manium is placed into the vacuum system by using a demountable arrangement with a ground glass joint. This avoids glass-blowing procedures which might result in impurities being deposited onto the germanium surface from the hot glass prior to heat treatment studies. The direct Joule heating of the germanium is then carried out in a vacuum of 5×10^{-7} mm Hg with cool walls surrounding the germanium. This provides a method for removing copper[2,6] and possibly other volatile surface impurities.

Since the concentration of quenched-in acceptors appears to be somewhat different after "identical" surface cleaning procedures, we do not feel justified in claiming that the acceptors quenched into germanium in the present experiment are the result of lattice defects. Rather, it is thought that even the acceptor centers here observed may arise from surface impurities which diffuse into the crystal during heating and which might conceivably have been removed with even more refined surface processing and handling. We are therefore led to question the earlier interpretation based upon lattice defects.[2] In view of the present experiment it appears likely that the earlier results may correspond to some unknown impurity not removed from the surface prior to heat treatment.

[1] R. A. Logan, Phys. Rev. **91**, 757 (1953).
[2] S. Mayburg, Phys. Rev. **95**, 38 (1954).
[3] M. B. Prince, Phys. Rev. **92**, 681 (1953).
[4] E. N. Clarke, Sylvania Technologist **7**, 102 (1954).
[5] E. N. Clarke, Phys. Rev. **95**, 284 (1954).
[6] G. Finn, Phys. Rev. **91**, 754 (1953).

Atomic Distribution in Liquid Helium-3*

R. M. Mazo and J. G. Kirkwood
Sterling Chemistry Laboratory, Yale University, New Haven, Connecticut
(Received September 26, 1955)

In a previous paper,[1] the authors have shown how the radial distribution function of a fluid obeying quantum mechanical laws, at a temperature T and molar volume v, can be approximated by the radial distribution function of a classical liquid with the same molar volume, and at a temperature $\tau(T,v)$. $3k\tau/2$ is the mean kinetic energy per molecule of the quantum fluid. We have recently applied this theory to liquid He^3.

The value of τ appropriate to 0°K and the experimental molar volume of He^3 was determined by calculating E, the internal energy as a function of τ, and equating this to the negative of the heat of evaporation at 0°K.[2] τ turned out to be 12.5°K. The radial distribution function, $g(R)$, was calculated from the tables of Kirkwood, Lewinsohn, and Alder.[3] $g(R)$ was Fourier-transformed numerically to give the coherent x-ray scattering factor. The resulting normalized intensity distribution is shown in Fig. 1 together with the corresponding calculated factor for He^4. We do not exhibit $g(R)$ since the scale used for reproduction would not show the difference between He^3 and He^4.

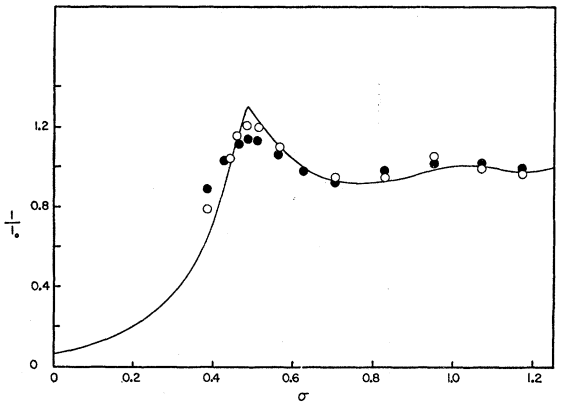

FIG. 1. $I(\vartheta)/I_0$ *versus* $\sigma=(a/\lambda)\sin\frac{1}{2}\vartheta$. ○—$He^4$ (calc); ●—He^3 (calc); — He^4 experiment [Gordon, Daunt, and Shaw, Phys. Rev. **96**, 1444 (1954)].

We hope that this communication will stimulate experimental work on the structure of He^3.

We should like to thank Miss Elaine C. Smith for carrying out the numerical integrations for He^3.

* This research was supported by the Office of Naval Research under contract with Yale University.
[1] R. M. Mazo and J. G. Kirkwood, Proc. Natl. Acad. Sci. (U. S.) **41**, 204 (1955).
[2] Abraham, Osborne, and Weinstock, Phys. Rev. **80**, 366 (1950).
[3] Kirkwood, Lewinsohn, and Alder, J. Chem. Phys. **20**, 929 (1955).

Radiation-Induced Amorphism in Diamond*

Paul W. Levy and Otto F. Kammerer
Brookhaven National Laboratory, Upton, New York
(Received October 26, 1955)

Diamond may be considered the least stable form of carbon, with graphite and amorphous carbon (lampblack), in this order, more stable. When one irradiates diamond with energetic particles such as are available in a reactor, the radiation damage may occur in several steps. The initial step is the creation of vacancies and interstitials, causing the lattice to be strained which results in an increased lattice parameter. Damage in this stage has been observed by Primak[1] and Wittels.[2] When the damage is more severe, or is concentrated, e.g., along the path of a charged damaging particle or recoil atom, the carbon atoms may rearrange by forming double or even triple bonds. This latter possibility has been dealt with by Dienes and Kleinman,[3] who considered the effects on the elastic constants of bombarded diamond containing regions of damage consisting of double-bonded carbon. In very severely

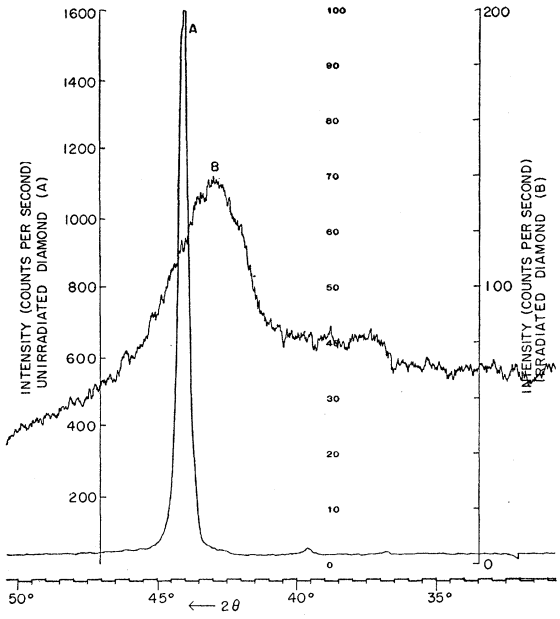

FIG 1. The (111) reflections of (A) normal and (B) severely damaged diamond.

damaged diamond, one may expect to find evidence for amorphous carbon, or perhaps, even graphite.

To search for these possibilities, 270-mesh diamond powder was first annealed at 500°C for two hours, to remove strain, and then irradiated in the Arco materials testing reactor. The total exposure was 2.4×10^{21} *nvt* "thermal" and about 3.8×10^{20} *nvt* "fast." It is estimated that the maximum temperature the sample reached was 65°C. Before irradiation the powder appeared perfectly white, and after irradiation it was shiny black, reminiscent of hardcoal dust. After irradiation, x-ray diffraction patterns of both irradiated and control material were run on a Norelco spectrometer using filtered Cu$-K_\alpha$ radiations. The pattern obtained from the unirradiated material was typical of normal diamond in every respect. In the irradiated sample, the normal reflections no longer appeared. Instead, we found the continuous almost structureless pattern of an amorphous material. Figure 1 shows the spectrometer tracings of the (111) reflection of both samples, and similarly, Fig. 2 is the tracings of the (220) reflections. Only these two reflections appear to be somewhat retained by the damaged material. From the data shown in Fig. 1, one can obtain a rough estimate of the lattice expansion, which is 2.4%. In addition, the damaged crystals contain a fairly definite but broad peak at $2\theta\approx18.5°$ and a much weaker broad peak at $2\theta=20.3°$. At the moment, we do not have a definite explanation for these reflections but they are probably due to hydrated aluminum oxide from the container in which the sample was irradiated. In summary, it can be said that this diamond sample has been damaged to the extent that it is now amorphous. A detailed x-ray study of this material is being made by D. T. Keating and will be published shortly.

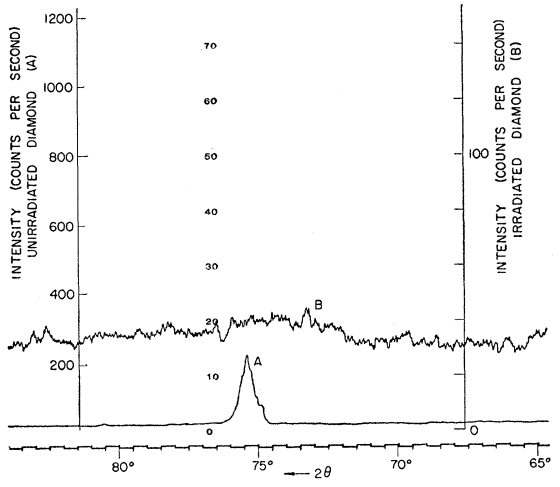

FIG. 2. The (220) reflection of (A) normal and (B) severely damaged diamond.

* Under the auspices of the U. S. Atomic Energy Commission.

[1] Primak, Fuchs, and Day, Phys. Rev. **92**, 1064 (1953).

[2] As described by J. H. Crawford and M. C. Wittels in paper No. 753, presented at the *International Conference for the Peaceful Uses of Atomic Energy* (1955).

[3] G. J. Dienes and D. F. Kleinman, Phys. Rev. **91**, 238 (1953).

Instability in the Motion of Ferromagnets at High Microwave Power Levels

P. W. ANDERSON AND H. SUHL
Bell Telephone Laboratories, Murray Hill, New Jersey
(Received September 22, 1955)

DAMON, Bloembergen, and Wang[1,2] were the first to measure ferromagnetic resonance at high power. Among other phenomena they found a marked broadening and lowering of the resonance line at powers rather low compared to those thought to be necessary for saturation.

We have found that the equations of motion of ferromagnetism lead to a physical instability which probably accounts for this result. Because of the nonlinear effect of the demagnetizing field certain spatially inhomogeneous perturbations tend to grow rather than decay at high enough powers. The simplest case which shows the physical origin of the effect occurs in the disk-shaped sample perpendicular to the dc magnetic field. Suppose there is a small perturbation in the precession angle of a horizontal stratum in this sample. (Figure 1 illustrates the quantities involved in the following.) Then the average moment of the stratum in the z-direction changes by $-\delta M_z$, and because of the demagnetizing effect the effective dc field changes by