

We investigated the possibilities of fixing holograms in iron-doped lithium niobate crystals and found a method whereby to store the information for an almost unlimited time. The sample with the recorded hologram was heated to 75°C. The heating continued for about 5 minutes and terminated before the image brightness began to decrease. The sample was then cooled to room temperature. Subsequent illumination of the hologram with the reference beam used in the photography, i.e., with an approximate power density 0.05 W/cm², led to a gradual enhancement of the brightness of the reconstructed image relative to the initial level. Such a fixation of the hologram of a binary matrix, with initial approximate efficiency 3%, enhanced the diffraction efficiency more than 5 times. The maximum efficiency (~16%) has remained unchanged for several months by now. The hologram was read during that time with power density exceeding 0.05 W/cm² for a total of 30 hours. It should be noted that the mechanisms whereby the hologram is fixed and subsequently enhanced have not yet been satisfactorily explained.

We have also rerecorded holograms repeatedly in the same crystal sample. To erase the information, the sample was heated to 150°C. After fivefold rerecording, the diffraction efficiency of the hologram remained the same as in the first use.

Thus, our experiments lead to the conclusion that iron-doped lithium niobate crystals can be used even now as the recording medium in permanent memories, and offer the possibility of rerecording holograms. The development of methods of "fast" fixation of the recorded information will make it possible to realize on the basis of these crystals high-speed operative memories.

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ROLE OF ELECTRON-ELECTRON INTERACTION IN THE FORMATION OF A METASTABLE STATE OF METALLIC HYDROGEN

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We analyze the question of the stability of the results obtained for the metallic phase of hydrogen with respect to changes in the character of the approximations used to take the electron-electron interaction into account.

1. In [1] we considered the possible existence, in principle, and the structure of a metastable phase of metallic hydrogen. To this end we analyzed the energy and the static and dynamic stability for all Bravais lattices and for a number of diatomic lattices. The most essential of the results can be reduced to the following: 1) At zero pressure the metallic phase of hydrogen is a metastable and locally stable state. 2) All the symmetric (and cubic) structures are unstable. 3) The energy minimum is realized for a sharply anisotropic structure. 4) The metastable state is stable against decay into atoms (transition to the atomic phase).

2. The analysis in [1] was based on the use of perturbation theory in the electron-ion interaction (see [2] and the review [3]), with terms up to third order retained and with the electron-electron interaction taken into account in all terms of the series. This, naturally, raises the question of the stability of the foregoing results to improvement (change) of the character of the approximations.

We present in this article the results of an analysis of the role of a change in the character of the approximation when account is taken of the electron-electron interaction, and demonstrate that the results are qualitatively stable. The effect of higher terms of the expansion in the electron-ion interaction will be considered in a separate article.

3. Definite progress was made recently in the determination of the static polarization operator $\pi(q)$ at intermediate values of the electron density (see, e.g., [4, 5]). Its value

determines completely $E^{(2)}$ and the screening of the external electron-ion interaction lines in $E^{(3)}$, and it is therefore of interest to perform the calculation within the framework of the improved approximations for $\pi(\vec{q})$. (In [1] we used the Hubbard theorem with allowance for the compressibility theorem.)

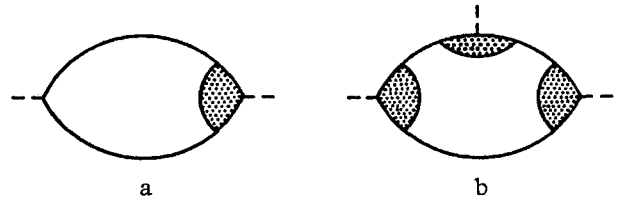


Fig. 1

In addition, the approximation for the irreducible 3-pole in $E^{(3)}$ can be improved by taking into account in each vertex the possible exchange between the electron scattered by the ions and the background that screens it [3, 6]. To this end we note that an analysis of the behavior of $\pi(\vec{q})$ leads to an expression of the type

$$\pi(\vec{q}) = \pi_0(\vec{q}) / [1 - (4\pi e^2 / q^2) G(\vec{q}) \pi_0(\vec{q})] \quad (1)$$

($\pi_0(\vec{q})$ is a simple loop and $G(\vec{q})$ is a function that determines the local field in the given theory). Considering the character of the approximations for $\pi(\vec{q})$, it is easily understood that they are actually equivalent to replacing the exact vertex (Fig. 1a) by an approximate one that depends only on the momentum transfer

$$T(\vec{p}, \vec{q}) \approx T(\vec{q}) = [1 - (4\pi e^2 / q^2) G(\vec{q}) \pi_0(\vec{q})]^{-1}. \quad (2)$$

Proceeding in similar fashion for the 3-pole, we obtain (Fig. 1b)

$$\Gamma^{(3)}(\vec{q}_1, \vec{q}_2, \vec{q}_3) = \Lambda_0^{(3)}(\vec{q}_1, \vec{q}_2, \vec{q}_3) / \tilde{\epsilon}(\vec{q}_1) \tilde{\epsilon}(\vec{q}_2) \tilde{\epsilon}(\vec{q}_3), \quad (3)$$

$$\tilde{\epsilon}(\vec{q}) = \epsilon(\vec{q}) / T(\vec{q}) = 1 + (4\pi e^2 / q^2) [1 - G(\vec{q})] \pi_0(\vec{q}).$$

Here $\Lambda_0^{(3)}$ is a ring diagram with three momenta of the external static field (see [1, 3]).

We emphasize that (1) and (3) contain the same function $G(\vec{q})$. Only under this condition, in particular, is the exact relation obtained in [7] between the two-pole and three-pole is satisfied when one of the momenta in the latter tends to zero.

4. We have calculated the energies of the metallic phase of hydrogen, using the approximations (1) and (3) for the three functions $G(\vec{q})$, namely G_{VS} [4], G_{TW} [5], and G_H [1]. The results were found to be qualitatively analogous, although they differed, of course, numerically.

The table gives the values of the energy and the equilibrium value of r_s ($P = 0$) for three cubic lattices and a primitive hexagonal lattice, which again turned out to be optimal. All the cubic structures are unstable; the last column of the table lists the negative elastic moduli, and explains by the same token the character of the long-wave instability. In all uniaxial structures the minimum of the energy corresponds to sharply anisotropic structures, and the corresponding c/a is even smaller than in [1] (the "filamentary" character of the structures is preserved). For the primitive hexagonal structure the values of $(c/a)_{\min}$ are close for different forms of $G(\vec{q})$ and are equal to ~ 0.47 .

It is important that the energy of the minima of all structures has decreased, i.e., the binding energy has increased in comparison with the results of [1]. It should be noted that the minimum in the PH structure lies near the non-analyticity of the "three-pole." In this region, strictly speaking, it is necessary to take into account the gaps in the electron spectrum, and this can alter slightly $(c/a)_{\min}$ and the corresponding value of E_{\min} . Figure 2 shows the equal-energy curves for the PH structure. These make it possible to analyze the character of formation of the "metallic" minimum and the barriers surrounding it. For comparison, data are

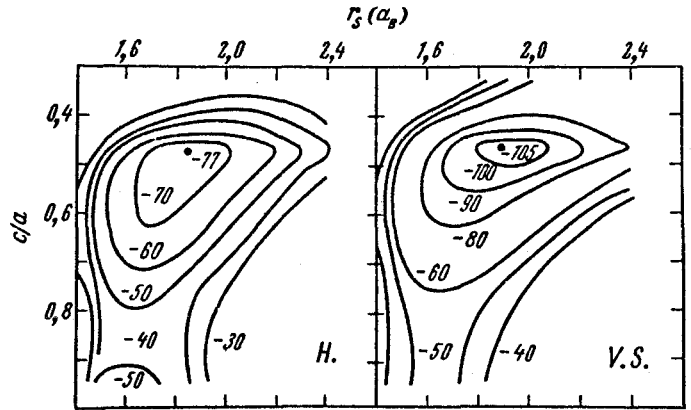


Fig. 2

Lattice type	$G(q)$	r_s, a_B	E , Rydberg	Unstable moduli
BCC	H	1.626	-1.047	B_{22}, B_{44}
	VS	1.629	-1.050	B_{22}, B_{44}
	TW	1.639	-1.056	B_{22}, B_{44}
FCC	H	1.625	-1.048	B_{44}
	VS	1.629	-1.051	B_{44}
	TW	1.639	-1.057	B_{44}
PC	H	1.645	-1.054	B_{22}
	VS	1.651	-1.059	B_{22}
	TW	1.665	-1.067	B_{22}
PH	H	1.856	-1.077	-
	VS	1.903	-1.105	-
	TW	2.009	-1.141	-

given also for G_H and G_{VS} . We see that the behavior of the level lines is similar in the two cases. The minimum itself is shifted, as a result of the enhancement of $E^{(3)}$, towards larger r than in [1]. (As noted in [1], $E^{(3)} \sim r_s$ and $E^{(2)} \approx \text{const.}$) A real improvement in the equilibrium value of r_s can apparently be obtained only by including terms of higher order in the electron-ion interaction. Of particular important is the departure from the assumed approximation on going over to even more distorted structures, where the contribution from the nearest reciprocal-lattice points increases sharply.

Thus, all the qualitative results obtained in [1] remain in force when a more consistent account is taken of the electron-electron interaction and the form of the approximate function $G(q)$ is varied simultaneously.

We note in conclusion that an incorrect representation was actually used for $\Lambda_0^{(3)}$ in a recent paper [6] (the correct expression is given, for example, in [3, 8]), so that all the statements made there concerning the position of the energy minimum and the role of the electron-electron interaction are incorrect.

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