collision probability, plotted in accord with the formula of [3], is well approximated by the equation $w_f(T) = \alpha T^3$ where α, determined by least square in a field H making an angle 20° to the [10$\bar{1}$0] axis, is equal to $(6.37 \pm 0.16) \times 10^5$.

In conclusion, the authors thank E. A. Kaner for a discussion of the results and Yu. D. Samokhin for help with the experiments.

[1] V. F. Gantmakher and E. A. Kaner, JETP 45, 1430 (1963), Soviet Phys. JETP 18, 988 (1964).
[2] V. G. Levich, Yu. A. Vdovin, and V. A. Myamlin, Kurs teoreticheskoy fiziki (A Course of Theoretical Physics), v. II, part V.
[3] V. F. Gantmakher and Yu. V. Sharvin, JETP 48, 1077 (1965), Soviet Phys. JETP 21, 720 (1965).
[4] I. P. Krylov and V. F. Gantmakher, JETP 51, 740 (1966), Soviet Phys. JETP 24, 492 (1967).
[5] V. P. Naberezhnykh, A. A. Mar'yakhin, and V. L. Mel'nik, JETP 52, 617 (1967), Soviet Phys. JETP 25, in press.

COMPRESSION OF ALKALI-EARTH METALS BY STRONG SHOCK WAVES

A. A. Bakanov and I. P. Dudoladov
Submitted 20 February 1967
ZhETF Pis'ma 5, No. 9, 322-325 (1 May 1967)

The authors of [1] observed, on the shock-compression curves of many rare-earth metals, adiabat kinks due most probably to the formation of low-compressibility electronic configurations as a result of the transition of 6s- or 4f-electrons to the d-levels. The occurrence of similar situations is to be expected in the compression of calcium, strontium, and barium, as a result of the displacements of their s-electrons to the d-levels of these elements, which are close in energy.

We present here the shock-compression curves of four alkali-earth elements (Mg, Ca, Sr, and Ba), obtained in a wide range of pressures.

To produce high shock pressures in the investigated metals, we used previously developed explosive devices [2,3], which produced shock waves of fixed intensity in the sample-covering screens. The shock-compression parameters were determined by the reflection method [4,5], whereby the wave velocities in the samples were determined experimentally, the pressures (p) and mass velocities (U) were determined by graphic constructions in pressure-velocity diagrams, and the densities (ρ) were determined from the mass-conservation equation.

The determined shock-wave kinematic parameters are shown in Fig. 1. The abscissas are the mass velocities and the ordinates the wave velocities.

The plots in the diagrams determine the experimentally obtained relations for the investigated metals. The D-U plot of magnesium is a straight line, and that of calcium consists of two linear segments of different slope, meeting in a kink at U ~ 3.8 km/sec. More noticeable is a kink on the strontium curve, at U ~ 2.8 km/sec. The increase in the slopes of the D-U plots of Ca and Sr to the right of the kinks is evidence of a jumplike decrease in the compressibility of these elements.

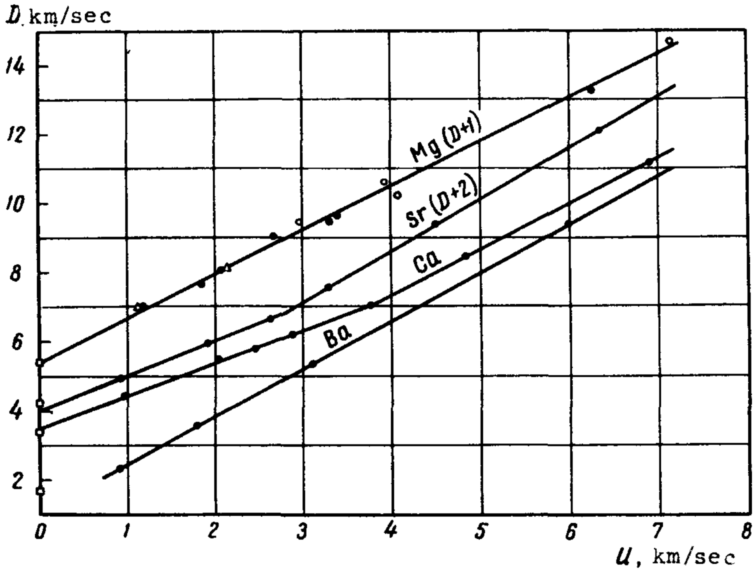

Fig. 1. D-U diagrams of Mg (ρ_0 = 1.74 g/cm^3), Ca (ρ_0 = 1.52 g/cm^3), Sr (ρ_0 = 2.60 g/cm^3), and Ba (ρ_0 = 3.63 g/cm^3); ● - experimental points obtained by the authors; △ - data of Walsh et al. [7]; o - experimental data of Skidmore and Morse [8]; □ - initial speed of sound calculated from the adiabatic compressibility coefficient.

In barium, the same kink occurs apparently at low pressures, since its D-U diagram is parallel to the right-hand sections of the diagrams for Ca and Sr. The conservation laws $P = \rho_0 DU$ and $\sigma = D/(D - U)$ ($\sigma = \rho/\rho_0$ is the degree of compression and ρ_0 is the initial density) relate the shock-wave kinematic parameters with the shock-compression thermodynamic characteristics p and σ. For Mg, Ca, and Sr the shock-adiabat configurations are shown in Fig. 2. The obtained form of the adiabats is characteristic of a second-order phase transition. According to Arkhipov [6], at high temperatures such transformation can be the result of electronic transitions. The fact that kinks appear on the compression curves of Ca and Sr (and possibly Ba) but not Mg confirms that they are due to electronic realignment - the transition of s-electrons to unfilled d-levels.

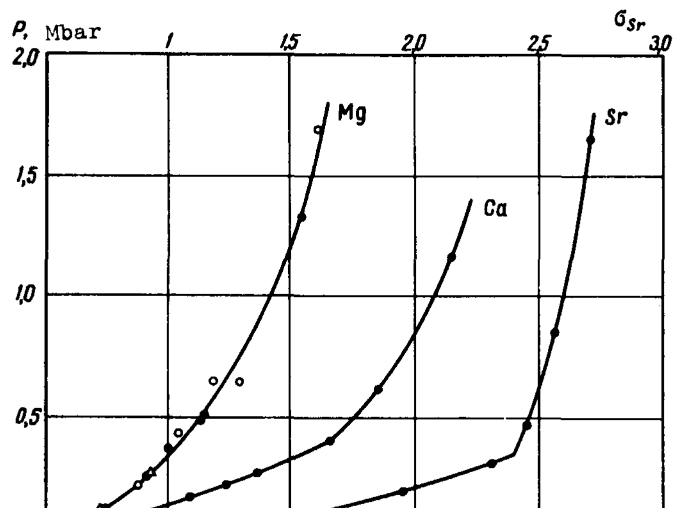

Fig. 2. P-σ diagram for three alkali-earth elements. Notation the same as in Fig. 1.

[1] L. V. Al'tshuler, A. A. Bakanova, and I. P. Dudoladov, JETP Letters 3, 483 (1966),

transl. p. 315.

[2] L. V. Al'tshuler, M. N. Pavlovskii, L. V. Kuleshova, and G. V. Simakov, FTT 5, 279 (1963), Soviet Phys. Solid State 5, 203 (1963).

[3] L. V. Al'tshuler, S. B. Kormer, A. A. Bakanova, and R. F. Trunin, JETP 38, 790 (1960), Soviet Phys. JETP 11, 573 (1960).

[4] L. V. Al'tshuler, K. K. Krupnikov, and M. I, Brazhnik, JETP 34, 886 (1958), Soviet Phys. JETP 7, 614 (1958).

[5] L. V. Al'tshuler, UFN 85, 197 (1965), Soviet Phys. Uspekhi 8, 52 (1965).

[6] R. G. Arkhipov, JETP 49, 1601 (1965), Soviet Phys. JETP 22, 1095 (1966).

RADIATIVE CAPTURE OF ELECTRONS BY NEUTRAL AND SINGLY-CHARGED ZINC IONS IN GERMANIUM

T. I. Galkina, V. A. Kurbatov, and N. A. Penin
P. N. Lebedev Physics Institute, USSR Academy of Sciences
Submitted 20 February 1967
ZhETF Pis'ma 5, No. 9, 325-328 (1 May 1967)

In radiative transitions of carriers to neutral impurity centers in semiconductors such as Ge and Si (minimum of the conduction band located at the center of the Brillouin zone), the probabilities of phononless and phonon transitions vary with the type of impurity. Pokrovskii and Svistunova [1] have shown that this is connected with the depths of the corresponding levels in the forbidden band. The extent to which the transition-probability ratio depends on the chemical nature of the impurity atoms or its charge state is still unclear, however. Thus, for example, in optical transitions in which As and Sb atoms take part, this ratio changes appreciably [2], in spite of the small difference in the energy levels (E_{Sb} = 0.0096 eV and E_{As} = 0.0127 eV). This is due apparently to the different sizes of the Sb and As atoms, and consequently to the different form of the Coulomb fields of these atoms in the lattice.

Special interest attaches to radiative recombination at deep multiply-charged impurities, all the more since there is still no adequate theory of deep impurities [3,4].

We have investigated the emission corresponding to electron transitions to the energy levels of zinc atoms in the charge states Zn^0 and Zn^-. Zinc produces in germanium two acceptor levels with energies 0.03 and 0.09 eV over the top of the valence band. The Zn concentration in our experiments ranged from 1×10^{15} to 4×10^{17} cm^{-3}. Nonequilibrium carriers were produced in the sample by injecting holes through a p-n junction or by illumination. All samples had n-type conductivity, so that under equilibrium conditions all the Zn atoms were in the $Zn^=$ state. The measurements were made in the temperature interval 20 - 150°K.

At temperatures from 60 to 150°K the recombination-radiation spectrum included lines corresponding to electron transitions to the Zn^- level (0.09 eV) and to the valence band. At low injection levels the spectrum contained only an emission line corresponding to an electron transition to the Zn^- level (Fig. 1, curve I). The maximum with quantum energy