

the quantum energy levels is $\Delta\epsilon_H \ll \epsilon_F$, large quantum numbers become significant, so that we can use in the calculation the quasiclassical approximation for the energy spectrum. The quantum energy spectrum of the conduction electrons is determined under the assumption that the electrons are specularly reflected from the boundary of the sample. The specular-reflection condition is sufficiently effective, since the main contribution to the effect under consideration is made by electrons that are tangent to the surface of the metal and thus have a sufficiently large wavelength, corresponding to the motion of the electron along the normal to the surface of the metal.

The values $\chi^{(s)}$ obtained in this paper describes the contribution of the boundary surface of the metal to the Landau diamagnetism (see Fig. d). Whereas in the calculation of the diamagnetic susceptibility of metals the presence of the metal boundary leads to the appearance of additional terms of the order of λ_F/L (see [9], λ_F is the Fermi wavelength of the electron), in the case of Landau diamagnetism the influence of the boundary is more significant and causes the appearance of additional terms of the order of

$$S \chi^{(s)} / V \chi^{(v)} \sim (H_c / H)^{1/2}.$$

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PURELY ROTATIONAL SPECTRA OF NONPOLAR MOLECULES IN THE VIBRATIONAL GROUND STATE

M.R. Aliev

Institute of Spectroscopy, USSR Academy of Sciences

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Fox [1] has shown recently that in spite of the fact that the methane molecule (point group T_d) has no dipole moment in the ground electron-vibrational state, this molecule can have a rotational spectrum of dipole transitions in the ground state as the result of vibrational-rotational interaction; the intensity of the strongest line of such a spectrum can be, under certain conditions, much higher than the intensity of the collision-induced rotational spectrum of methane. It is shown in the present communication that as a result of the effect of first-order centrifugal distortion, purely rotational spectra of dipole molecules in the ground state can be possessed not only by methane [1], but also by all nonpolar molecules belonging to the point groups D_n , D_{2d} , D_{3h} , S_4 , T , and T_d .

A nonpolar molecule has no rotational spectrum in the ground state only if no account is taken of the centrifugal distortion in the calculation of the matrix elements of the dipole-moment operator (or, equivalently, no account is taken of the dependence of the dipole moment on the rotational state), for in this case the total matrix element of the dipole moment takes the form of a product of the dipole moment, averaged over the vibrational wave function, by matrix element of the direction cosines of the axes of the moving coordinate system relative to the axes of the fixed system:

$$\begin{aligned} & \langle 0, J, K, \Gamma | \mu_z | 0, J', K', \Gamma' \rangle = \\ & = \sum_{\alpha} \langle 0 | \mu_{\alpha} | 0 \rangle \langle J, K, \Gamma | \lambda_{z\alpha} | J', K', \Gamma' \rangle. \end{aligned} \quad (1)$$

Here J and K are the quantum numbers of the total angular momentum and its z -projection, Γ are irreducible representations of the point group of the molecule, μ_z is the operation of the Z -projection of the dipole moment in the fixed system, and μ_{α} ($\alpha = x, y, z$) is the operator of the α projection of μ in the moving coordinate system. Since the ground vibrational state of all molecules belongs to the fully-symmetrical representation, and none of the dipole-moment components for unpolarized molecules belongs to the fully-symmetrical representation, the factor $\langle 0 | \mu_{\alpha} | 0 \rangle$ in (1) vanishes for all nonpolar molecules. However, if we calculate the wave functions in the left-hand side of (1) with allowance for the centrifugal distortion, for example by the contact-transformation method [2], then we obtain already in the first approximation in place of (1)

$$\begin{aligned} & \langle 0, J, K, \Gamma | \mu_z | 0, J', K', \Gamma' \rangle = \\ & = \frac{1}{2} \sum_{\alpha, \beta, \gamma} (I_{\gamma}^{\alpha} I_{\beta}^{\alpha})^{-1} (a_n^{\beta\gamma} / \omega_n^{3/2}) (\partial \mu_{\alpha} / \partial q_n)_e \times \\ & \times \langle J, K, \Gamma | \lambda_{z\alpha} P_{\beta} P_{\gamma} | J', K', \Gamma' \rangle, \end{aligned} \quad (2)$$

where I_{α}^e and I_{β}^e are the principal moments of inertia, $a_n^{\beta\gamma}$ ($\beta, \gamma = x, y, z$) are the first derivatives of the components of the inertia tensor with respect to the normal coordinates, ω_n are the oscillation frequencies, $(\partial \mu / \partial q_n)_e$ are the derivatives of the dipole moments, and P_{β} and P_{γ} are the components of the angular momentum. In order for the matrix elements (2) for a nonpolar molecule to be different from zero, it is necessary to satisfy two fundamental conditions: 1) the molecule should have at least one normal coordinate of symmetry type Γ_n , the derivatives with respect to which do not vanish for at least one component of the inertia tensor and one component of the dipole moment; 2) the direct product of the irreducible representations Γ and Γ' should contain a certain irreducible representation Γ_z , in accordance with which there is transformed μ_z or, equivalently [3], the product of the polar-vector component T_z by the axial-vector component R_z .

It can be shown with the aid of group-theoretical methods [3 - 5] that the first condition is more stringent than the second and excludes from consideration all nonpolar molecules with the exception of those belonging to the point groups D_n , D_{2d} , D_{3h} , S_4 , T , and T_d . Thus, the first condition is satisfied only for those molecules for which at least one of the normal vibrations is active both in the infrared spectrum and in the Raman-scattering spectrum.

It can be shown that the second condition is also satisfied for the indicated point groups. The selection rules and the formulas for the intensities of the transitions can be easily obtained from expression (2) by known methods, and are therefore not given here.

The quantities $a_n^{\beta\gamma}$ in (2) can be calculated from the matrix formula $a^{\beta\gamma} = L^{-1}A^{\beta\gamma}$, where L is the matrix of the forms of the oscillations, the elements of the column matrix $A^{\beta\gamma}$ depend on the structural parameters of the molecule [2], and the quantities $(\partial\mu/\partial q_n)_e$ can be obtained from the intensities of the infrared absorption ground bands.

The estimates in [1] for methane and our estimates for the boron trichloride molecule show that the spectra considered here can be observed in the microwave and the long-wave infrared regions of the spectrum.

A detailed description of the investigation with the results of the numerical calculations, and also questions pertaining to induced centrifugal distortions by rotational spectra of nonpolar molecules in excited vibrational states will be published separately.

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A NOTE ON THE ASYMPTOTIC CONDITION OF NUCLEAR-FORCE SATURATION

V.F. Demin

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Simonov and Calogero (see, e.g., [1]) have recently derived the necessary asymptotic conditions for the saturation of nuclear forces and have shown that they impose rather stringent limitations on the nuclear forces. In any case, practically none of the presently known NN potentials satisfy these conditions. This means that when a number of nucleons A is sufficiently large, the system collapses and the binding energy per nucleon increases with increasing A .

In this article we wish to call attention to the fact that the asymptotic saturation conditions need not always be related to saturation in real nuclei.

The figure shows three possible plots of the binding energy per nucleon ϵ against A . Curve 1 corresponds to the case when the asymptotic behavior with respect to A sets in already in the region of real nuclei. It was obtained for the well-known Volkov potential [2]: for He^4 and O^{16} it gives more or less good results, and collapse takes place already starting with Ca^{40} (see [3]). If the NN potential leads to an $\epsilon(A)$ plot of type 1, then one can state quite definitely that it is not

