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1) If this medium (i.e., the substrate) is opaque to the laser then Raman scattering of light in reflection can be used.

2) Allowance for the effect of the substrate on the dispersion of surface polaritons does not raise any difficulties (see [2] and below).

3) For concreteness, we use the data for GaP in the He-Ne emission region (in cgs esu).

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USE OF PROTON CHANNELING TO DETERMINE THE LOCATION OF OXYGEN DISSOLVED IN A NIOBIUM SINGLE CRYSTAL

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Using the fact that the flux density of charged particles becomes redistributed in a channel, we determine the location of oxygen introduced into a niobium single crystal. The oxygen is identified by the nuclear reaction $O^{18}(p, \alpha)N^{15}$. It is shown that the oxygen occupies octahedral interstices.

The dynamic redistribution of the flux density of self-trapping particles in a single crystal [1 - 3] uncovers prospects for investigating the positions occupied in the lattice of a single crystal by as few foreign atoms as several tenths or hundredths of an atomic percent of the impurity.

To determine the positions occupied by the oxygen in the single-crystal niobium, we used the nuclear reaction $O^{18}(p, \alpha)N^{15}$. The differential cross section of the reaction is ~ 50 mb at a proton energy $E_p = 700$ keV. The niobium single crystal was oriented relative to a proton beam with a divergence angle not exceeding 0.05° by using a goniometer having three degrees of freedom [4]. The elastically scattered protons and α particles of the reactions were registered with charged-particle spectrometers based on semiconductor detectors.

Niobium single-crystal samples measuring 10×5×1 mm were cut perpendicular to the <111>, <110>, and <100> axes and were saturated with oxygen enriched with O^{18} to 42% at a pressure 4×10^{-4} mm Hg and a temperature 1150°C. The homogenization was at 1750°C and 5×10^{-6} mm Hg for 20 minutes. The oxygen concentration in the samples was 0.1 to 0.2 at.%.

Figure 1 shows the spectrum of the protons elastically scattered by the niobium atoms (a) and of the α particles of the reaction (b), with the proton direction coinciding with the <100> axis. It shows the spectrum of the protons (A) and α particles (B) when there is no channeling. The yield of the scattered protons is one-ninth that for the channeled beam, thus indicating that the original single crystal was of good quality.

To determine the positions occupied by the oxygen, we performed angle scanning in steps of 0.05° in the vicinities of the axes <111>, <100> and the planes {100}, {110}, and {122} with simultaneous registration of the yields of protons elastically scattered by the niobium atoms, and of the α particles from the reaction $O^{18}(p, \alpha)N^{15}$. The results of the scanning are shown in Fig. 2. An appreciable increase in the yield of the α particles is observed when the direction of the proton beam coincides with the crystallographic axes <111> and <100> and with the planes {110} and {122}. This indicates that oxygen is an interstitial impurity occupying regular interstices [5].

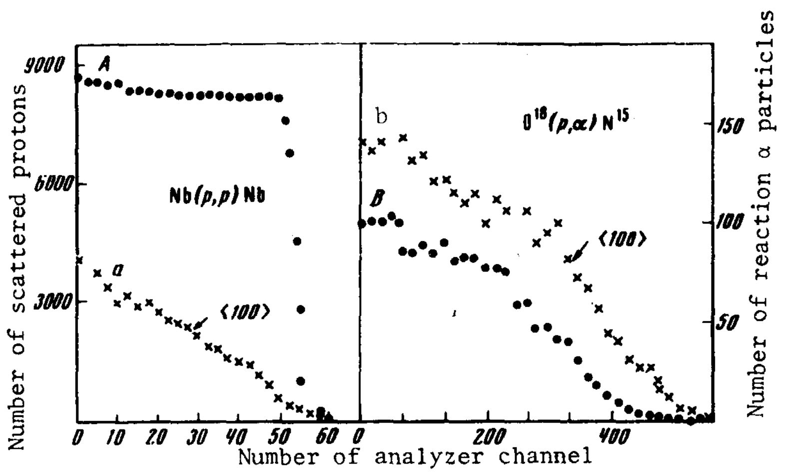

Fig. 1. Energy spectra of protons elastically scattered by niobium atoms (left side), and of the α particles of the reaction $O^{18}(p, \alpha)N^{15}$ (right side), when the direction of the proton beam coincides with the <100> crystallographic axis of the niobium lattice (circles) and in the case of arbitrary orientation (circles). The initial proton energy is E_p = 700 keV.

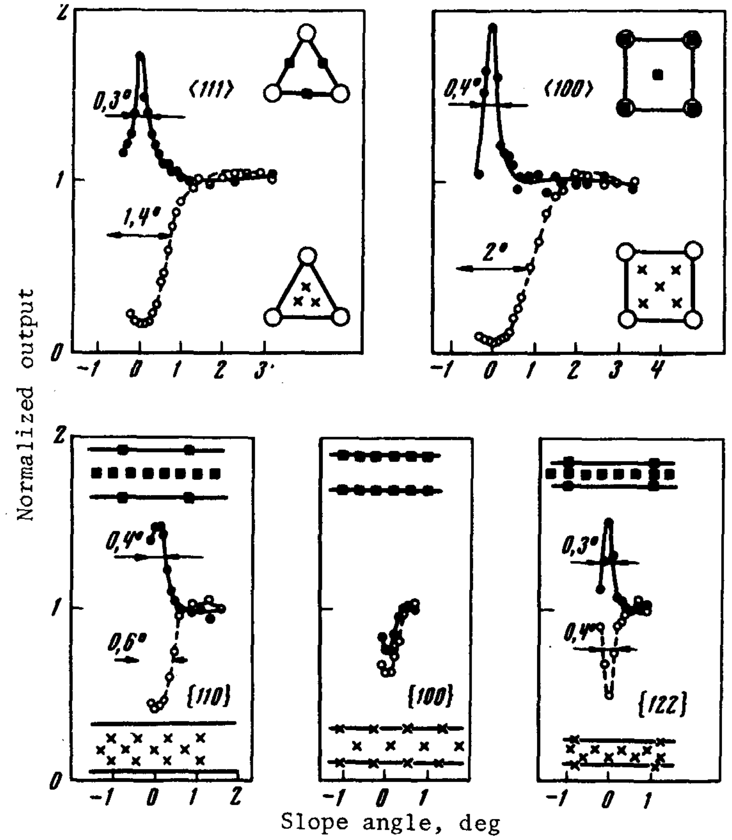

Fig. 2. Results of angle scanning in the vicinity of the crystallographic axes <111> and <100> and of the planes {110}, {100}, and {122}: ● — yield of α particles in the reaction $O^{18}(p, \alpha)N^{15}$, ○ — yield of protons elastically scattered by the niobium atoms. For each case we show the projections of the chains of atoms (○) and of the atomic planes (solid line) of the niobium, and also of the chains of the possible interstitial positions of the oxygen (octahedral (■) or tetrahedral (×) interstices) on a plane normal to the given direction.

The results of angle scanning in the vicinity of the {100} plane shows that the oxygen occupies positions in octahedral interstices. Indeed, were the oxygen to be situated in tetrahedral voids, the α-particle yield would expect to increase when the proton-beam direction coincides with the {100} plane [6], for in this case part of the oxygen lies between the planes of the niobium atoms. If, however, the oxygen occupies octahedral interstices, the decrease in the yield of the reaction α particles should be the same as the decrease in the yield of scattered protons (as is indeed observed in the experiment), since all the octahedral voids are in the {100} atomic planes of the niobium lattice. Some difference between the angle half-widths for the yields of the α particles and the elastically-scattered protons is apparently connected with the fact that the amplitude of the thermal oscillations of the oxygen, which occupies the octahedral voids, is larger than for the lattice atoms. The relation between the indicated half-widths for the 110 and 122 planes serves as an additional confirmation of the hypothesis that the oxygen is located in octahedral voids.

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DYNAMICS OF ACTIVE MODE PHASING IN A PULSED LASER WITH PERIODIC LOSS MODULATION

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Ultrashort pulses with energy on the order of the gain saturation energy (6 J/cm^2) were obtained directly in a laser for the first time; this is important when it comes to effective amplification of the pulse energy. It is demonstrated that in the giant-pulse regime it is possible in principle to phase the spectral components of the emission within the limits of the generation spectrum. This spectrum contains frequencies that differ strongly from the resonator modes.

It is well known that the energy of single pulses in the mode self-locking regime does not exceed 10^{-3} - 10^{-2} J. This is why multistage amplification could not yield ultrashort pulses with energy exceeding 10^2 J [1]. At the same time, the time of active phasing of the modes [2 - 4] differs in that the phasing regime is stable against an increase of the pumping, and the output energy is limited only by the optical strength of the laser components. It is shown in the present paper that by using this method one can focus in a laser pulses that come close in duration to the pulses obtained in the self-locking method, but their energy is larger by two or three orders of magnitude.

At the instant when the Q is switched on, the spontaneous-noise field has uniform frequency and phase distributions. Owing to the dependence of the loss in the resonator on the frequency, the lasing develops in a manner such that the frequency spectrum becomes narrower. A similar narrowing should be observed also in the phase spectrum. When the Q-switching frequency Ω coincides with the intermode frequency c/2L, the loss has a minimum at a field combination in which these frequencies are spaced nΩ apart, and the phases coincide with the Q-switching phase. This is an obvious fact, from which it follows that after the Q is turned on there should take place a predominant development of fields with a definite phase, i.e., they should acquire a distribution P(ϕ, t) with a maximum at the Q-switching phase. For a field of frequency ω we have

$$\tilde{a}(\omega, t) = \int_{-\pi}^{\pi} a(\omega, t)\cos\phi\, P(\phi, t)\, d\phi = a(\omega, t)\overline{\cos\phi(t)},$$

$$a(\omega, t) = \mathbf{E}(\omega, t)\exp(i\omega t). \tag{1}$$

In analogy with [5], the field intensity in the resonator is

$$I(t) = \sum_{m,n} a_m a_n \overline{\cos\phi_m}\,\overline{\cos\phi_n}\exp\{i\Omega t(m-n)\} + \sum_n a_n^2(1-\overline{\cos^2\phi_n}) = I_{\text{pul}}(t) + I_{\text{backg}} \tag{2}$$