splittings of several terms. Using Arroe's data for the interval factor $A(4d^3 5s^6F_5) = -0.0078$ cm^{-1} (which are naturally more accurate than the present measurements), the value $a(5s) = -0.078$ cm^{-1} was obtained; and putting this into the Goudsmit-Fermi-Segrè formula, the value of the magnetic moment

$$\mu(Zr^{91}) = -1.1 \pm 0.3 \text{ nm}$$

was obtained.

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Radiations from Ne^{19} and Na^{21}†

G. SCHRANK AND J. R. RICHARDSON
University of California, Los Angeles, California
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THE half-lives, β-spectra, and accompanying γ-rays have been measured for the positron emitters Ne^{19} and Na^{21} with a 180° beta-ray spectrometer and a NaI crystal gamma-ray spectrometer. Calibration of the former was accomplished with the Cs^{137} conversion line and the 2.36-Mev β^+ spectrum[1] of Zn^{63}, while Na^{22} and Co^{60} were used with the latter. The samples were prepared from the reactions $F^{19}(p, n)Ne^{19}$ in BaF and CsF and $Mg^{24}(p, \alpha)Na^{21}$ in magnesium metal.

By means of a special probe it was possible to transfer the sample from the cyclotron to the spectrometer in about 30 seconds. With the β-spectrometer counting rate being recorded automatically the sample was allowed to decay for about two half-lives, the spectrometer field changed to a second value, and the sample then allowed to die out. These two decay rates were plotted on log paper using the previously determined half-life and so two relative values of momentum *vs* activity were obtained. Returning to a fiducial field value with each sample allowed data for a complete momentum plot to be accumulated.[2] It is clear that this method is useful with short-lived activities for which: (1) monitoring the total activity is unsatisfactory because the method of production does not insure the same ratio of "desired" to total activity for each sample and; (2) the time necessary to change the spectrometer field $\lesssim$ the half-life.

Ne^{19} and Na^{21} exhibited half-lives of 18.5 ± 0.5 sec and 22.8 ± 0.5 sec, respectively, while the allowed Kurie plots gave end points of 2.18 ± 0.03 Mev and 2.50 ± 0.03 Mev, respectively.[3-7] Because of the necessity of source thickness the Kurie plots curved upward at lower energies and so masked possible low energy β^+ groups. Consequently, a search for accompanying γ-rays was made with a NaI crystal spectrometer. Whereas Ne^{19} was exposed to the crystal for about three half-lives as soon after production as possible, it was necessary to wait about 60 sec after bombardment before exposing Na^{21} in order to allow the competing shorter Al activities to die out. Several photographs with different numbers of exposures on each showed the 0.51-Mev annihilation line superimposed upon the expected continuous γ-distribution, but no line was detected above 0.51 Mev for either Ne^{19} or Na^{21}.

Comparison of *ft* values for this series of transitions ($T_z = -\frac{1}{2} \rightarrow T_z = +\frac{1}{2}$) shows most of them to be in the range 3 to 4×10^3. While Na^{21} falls within this range Ne^{19} with $Z = 10$ is the notable exception[8] of the group having the lowest *ft* value at 1.8×10^3. Since differences in radial distributions are not expected to cause this much variation here, the proper choice of ground states from the shell models together with tensor or axial interaction should eliminate this difference. An experimental point at $Z = 20$ would be of interest.

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Crystal Structure of the Ferroelectric Phase in $PbZrO_3$ Containing Ba or Ti

GEN SHIRANE* AND SADAO HOSHINO
Tokyo Institute of Technology, Oh-okayama, Tokyo, Japan
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A RECENT investigation[1] of $(Pb92.5\text{-}Ba7.5)ZrO_3$ has shown that this solid solution transforms, with rising temperature, from an antiferroelectric phase to a ferroelectric one at 175°C and further to a paraelectric phase at 200°C. The present authors have been studying the crystal structure of this ferroelectric phase in the same ceramic that was used for the previous dielectric study.

A series of powder photographs with rising temperature was taken with Cu $K\alpha$ radiation by using a high temperature camera of radius 5.5 cm. The Debye lines show pseudo-cubic features in the whole temperature range. The high order reflection lines in the photograph taken at 190°C show very small but definite line splittings: among them the (422) and (332) groups can be effectively used for the structure determination. In order to explain these line splittings, three possible lattice types are considered, namely, tetragonal, orthorhombic, and rhombohedral, corresponding to modifications of the perovskite structure. It has been proved that all of the multiplets can be well explained by assuming a rhombohedral lattice with $a = 4.153$A and $\alpha = 89° 51'$. This conclusion is strongly supported by the behavior of the (400) group, which shows no multiplet structure besides the single $K\alpha_1 K\alpha_2$ doublet.

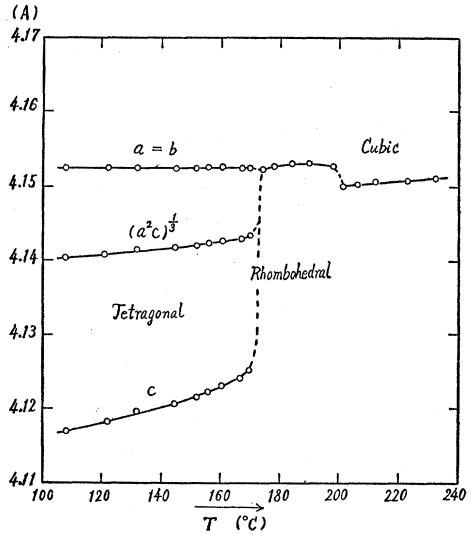

FIG. 1. Lattice spacing *vs* rising temperature for $(Pb92.5\text{-}Ba7.5)ZrO_3$.

Attention should be called here to the remarkable intensity anomalies observed in this photograph. Firstly, the relative intensities of reflections with odd values of $(h^2+k^2+l^2)$ to those with even values are anomalously large when compared with the case in the cubic phase. Secondly, we found a peculiar intensity relation among a certain line group; for example, the intensity of the $(430)(\bar{4}\bar{3}0)$ reflections is much stronger than that of the $(\bar{4}30)(4\bar{3}0)$ reflections, whereas their intensity ratio should be equal if the atoms occupied the special positions in the unit cell. These anomalies can be well understood when we assume that Zr (or Pb) ions are displaced along the [111] direction. This displacement is the most plausible one to be expected in the ferroelectric rhombohedral lattice. Such a structure is similar to that observed in $BaTiO_3$ below $-70°C$.[2] This conclusion seems to be rather unexpected, because all of the other perovskite type ferroelectrics, such as $BaTiO_3$,[2] $PbTiO_3$,[3] and $KNbO_3$,[4] show lattice changes in the following sequence for falling temperature: cubic—tetragonal—orthorhombic—rhombohedral.

The temperature change of the lattice spacing of (Pb92.5-Ba7.5)ZrO_3 was calculated from the (510) group and is shown in Fig. 1. Below 175°C the structure has a tetragonal lattice with $c/a<1$, giving superstructure lines like those observed in pure $PbZrO_3$. These superstructure lines disappear at the antiferroelectric to ferroelectric transition at 175°C.

It has been known that Pb(Zr-Ti)O_3 compositions show a similar ferroelectric phase[5] to that observed in (Pb-Ba)ZrO_3. In the previous x-ray study of Pb(Zr95-Ti5)O_3,[6] however, we were unable to determine the structure of this ferroelectric phase, though we found very small splittings of the Debye lines. A re-examination of this structure was carried out with a high purity specimen of the same composition, which is ferroelectric between 150° and 230°C. The structure of this ferroelectric phase has now turned out to be also rhombohedral, with $a=4.143$A and $\alpha=89°\,51'$ at 200°C. We found, in this phase also, similar intensity anomalies to those observed in the corresponding phase in (Pb92.5-Ba7.5)ZrO_3.

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* Now at Department of Physics, Pennsylvania State College, State College, Pennsylvania.

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$\beta-\gamma$ Polarization Correlation in Sb^{124}

ROBERT STUMP
Department of Physics and Astronomy, Kansas University, Lawrence, Kansas
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IT is well known that there is an angular correlation between the direction of the highest energy β-particle (2.29 Mev) and the succeeding γ-ray (0.60 Mev) in the decay of Sb^{124}.[1-3] As a consequence of the existence of this correlation, it may be shown that the γ-ray will exhibit a polarization correlation. The $\beta-\gamma$ angular correlation depends upon the spins of the nuclear states involved in the decay, and upon the matrix element of the β-decay. On the other hand, the $\beta-\gamma$ polarization correlation depends only on the observed angular correlation, and the parity change (yes or no) of the γ-transition. Thus a measurement of the polarization leads to a unique assignment for the parity of the level from which the 0.60-Mev γ-ray is emitted.

In general, if the angular correlation has the form $W(\theta)=1+\alpha\cos^2\theta$ then the γ-ray emitted at $\theta=\pi/2$ (i.e., perpendicular to the direction of the preceding β) will be polarized. The polarization is given in terms of the number of quanta polarized in the θ-direction, J_θ, and the number in the ϕ-direction, J_ϕ. Then $J_\theta/J_\phi=(1+\alpha)/(1-\alpha)$ in case the γ-radiation is dipole or quadrupole radiation with no change in parity, and the reciprocal of this if there is a change in parity.[4] Hence, to determine the parity change it is necessary to know only the angular correlation coefficient α, and whether J_θ/J_ϕ is experimentally greater or less than one.

The observation of the polarization correlation of Sb^{124} was made with an arrangement similar to that of Metzger and Deutsch,[5] with the source and β-detector in a vacuum chamber to avoid the effect of scattering of the β-particles. The source was a thin film of Sb^{124} (supplied by Oak Ridge National Laboratory) which was evaporated on an aluminum backing, then stripped off and mounted on Nylon. The detector was a thin crystal of anthracene connected by a Lucite light pipe to a photomultiplier tube outside the chamber.

The polarization detector consisted of a scintillation counter with a large anthracene crystal to scatter the radiation by Compton collision, and two sodium iodide scintillation counters to detect the scattered radiation. The polarization of the γ-ray was determined by the anisotropy of the Compton scattering from the anthracene crystal.

The measurement of the polarization correlation consisted of determining the rate of triple coincidences between the β-particle, the γ-, and the scattered γ-rays, for two scattering directions. The triple coincidence rate with the scattering direction perpendicular to the plane of the β-particle and γ-ray is N_θ. The rate with the scattering direction in the plane of the β-particle and γ-ray is N_ϕ. The angle between the β and γ was always $\pi/2$. From the anisotropy in scattering predicted by the Klein-Nishina formula it is obvious that N_θ/N_ϕ has the same significance (although not the same size, because of inefficiency in the polarization detector) as does the term J_θ/J_ϕ in determining the parity change.

Since the decay of Sb^{124} is complex, aluminum absorbers were placed directly in front of the β-detector to eliminate the low energy β-particles which do not contribute to the correlation.[2] The ratio of the observed triple coincidence rates with $\sim$200 mg/cm^2 of aluminum was $N_\theta/N_\phi=0.93\pm0.04$ and with $\sim$400 mg/cm^2 of aluminum was $N_\theta/N_\phi=0.89\pm0.11$. Since the angular correlation coefficient $\alpha\simeq-0.4$, these data indicate that the γ-transition must occur with no change in parity. This result is in agreement with the decay scheme proposed by Stevenson and Deutsch to explain their angular correlation results.[3] It is also in agreement with the empirical rule of Goldhaber and Sunyar[6] that the first excited state of an even-even nucleus has spin two, even parity.

Measurements of the $\beta-\gamma$ polarization correlation are now being made on other nuclei in whose decay a $\beta-\gamma$ angular correlation has been observed.

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New Technique for the Determination of Photonuclear Cross Sections*

LESTER L. NEWKIRK†
Institute for Atomic Research and Department of Physics, Iowa State College, Ames, Iowa
(Received February 21, 1952)

A NEW technique for measuring photonuclear cross sections has been developed and applied to the $Cu^{63}(\gamma,n)Cu^{62}$ and $C^{12}(\gamma,n)C^{11}$ reactions up to 60 Mev. Induced radioactivity is employed to monitor the synchrotron beam. A mechanical device, called an oscillator, slides a test sample and a similar monitor