magnetic field (up to 5000 Oe) at 82°K. The magnetic rotation was also measured as a function of temperature for a (100) plate at 6330 Å. It decreased from 570°/cm to 400°/cm as the temperature was raised from 80 to 85°K. The transmitted light then becomes elliptically polarized from 85 to 100°K and linearly polarized again at 100°K, but the rotation above 100°K was small.

Finally, the Cotton-Mouton effect (magnetic birefringence) at 82°K was measured by applying the magnetic field perpendicular to the direction of propagation of light, which was along the [100] direction of the sample. For this purpose a Babinet-Soleil compensator was used between the crossed polarizers. The difference of the indices of refraction $\Delta n = n_{\parallel} - n_{\perp}$, where $n_{\parallel}$ and $n_{\perp}$ are the indices parallel and perpendicular to the applied magnetic field, varies with magnetization. Δn was found to be negative and remained unchanged upon reversal of the magnetic field. The difference of Δn measured at $H = 5$ kOe and $H = 0$ was found to vary linearly with wavelength. It is 9×10^{-5} at 4000 Å and 1.6×10^{-4} at 8000 Å.

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CHARACTERISTIC EXTREME uv EMISSION FROM CHANNELED POSITIVE IONS*

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The phenomenon known as "channeling" has been studied by many.[1,2] Although different methods have been used, basically they all have as a common ground the observation of a reaction that takes place at the lattice points of the crystal under investigation. To enumerate, one would mention the study of the emission of x-ray characteristic lines from a single crystal,[3] the scattering of protons from the nuclei of a single crystal,[4] the emission of beta particles from radioactive nuclei embedded in the crystal,[5] etc.

In the present work, experiments have been conducted to measure the photon yield resulting from neutralizing the incident charged particles. The intensity of such emission is observed as a function of the orientation of the planes of a single crystal with respect to the direction of incidence of the impinging collimated beam.

A single crystal of copper was cut, cleaned, and mounted in a crystal holder,[6] and then exposed to a monoenergetic (±0.5%) beam of protons. The incident beam was collimated to about ±0.2°. The intensity of the Cu L radiation was measured by means of a proportion-

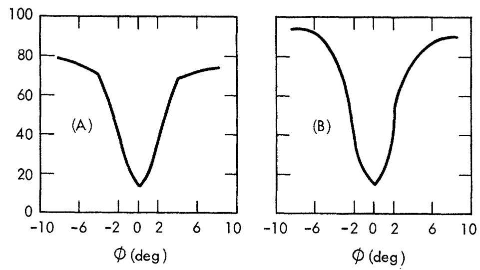

FIG. 1. (a) The Cu L x-ray yield and (b) the intensity of the hydrogen 1216-Å line as a function of φ for a proton energy $E_p = 70$ keV. The two curves were taken simultaneously.

al counter, while a windowless photomultiplier tube, in conjunction with a 50-cm vacuum uv scanning monochromator, was used to observe the intensity of the hydrogen 1216-Å line. The two counting units were mounted on the same side of the vacuum chamber, with their lines of sight making an angle of about 10°. This geometry enables one to study the x-ray yield from the Cu L shell and the intensity of the hydrogen 1216-Å line simultaneously and under identical conditions.

The results shown in Fig. 1 give the intensity of the Cu L radiation and that of the hydrogen 1216-Å line as a function of the angle φ, for 70-keV protons. The angle φ represents a rotation of the crystal about the normal to its face. The [001] direction is along the normal and makes an angle $\theta = 45°$ with the incident proton beam. The observed minimum occurs at the [011] direction. The data indicate that the widths of the yield profile observed under the same energy conditions by the two different methods are the same and, within experimental error, have the same energy dependence of $(E_p)^{-1/2}$, where E_p is the energy of the incident particles. Figure 2 gives the widths of the yield profile as a function of the incident proton energy.

To investigate the possibility that the hydrogen line might be emitted by hydrogen atoms that have been trapped in the copper crystal, we exposed our crystal, alternately, to beams of protons and ionized helium. The observed spectra suggest that under the present conditions of operation, characteristic emission from particles already trapped in the crystal is negligibly small.

The channeling of the He^+ particles in a single crystal of copper was also observed. The

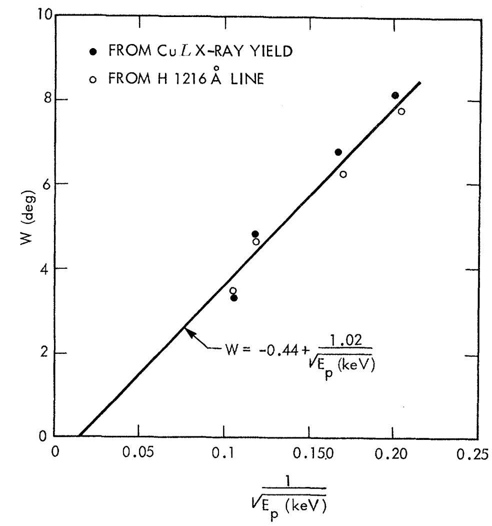

FIG. 2. The width of the yield profiles is plotted as a function of $E_p^{-1/2}$.

variation in the Cu L yield and in the intensity of the He 584-Å line[7] as a function of the crystal orientation is shown in Fig. 3. Under similar conditions, the channeling of He^+ particles, although clearly observable, was less pronounced with the He 584-Å line than with the Cu L radiation. The channeling of protons observed with either the Cu L radiation or the hydrogen 1216-Å line was more pronounced than that of He^+. As previously reported,[8] an extended period of He^+ ion bombardment was found to disrupt channeling.

In conclusion, one may say that characteristic extreme uv emission as a new observable for the study of channeling of charged particles by a single crystal has been established. It reflects upon the attachment, in an excited state, of an electron to a positively charged particle and the subsequent decay from that

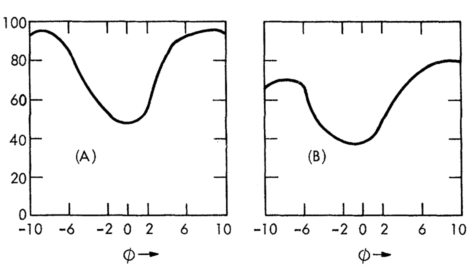

FIG. 3. (a) The Cu L x-ray yield and (b) the intensity of the He 584-Å line as a function of φ, for an He^+ energy of 70 keV.

state. Thus, this observable overrides the usual energy limitations, and its study may be extended to cover energies from a few eV to tens of MeV.

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CYCLOTRON RESONANCE OF THE POLARON IN KCl, KBr, KI, RbCl, AgCl, AgBr, AND TlCl*

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In this Letter we report observations of cyclotron resonance and approximate values for polaron masses in seven different ionic crystals. For the first time, the size of the polaron effect can be estimated in a variety of materials over a wide range of coupling constants. The measurements were carried out at 2-mm wavelengths and magnetic fields up to 140 kOe using an electron-heating technique previously applied to KBr at longer wavelengths.[1] The results can be used to compute band masses (effective masses in the absence of lattice polarization) for the purpose of comparison with recent band calculations.[2-4]

Transient currents about 2 μsec in duration were excited in the insulating crystals studied by repeated flashes of a small xenon flash lamp. The alkali halides were either x rayed or additively colored with F centers, and electrons were excited by K- and L-band illumination. In the case of the silver and thallium halides, the carriers were produced by band-to-band excitation. Identical positive and negative voltage pulses were repetitively applied to the specimen, placed between blocking electrodes immersed in liquid helium. The small transient photocurrents were then amplified by a low-noise wide-band preamplifier[5] and pulse-shaping main amplifier. The repeated pulses were averaged in a two-channel boxcar integrating circuit[6] in such a way that the photoresponse could be continuously recorded as a function of various parameters, for example, as a function of transverse or longitudinal magnetic fields. Polarization effects were minimized by the symmetrical conditions of drift during positive and negative voltage pulses and by the use of a depolarizing light during the dark intervals between pulses. The rms noise of the amplifier was equivalent to a single input pulse of about 450 electrons; however, repeated pulses of only five electrons each could be detected by pulse averaging. Further apparatus details will be given elsewhere.[7]

In order to observe cyclotron resonance of the photocarriers, 140-GHz microwave power from a COE-20C Carcinotron was switched on during alternate pulses of the flash lamp. The output of the boxcar integrating circuit was arranged to be proportional to the difference between alternate photopulses. When using this differential mode, microwave-induced changes in the photoresponse as small as 0.1% could be observed. The crystal was located