some other mechanism not associated with the Stark effect.

The thoughts expressed in this paper may be useful in developing a simple criterion for evaluating pressure shifts of molecular lines; this would be important for high-resolution molecular spectroscopy, particularly if we hope for the existence of a single coefficient for the lines of a given molecule, that would relate the Stark displacement and the pressure shift of the spectral lines.

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WAVE PROPAGATION IN A RECTANGULAR WAVEGUIDE WITH A THIN ABSORBING FERRITE FILM

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This paper is a continuation of [1], where the results were presented of a calculation of the propagation constants of the LE and LM waves in a rectangular waveguide with a thin poly- or monocrystalline ferrite film, lying on one of the walls of the waveguide and magnetized normally or tangentially in the region of values of the parameter $\xi = \omega_0/\omega$ where the imaginary parts of the diagonal μ - and nondiagonal μ_a -components of the magnetic permeability tensor can be neglected if the width $2\Delta H$ of the ferromagnetic resonance curve of the ferrite film is small.

As follows from [1-3], the propagation constants h of the LM_{mn} and LE_{mn} waves can be determined from the equations

$$qb \operatorname{tg} qb = -\frac{ikb}{2} \left[a_{12} + a_{21} \pm \sqrt{(a_{12} - a_{21})^2 + 4a_{11}a_{22}} \right] \quad (1)$$

for waves of the LM_{mn} type and

$$\frac{\operatorname{tg} qb}{qb} = -\frac{i}{2kb} \left[a_{12} + a_{21} \pm \sqrt{(a_{12} - a_{21})^2 + 4a_{11}a_{22}} \right] \quad (2)$$

for waves of the LE_{mn} type

$$\left(h = \left[k^2 - q^2 - \left(\frac{\pi m}{a} \right)^2 \right]^{1/2} \right).$$

Here a_{ij} are the components, normalized to the wave impedance of the vacuum $\rho_0 = \sqrt{\mu_0/\epsilon_0}$, of the input impedance tensor of the layer $z_{ij} = -\rho_0 a_{ij}$, relating the tangential components of the electric and magnetic fields on the surface of the ferrite film [2].

Using the values of the components of a_{ij} for a thin ferrite film ($kd \ll 1$) [3], Eqs. (1) and (2) take the form [with accuracy $O(ka)^2$]

$$\begin{aligned} q_{n1} b \operatorname{tg} q_{n1} b &= k^2 b d, \\ q_{n2} b \operatorname{tg} q_{n2} b &= k^2 b d \mu_{\perp} \end{aligned} \quad (3)$$

for LM_{mn} waves with tangential magnetization,

$$\begin{aligned} q_{n1} b \operatorname{tg} q_{n1} b &= k^2 b d (\mu + \mu_a), \\ q_{n2} b \operatorname{tg} q_{n2} b &= k^2 b d (\mu - \mu_a) \end{aligned} \quad (4)$$

for LM_{mn} waves with normal magnetization,

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