Taking (4) into consideration, we transform (1) into the form

$$(\partial\varphi/\partial t) + (\mathbf{v}\nabla)\varphi + A\varphi = q, \quad (5)$$

where A is an operator determined by the expression $A\varphi = -S(f, \varphi) - S(\varphi, f)$ and $q = S(\varphi, \varphi)$. Since use of a distribution function makes sense only where one deals with sufficiently large volumes containing many particles, we must assume the function φ to be a small quantity. Therefore, we may approximately use in q, which is a quantity of the second order of smallness with respect to φ, the correlation (2) whence we obtain

$$\langle q(\mathbf{r}, \mathbf{v}, t)\, q(\mathbf{r}_0, \mathbf{v}_0, t_0)\rangle$$
$$= (A + A^*) f(\mathbf{r}, \mathbf{v}, t)\, \delta(\mathbf{r} - \mathbf{r}_0)\, \delta(\mathbf{v} - \mathbf{v}_0)\, \delta(t - t_0), \quad (6)$$

where A^* is the operator acting upon the velocity $\mathbf{v}_0$.

Let us denote by G the Green function for Eq. (5), *i.e.*, the operator by whose action on the source we can obtain the solution of this equation. Then we obtain from (5) and (6):

$$\langle \varphi(\mathbf{r}, \mathbf{v}, t)\, \varphi(\mathbf{r}_0, \mathbf{v}_0, t_0)\rangle$$
$$= GG^*(A + A^*) f(\mathbf{r}, \mathbf{v}, t)\, \delta(\mathbf{r} - \mathbf{r}_0)\, \delta(\mathbf{v} - \mathbf{v}_0)\, \delta(t - t_0), \quad (7)$$

where G^* is the operator acting upon $\mathbf{r}_0$, $\mathbf{v}_0$, t_0.

Eq. (7) also furnishes a solution for our problem. If we put, approximately, $A = 1/\tau$, where τ is the average time between collisions and assume that f is not a function of $\mathbf{r}$ and t, then (7) takes the form

$$\langle \varphi(\mathbf{r}, \mathbf{v}, t)\, \varphi(\mathbf{r}_0, \mathbf{v}_0, t_0)\rangle$$
$$= e^{-|t-t_0|/\tau} f(\mathbf{v})\, \delta(\mathbf{r} - \mathbf{r}_0 - \mathbf{v}(t - t_0))\, \delta(\mathbf{v} - \mathbf{v}_0). \quad (8)$$

However, for a more exact consideration of the problem and also in the non-stationary case, we must solve Eq. (5), that is, a linearized kinetic equation with a random source.

The physical sense of this equation is evident. Actually, every act of collision leads to two particles being withdrawn from the initial density and to two particles with different velocities appearing in their place at that same point in the space. Eq. (5) also describes the further development of such a random disturbance of the distribution function.

Eq. (5) is, with respect to form, entirely analogous to the Maxwell equations with random sources[1] used in the theory of electric fluctuations. This is not surprising, since in the case of thermodynamic equilibrium, equations of this type can be obtained by starting from the general theory of fluctuations[2,3]. The kinetic derivation of the formulae (5) and (6) considered here possesses, in addition to greater clarity, the advantage that it is correct also in the non-stationary case.

It must be noted that according to (7) the particles are found to be only slightly correlated before collision. The correlation arises from such chains of collisions where two impinging particles collide with two others and these latter collide with one another. Since four particles participate in this chain and we have even neglected triple collisions, we may neglect the correlation of the particles before the collision resulting from (7).

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The Effect of Neutron Irradiation on the Compressibility of Metals

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THE FEW STUDIES that have been made so far on the effect of fast neutron irradiation on the elastic properties of metals and alloys show either that the effect is entirely absent or that it is exceedingly small. The modulus of elasticity, as far as we know, has been studied only in austenite steel and in copper. Neither case showed any change in the modulus of elasticity for a total flux of 10^{19} neutrons/cm^2 [1]. The shear modulus was studied in neutron-irradiated copper, and the residual change at room temperature was not greater than 1%[1].

The latest measurements on copper[2] show that the change in the modulus of elasticity on irradiation does not amount to more than 1 – 2%.

We studied the effect of fast neutron irradiation in a nuclear reactor on the compressibility of aluminum and magnesium. Since this quality is directly connected with the elasticity and shear moduli, and since no change in these moduli was found in the materials investigated so far, it was to be expected that the compressibility, too, would not change appreciably, under the influence of neutron irradiation. Samples in the form of cylinders 6 mm in diameter and 6 mm high, were prepared from electrolytic materials of engineering purity. The compressibility measurement was made with apparatus developed in the ultra-high-pressure physics laboratory for measuring volume compressibility by the piston displacement method, which apparatus will be described in another communication. The effect of friction was allowed for by taking the piston displacement *vs.* pressure curves on both rising and falling pressure and plotting the mean curve. The measurements were carried out after first subjecting the sample to a maximum pressure of about 15,000 kg/cm².

The samples were irradiated in a nuclear reactor. The total neutron irradiation was 1.07×10^{19} neutrons/cm². After irradiation, the compressibility was measured under the same conditions as before irradiation, although, on account of the residual activity of the samples, the measurements could not be carried out until 72 hours after the irradiation.

The measurements showed that for magnesium and aluminium the piston displacement *vs.* pressure curves coincide completely before and after irradiation, *i.e.*, irradiation has no effect on the compressibility, to the accuracy of our measurements, about 5%. Since the experiments were carried out at ordinary temperature, the distortions produced by the irradiation may have been partly wiped out. Possibly at lower temperatures, with a preliminary annealing of the samples, the effect of irradiation would be considerably greater.

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Quadrupole Moments and Zero-Point Surface Vibrations of Axially Symmetrical Nuclei

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FOR SIMPLICITY WE SHALL consider even-even nuclei. In the collective model of the nucleus it is assumed that nucleons outside of filled shells can be described by a single-particle approximation and that the nucleons in the nuclear core of completely filled shells have only collective properties. As collective coordinates we shall use the three Euler angles which describe the orientation of the nucleus in space and β and γ[1], which define the deviation of the nucleus from a perfectly spherical shape.

In an adiabatic approximation we can regard the outer nucleons as moving in the field of a nuclear core of fixed shape. The interaction energy of the outer nucleons with the core, averaged over their states of motion is $\langle H_{\text{int}} \rangle = A\beta \cos \gamma$, which will depend on the coordinates β and γ and will act as additional energy to determine the equilibrium shape of the nucleus. A depends on the number of outer nucleons and their quantum numbers and can be either positive or negative.

In the collective model[1] this energy is defined by

$$E = \frac{B}{2}(\dot{\beta}^2 + \beta^2\dot{\gamma}^2) + \frac{C}{2}\beta^2 + \sum_{\lambda=1}^{3} \frac{M_\lambda^2}{8B\beta^2 \sin^2(\gamma - 2\pi\lambda/3)} + A\beta\cos\gamma + E_p. \quad (1)$$

For a given value of β the potential energy in (1) possesses a minimum at $\gamma = 0$ and π and becomes infinite for $\gamma = \pm\,\pi/3,\ \pm\,2\pi/3$.

Nuclei are evidently very stable with respect to variation of γ around the two possible equilibrium values 0 and π, which correspond to axial symmetry. Therefore we shall hereinafter consider only the vibrations which are associated with a variation of of β for the fixed values $\gamma = 0,\ \pi$.

For $\gamma = 0$ Eq. (1) becomes

$$E - E_p + \frac{C}{2}\beta_0^2 = \frac{B}{2}\dot{\beta}^2 + \frac{C}{2}(\beta - \beta_0)^2 + \frac{M^2}{6B\beta^2}, \quad (2)$$