Experiments are continuing in this direction.

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ELECTRON DENSITY IN TUNGSTEN CRYSTAL ACCORDING TO NEUTRON-ELECTRON INTERACTION DATA

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Submitted 29 February 1972
ZhETF Pis. Red. 15, No. 7, 398 - 400 (5 April 1972)

The most thoroughly investigated interactions between the neutron and the atom are the nuclear and magnetic ones (in the former case, the neutron interacts with the nucleus of the atom), and in the latter with the electron shell). These interactions are characterized by an amplitude on the order of $b \sim 10^{-12}$ cm. There exist, however, weaker interactions having a different nature. These include the relativistic neutron-electron (ne) interaction (cf., e.g., [1]). The experimental determination of the amplitude a_{ne} of this process entails great difficulties, since this effect is very small (the ne-interaction amplitude is smaller by four orders of magnitude than that indicated above, i.e., $a_{ne} \sim 10^{-16}$ cm).

One of us proposed in [2] a method of determining a_{ne}. It is based on measurements of the intensity of the diffraction reflections of monochromatic neutrons from a tungsten single crystal strongly enriched with W^{186}. In this case the nuclear scattering is very small, owing to the interference between the resonant and potential scattering of the neutrons, and the magnetic scattering, if it exists at all, is not coherent. Preliminary results of these measurements were given in [3].

We plotted the electron-density distribution by using the intensities of neutron reflection from all planes of the [00ℓ] zone of a tungsten crystal enriched to 90.7% with the isotope W^{186}. Since ne scattering of neutrons by atoms is characterized by the same angular dependence as x-ray scattering (the geometric relations are assumed to be fully identical in both cases), the same electron-distribution density should be obtained by both methods.

The reflection intensities were measured with a multicrystal setup in the VVR-Ts reactor of a branch of our Institute [4]. We used monochromatic neutrons of wavelength $\lambda = 1.145$ Å. A spherical W^{186} sample of 5.5 mm diameter had in the range $\sin\theta/\lambda < 0.85$ approximately 44 reflections of which eight were

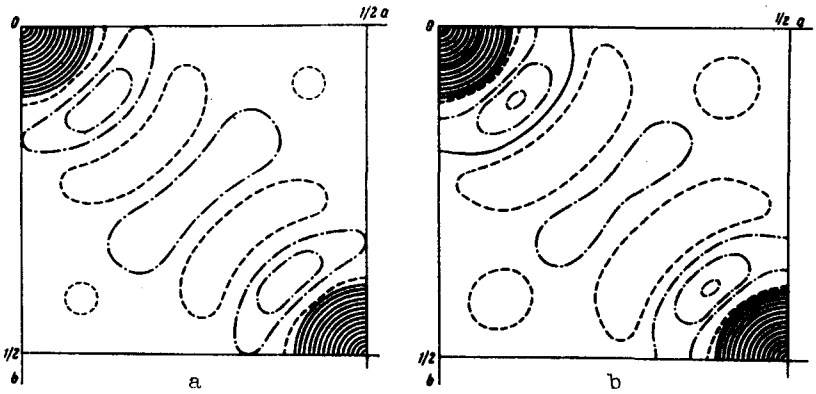

Fig. 1. Projection of electron density on the (001) plane in tungsten crystal: a) from experimental neutron-diffraction data, b) from the calculated values of F(hk0) using the atomic x-ray curve. The dashed curves show the null level and the dash-dot curves the regions of "negative" electron density.

independent. The intensities were converted into structure amplitudes by the usual method, with allowance for absorption with $\mu R = 0.39$, at a thermal isotropy factor $B = 0.17$ Å^2 [5]. These data were used to construct the projection of the electron density on the (001) plane, as shown in Fig. 1a.

Naturally, when such a small number of reflections is used the electron-density picture is very strongly influenced by where the series is terminated. To estimate its influence, an analogous x-ray projection was plotted: the Fourier-series coefficients were taken to be the theoretical structure amplitudes calculated for the well-known tungsten structure using the f_W curve from [6]. The series was then arbitrarily terminated at the eighth term. The obtained projection is shown in Fig. 1b. A comparison of the dependence of the electron density on the distance in the [110] direction is shown in Fig. 2 for the two indicated cases.

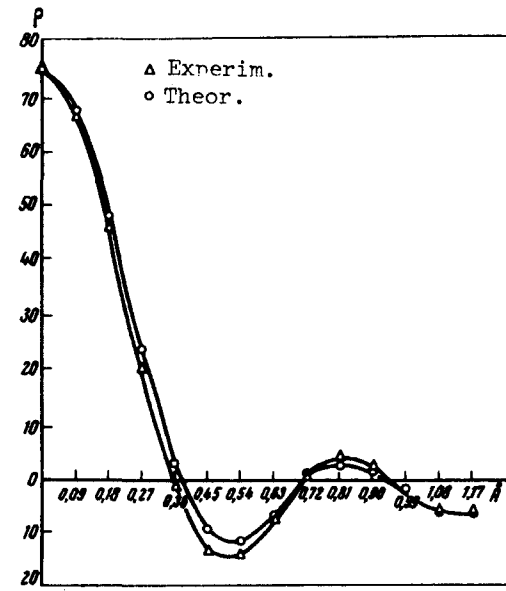

Fig. 2. Electron density in tungsten crystal vs. the distance in the [110] direction, obtained from experimental data on neutron scattering and from the calculated x-ray data.

The fact that the pictures are perfectly identical indicates that the Fourier transform obtained from the ne-interaction data actually represents the distribution of the electron density in the crystal.

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OBSERVATION OF FINE STRUCTURE WITHIN THE LIMITS OF HOMOGENEOUS LINE WIDTH

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ZhETF Pis. Red. 15, No. 7, 401 - 404 (5 April 1972)

It has been shown in a number of theoretical papers for the case of gaseous, liquid, and solid media [1 - 4] that in a strong resonant optical field the frequency dependence of the gain (absorption) of a weak field in a saturable transition has a dip that is narrower than the homogeneous line width. The dip width is determined by the lifetimes of the transition levels [2]. A study of these structures is useful, first, for the understanding of the physical processes in a laser [1, 5] and, second, can yield an effective method of determining the lifetimes and other level characteristics.

We report here observation and a qualitative analsyis of the fine structure in the 3.3912-μ saturated line $5s'[1/2]_1^0 \to 4p'[3/2]_2$.

It follows from the experimental data below that the influence of the atomic collisions on the fine structure of the saturated line cannot be explained without taking level degeneracy into account. Allowance for degeneracy in the presence of collisions was carried out only in [3] for the $J = 1 \to J = 0$ transition. Since we used here the transition $J = 1 \to J = 2$, we calculated the saturated gain line in third order of perturbation theory with allowance for the depolarizing collisions for the indicated transition. In the case of unidirectional motion of linearly polarized waves in a strong and weak field, the frequency dependence of the gain $f(\Omega)$ of the weak field, in the limiting case of inhomogeneous and homogeneous broadening, is given by

$$f(\Omega) \propto \begin{cases} \exp\left[-\left(\frac{\Omega}{kv}\right)^2\right] - \frac{E^2d^2}{1800} L_{2\gamma}[B + b(\Omega)]; \quad kv \gg \gamma, & (1) \\ L_\gamma\left(1 - \frac{E^2d^2}{900}[B + b(\Omega)L_\gamma]\right); \quad kv \ll \gamma, & (2) \end{cases}$$

where Ω is the frequency deviation of the weak or strong field, the latter being tuned to the center of the line (ω_0); $L_x = x^2/(\Omega^2 + x^2)$, E^2 is the strong-field intensity, d the modulus of the reduced matrix element of the transition, 2γ the homogeneous width of the transition, k the wave vector and v the average thermal velocity of the atom:

$$B = \begin{cases} B^{\uparrow\uparrow} = 100/\gamma_a^{(0)} + 2/\gamma_a^{(2)} + 60/\gamma_b^{(0)} + 42/\gamma_b^{(2)} & (3) \\ B^{\uparrow\downarrow} = 100/\gamma_a^{(0)} - 1/\gamma_a^{(2)} + 60/\gamma_b^{(0)} - 21/\gamma_b^{(2)} & (4) \end{cases},$$