

# **Channeling and Quasi-characteristic Radiation of the Charged Particles in the Charged Axes of the Ionic Crystals with a Zinc Blende Structure**

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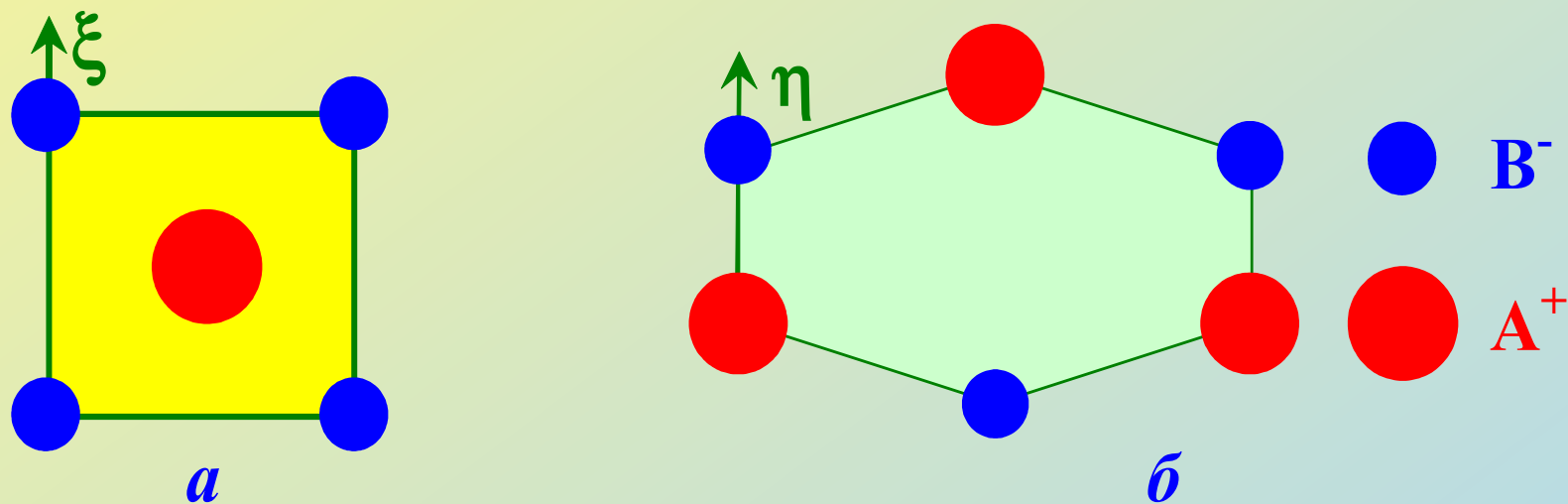
## CONTENTS

1. Putting of the problem.
2. The calculation of the interaction potentials of electrons with [100] and [110] charged axes of the ionic crystals with a zinc blende (besides, the interaction potential calculation in high-indexed axes of [11n]) was made.
3. Discovering of the transverse energy levels and corresponding to them wave functions in ZnS, ZnSe and ZnTe crystals in the result of numerical solutions of Shrodinger equation.
4. The investigation of quasi-characteristic radiation spectra (in a dipole approximation ) arising at the channeling of electrons with Lorentz-factor 2, 6 and 10 in the isolated [100] and [110] charged axes of ionic ZnS, ZnSe and ZnTe crystals.
5. Conclusion.

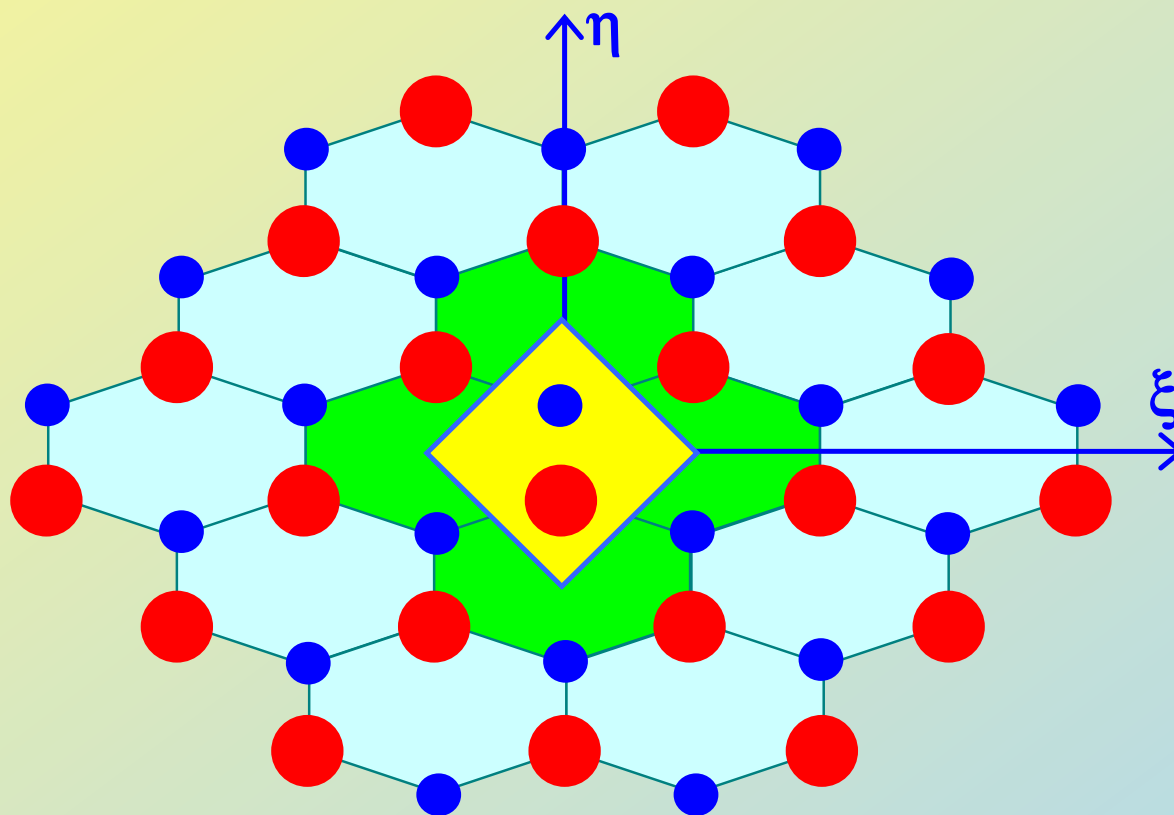
Here the following problems are solved:

- 1)** the oriented motion and QCR spectra for weakly relativistic electrons are studied (for example, with Lorentz-factors of 2, 6 and 10) in main charged [100] and [110] axes in zinc blende-type crystals (the consideration is done at the example of ZnS, ZnSe and ZnTe crystals and with usage of various approximations for one-particle potentials);
- 2)** it is shown that the transformation of the kinetic energy of electrons into the energy of radiation is considerably effective in [110] direction than, for example, at the channeling along [100] axes;
- 3)** potential relieves are calculated in the case of electron channeling along high-indicial directions in CuBr, AlP and GaAs crystals, they are interesting by the fact that some potential wells minimums in them may be in inter-axial space;
- 4)** equipotential lines are built of electrostatic potentials of the considered axes for the whole number of crystals with a zinc blende structure to find the best conditions for oriented motion of positively charged particles (positrons, ions);
- 5)** the influence of thermal factor on the structures of potential wells in the charges axes is investigated.

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**Fig. 1. Schematic representation of the projections of [100] axes (Figure a) and [110] axes (Figure b) on the planes perpendicular to them.**



**Fig. 2. Schematic representation of the charged axes group of [110] in ionic covalent  $A+B^-$  crystals with a zinc blende structure by the electro-neutral shells (red circles indicate the axes built of  $A^+$  ions, dark blue ones, correspondingly, built of  $B^-$  ions, and a yellow rhomb indicates two-dimensional period).**

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[Channeling and quasi-characteristic radiation of charged particles in charged axes of CsCl-type ionic crystals](#) // Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with

Materials and Atoms, Volume 355, 15 July 2015, Pages 90-93.

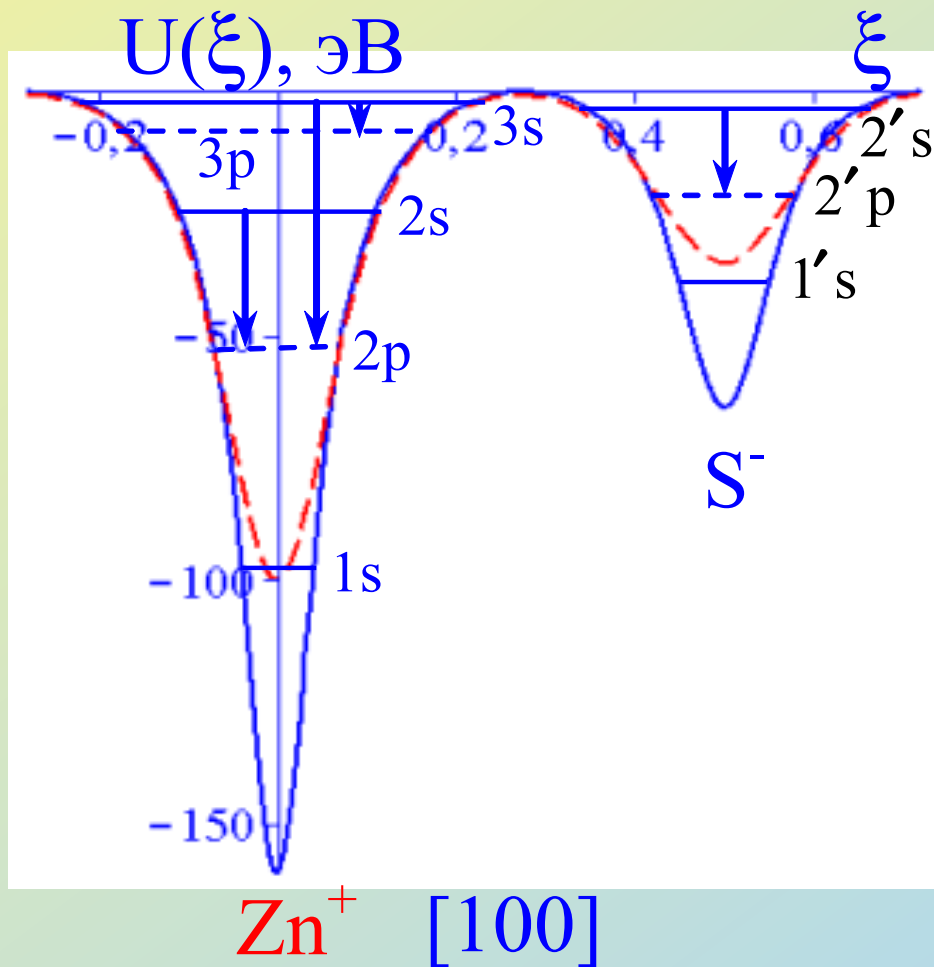


Fig. 3. The graphs of the interaction potentials of the electrons with  $[100]$  charged axes of ZnS crystal: the solid curve at  $T = 300\text{K}$ , the dashed curve at  $T = 1000\text{K}$ .

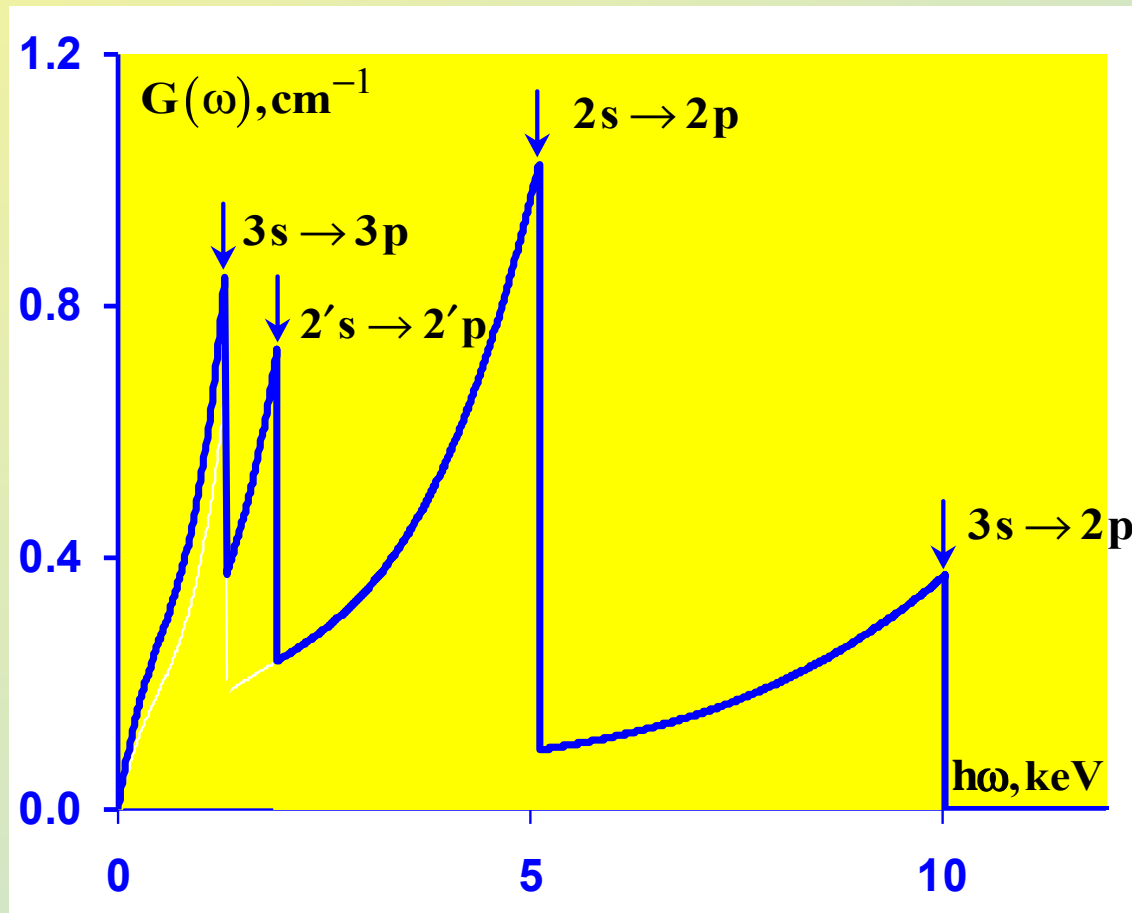


Fig. 4. Spectral distribution of QCR energy by a relativistic electron on a unit path at its flight at a zero angle regarding  $[100]$  axes of ZnS crystal at Lorentz-factor  $\gamma = 10$ .

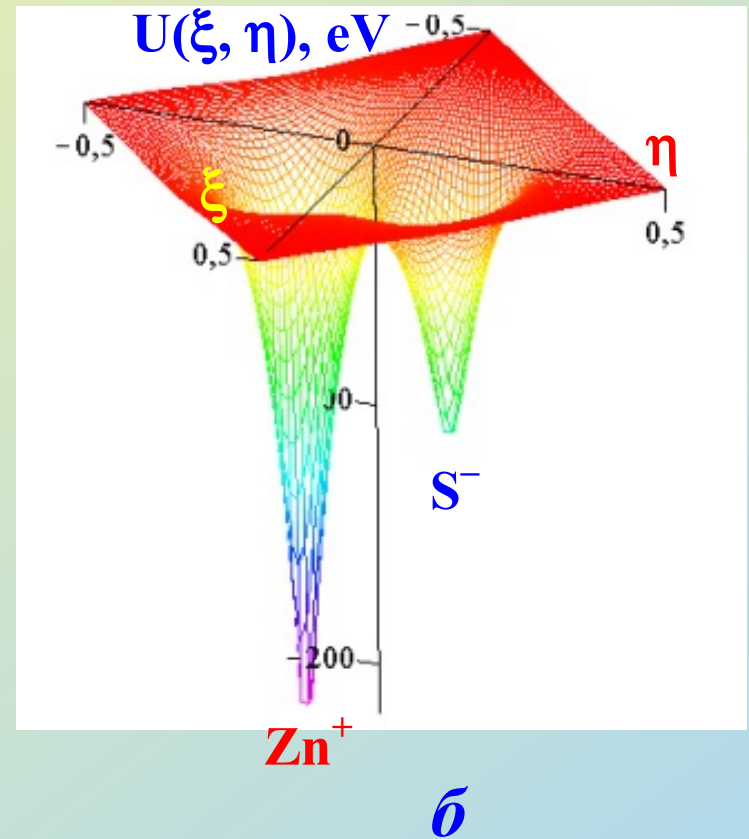
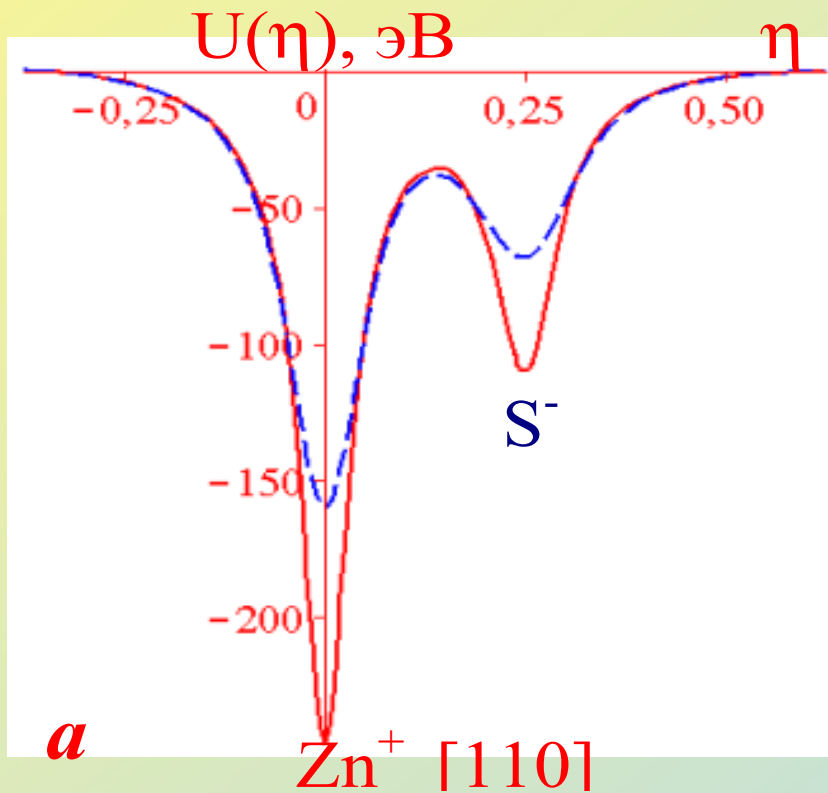


Fig. 5. a) the graphs of the interaction potentials of the electrons with [110] charged axes of ZnS crystal: the solid curve at  $T = 300\text{K}$ , the dashed curve at  $T = 1000\text{K}$ ; b) 3D – the graph of the interaction potential of the electrons with [110] charged axes of ZnS crystal at  $T = 300\text{K}$ .



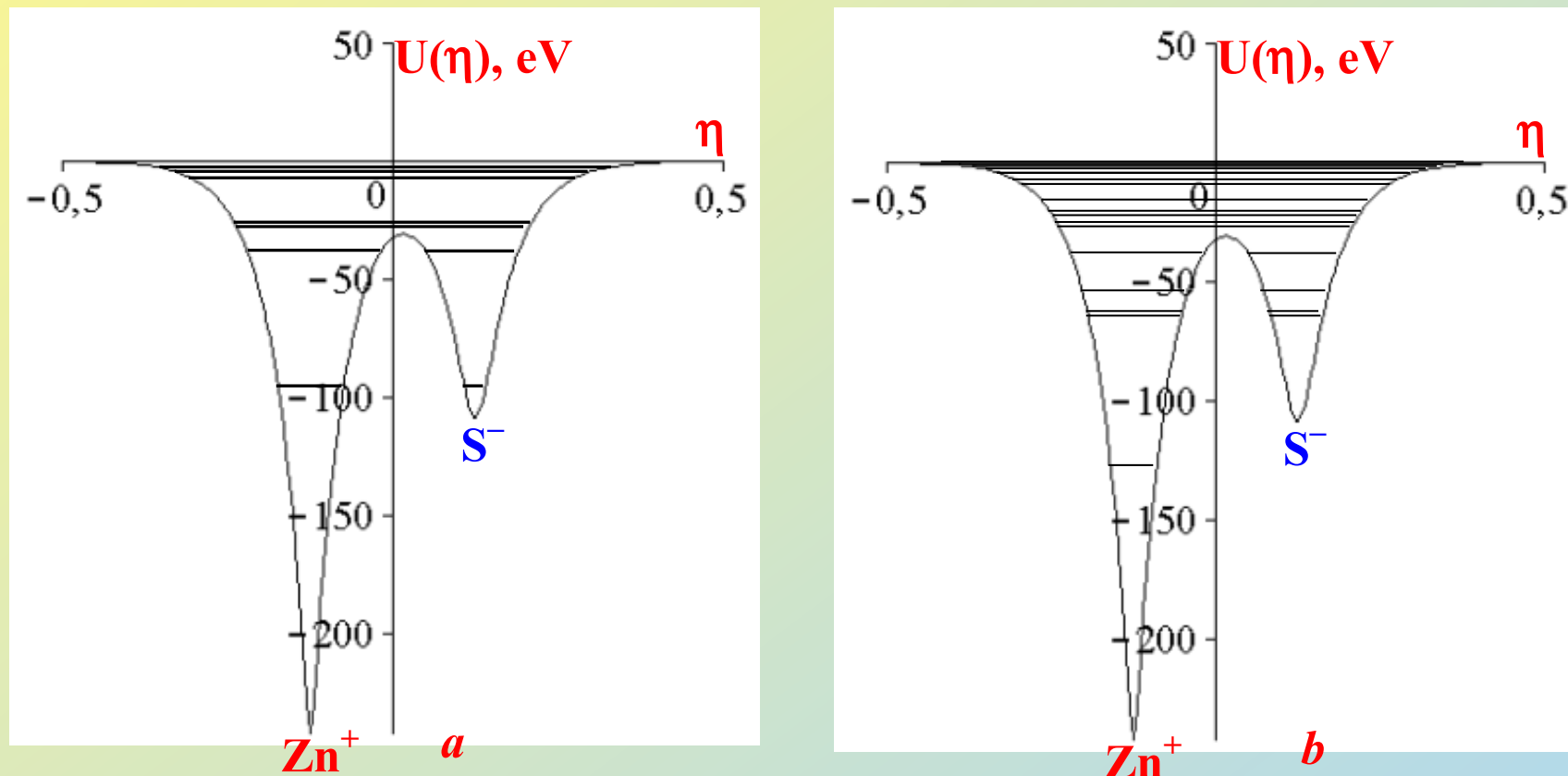


Fig. 6. The systems of energy levels of a transverse energy arising at  $T = 300\text{K}$  in ZnS crystal for the slight relativistic electrons with Lorentz-factors channeling along  $[110]$  charged axes : a)  $\gamma = 2$ , b)  $\gamma = 5$ .

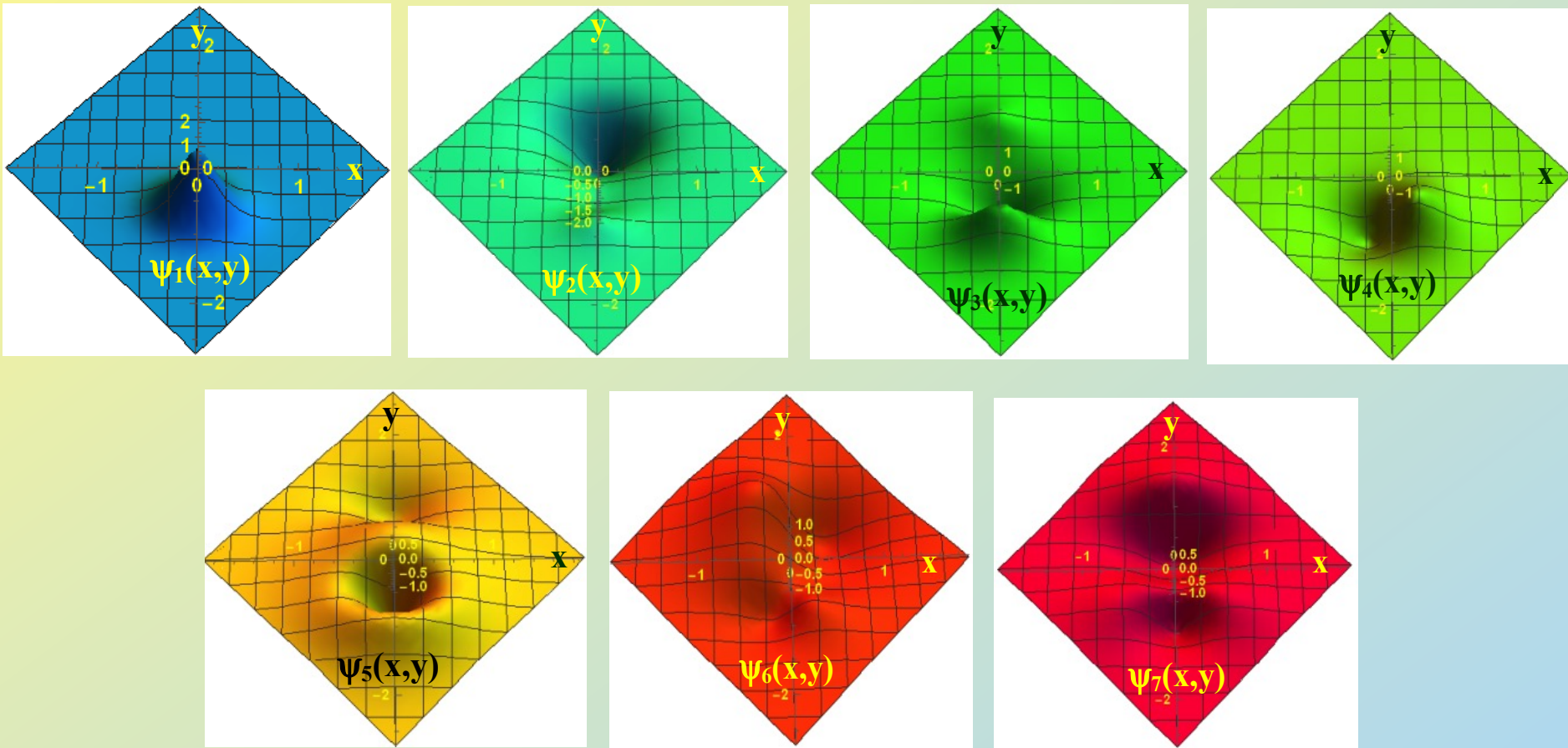
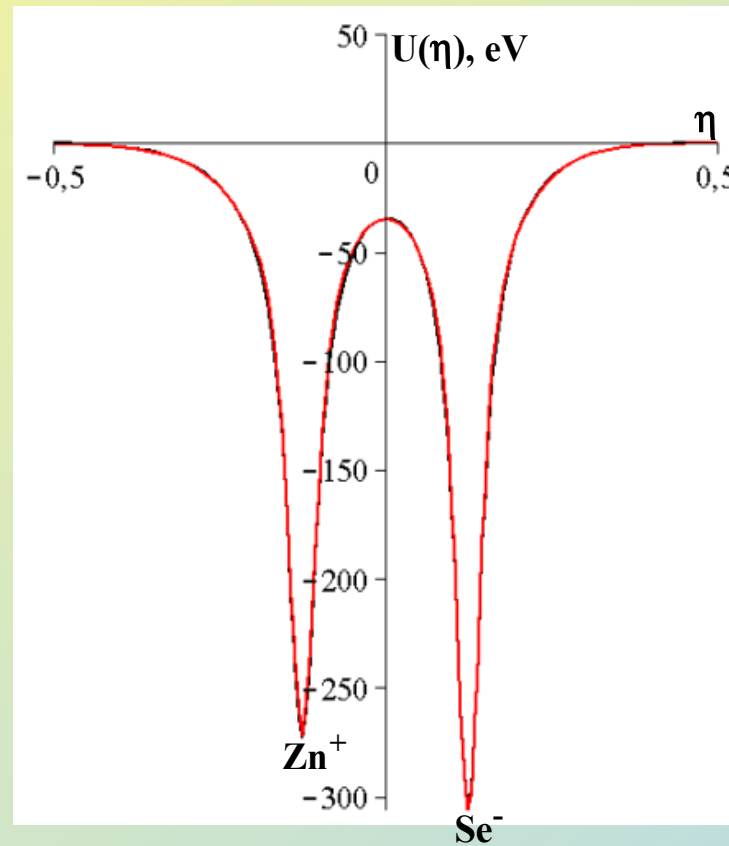
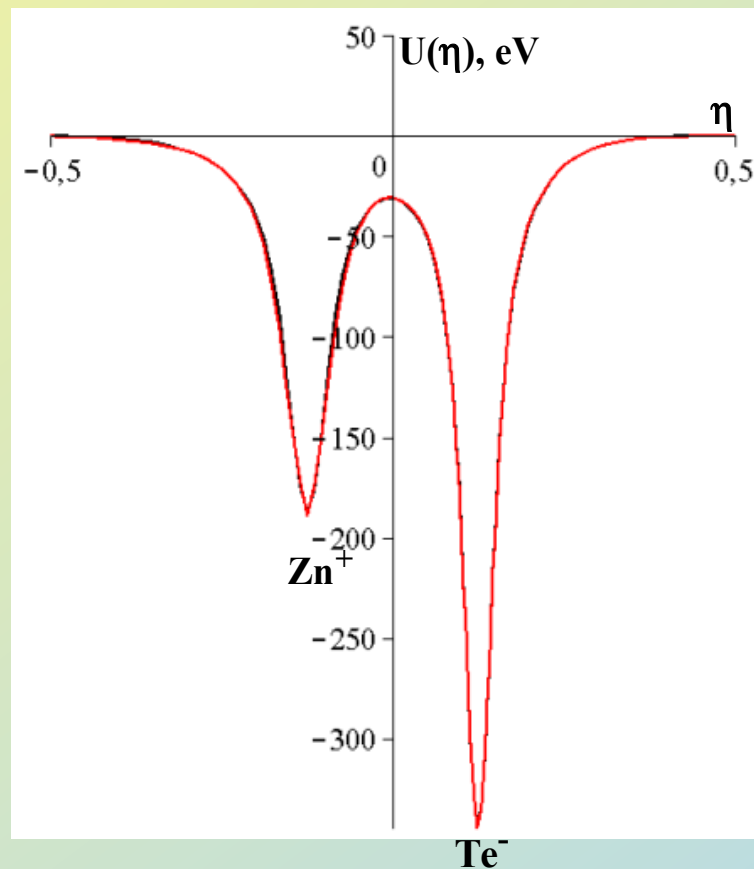


Fig. 7. 3D-graphs of the wave functions arising at the channeling of electrons with Lorentz-factor  $\gamma = 2$  along  $[110]$  charged axes in ZnS crystal.

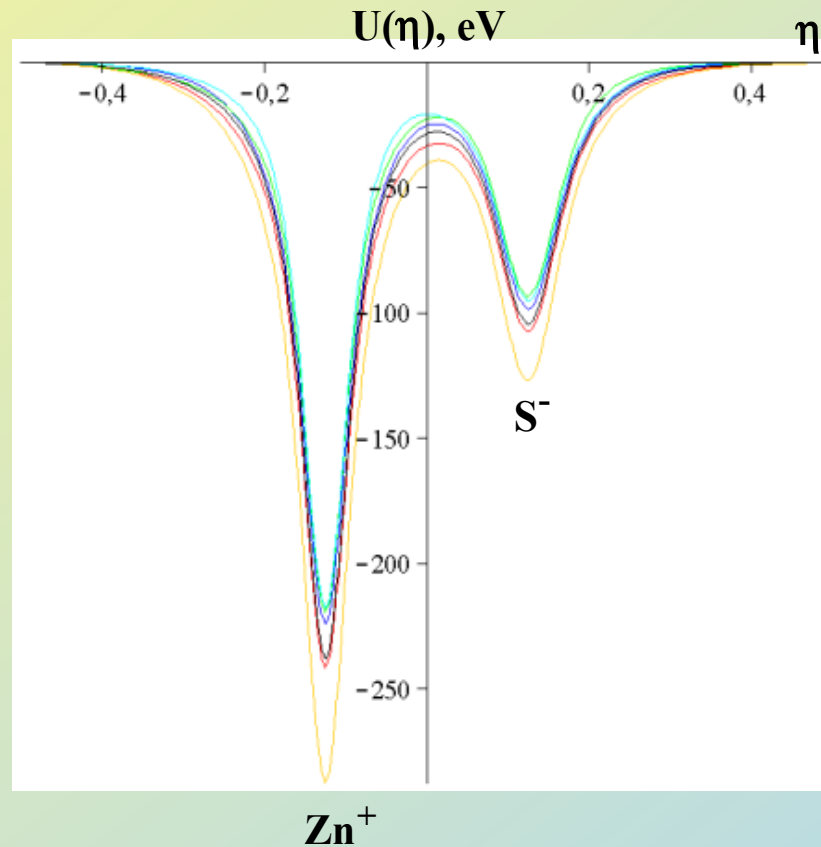


**Fig. 8.** 2D –graph of the interaction potential of the channeling electrons (using Moliere approximation) along [110] axes of ZnSe crystal.

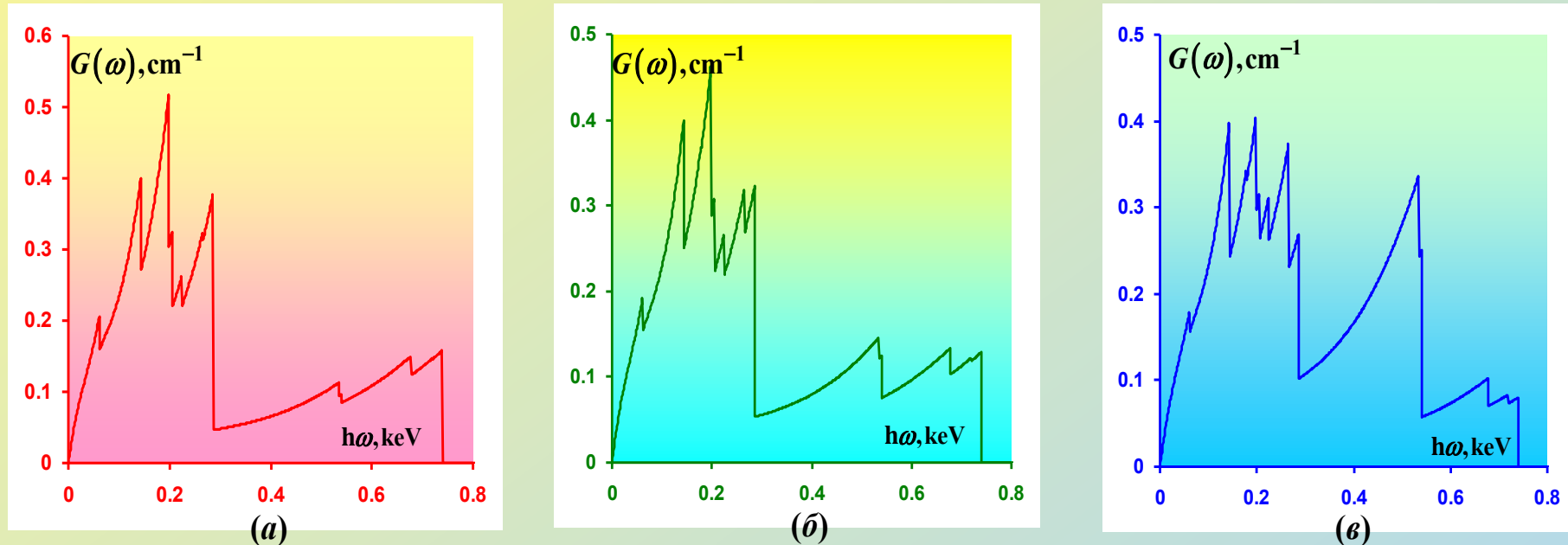
$$V(\xi, \eta) = - \frac{U_{01}}{\cosh^{\alpha_1} \left[ \frac{a\sqrt{\xi^2/2 + (\eta+1/8)^2}}{b_1} \right]} - \frac{U_{02}}{\cosh^{\alpha_2} \left[ \frac{a\sqrt{\xi^2/2 + (\eta-1/8)^2}}{b_2} \right]}$$



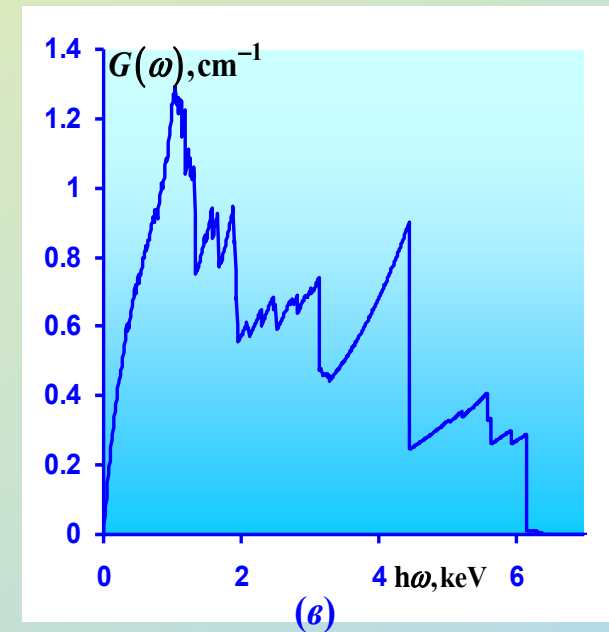
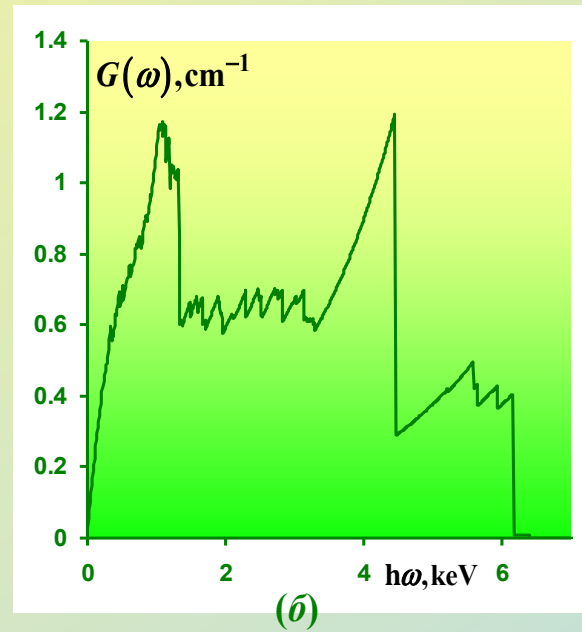
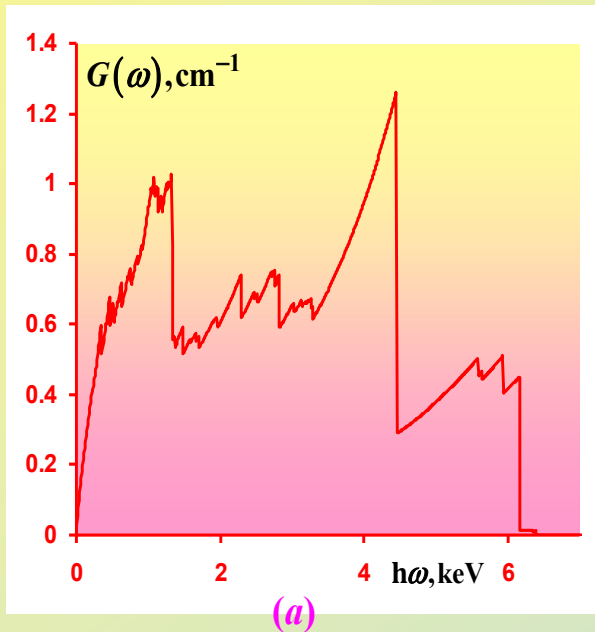
**Fig. 9 2Д – graph of the interaction potential of the channeling electrons (using Moliere approximation) along [110] axes of ZnTe crystal.**



**Fig. 10.** Graphs of interaction potentials of the channeling electrons (using Moliere approximations (red curve), Firsov's (dark blue curve), Barrette (green curve), Doil and Ternier (turquoise curve), Zigler, Birsac and Littmark (orange curve) along [110] axes of ZnS crystal.



**Fig. 11. Spectral distributions of QCR by an electron on a unit path falling at zero angle regarding [110] axes of ZnS crystal at Lorentz-factor  $\gamma = 2$ . The bundle has angular dispersions by x and y axes, correspondingly, (a) – 0,5 mrad; (b) – 1 mrad; (c) – 2 mrad.**



**Fig. 12. Spectral QCR distributions by an electron on a unit path by a falling at a zero angle regarding [110] axes of ZnS crystal at Lorentz-factor  $\gamma = 5$ . The bundle has angular dispersions by x and y axes, correspondingly, (a) – 0,5 mrad; (b) – 1 mrad; (c) – 2 mrad.**

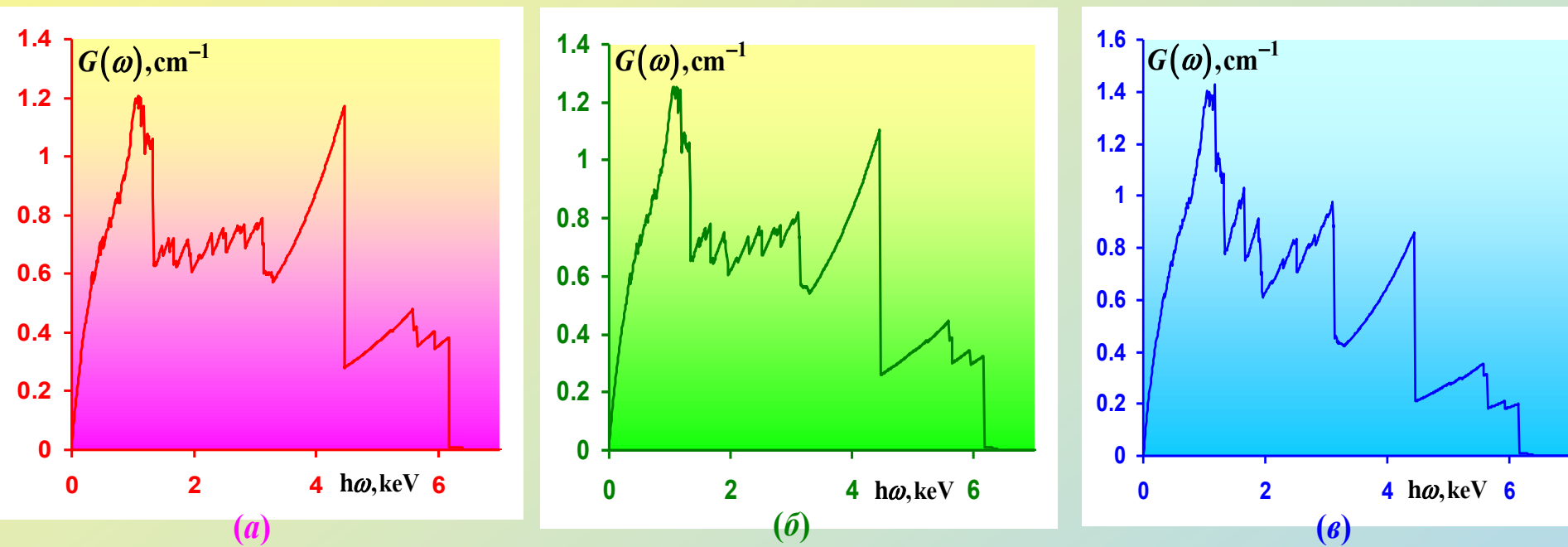


Fig. 13. Spectral QCR distributions by an electron with Lorentz-factor  $\gamma = 5$  on a unit path (angular dispersions by x and y axes equal to 1 mrad) and falling regarding [110] axes of ZnS crystal at the angles (a) –  $\alpha_x = 0,5$  mrad; (b) –  $\alpha_x = 1$  mrad; (c) –  $\alpha_x = 2$  mrad (in all the cases  $\alpha_y = 0$  mrad).



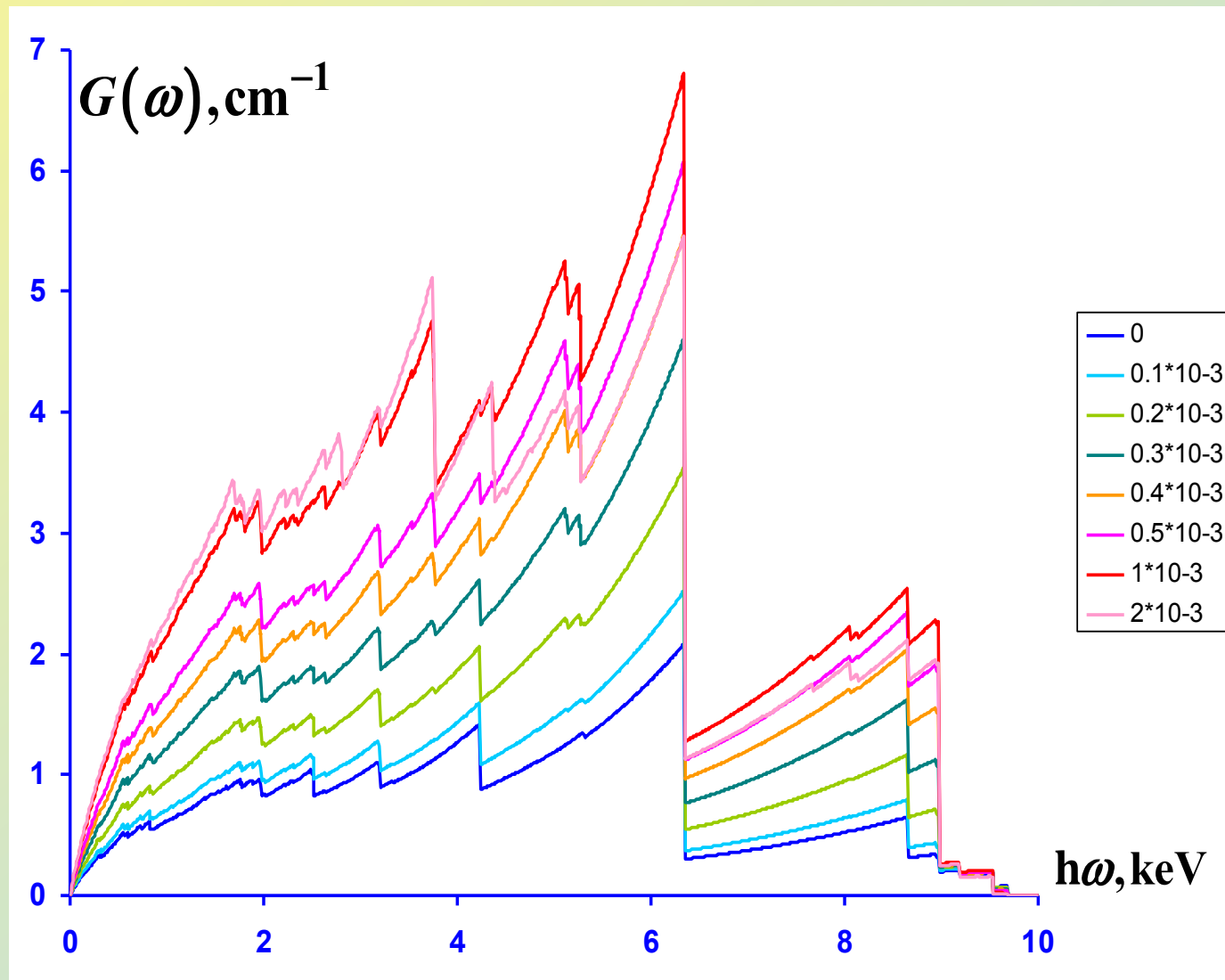


Fig. 14. Spectral QCR distribution by an electron with Lorentz-factor  $\gamma = 6$  on a unit path at various dispersions in ZnS crystal.

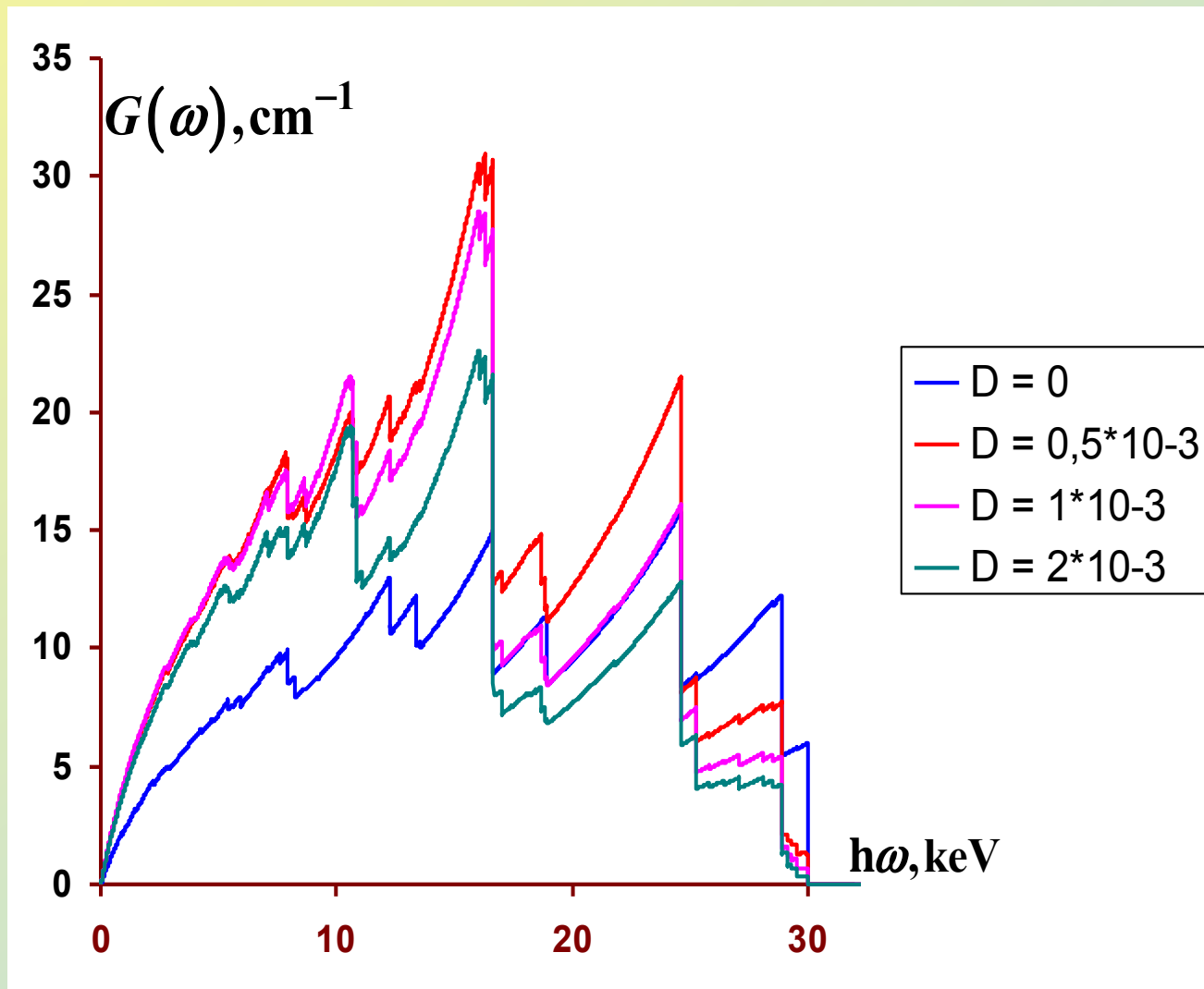


Fig. 15. Spectral QCR distributions by an electron with Lorentz-factor  $\gamma = 10$  on a unit path at various dispersions in ZnS crystal.

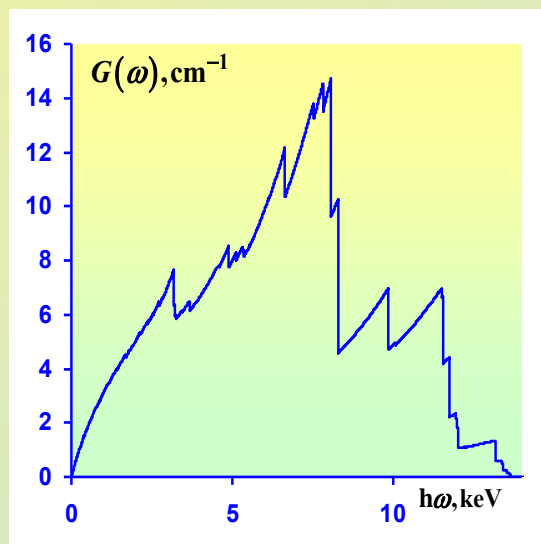


Fig. 16. Spectral QCR distribution by an electron on a unit path by a falling at a zero angle (without a dispersion) regarding [110] axes of ZnSe crystal at Lorentz-factor  $\gamma = 10$

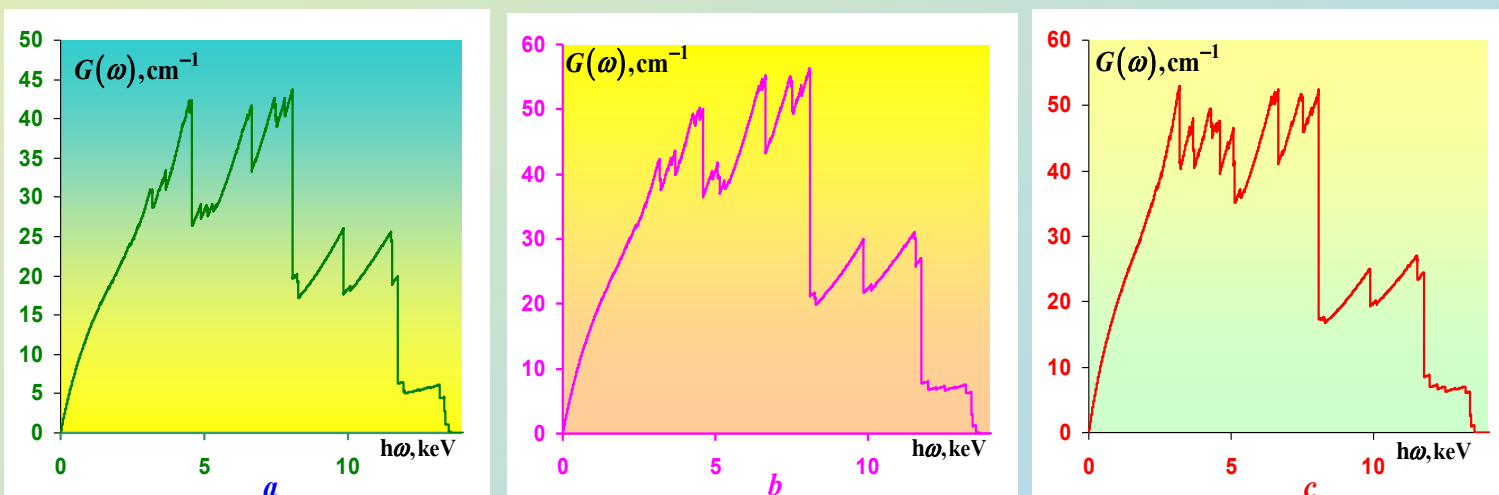
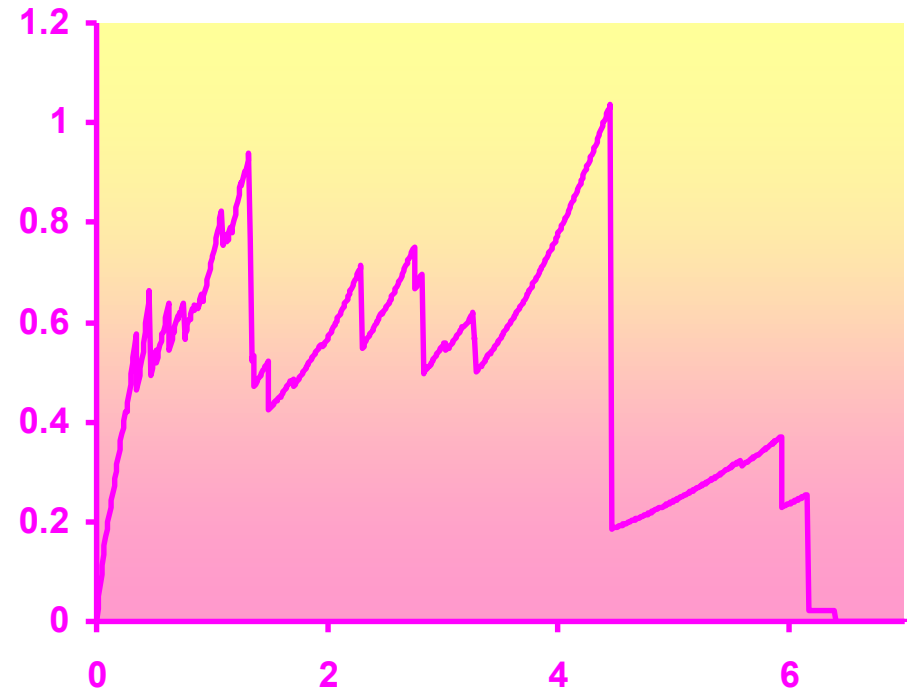
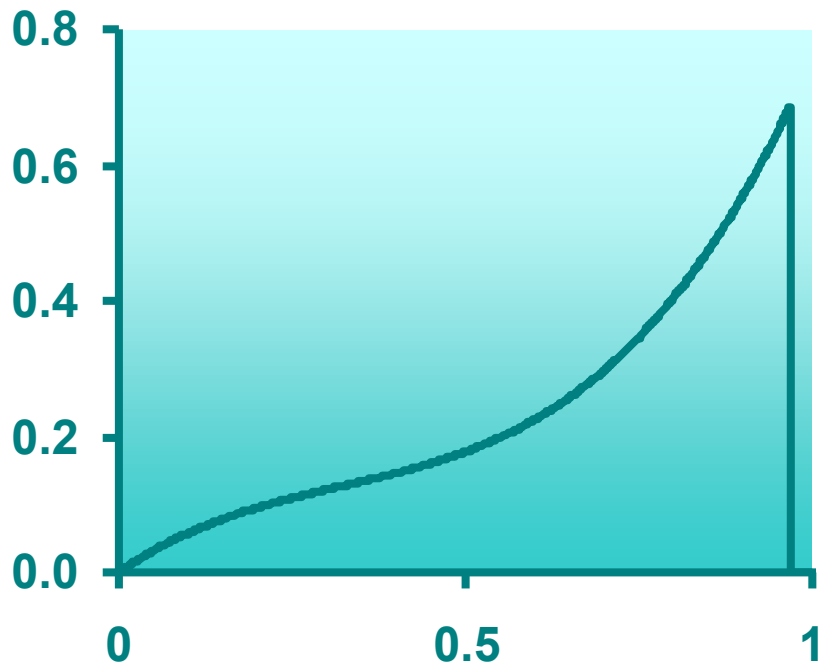


Fig. 17. Spectral QCR distribution by an electron on a unit path by a falling at a zero angle regarding [110] axes of ZnSe crystal at Lorentz-factor  $\gamma = 10$ . The bundle has an angular dispersion by x and y axes, correspondingly, (a) – 0,5 mrad; (b) – 1 mrad; (c) – 2 mrad.



**Fig. 18. Spectral QCR distributions by an electron on a unit path falling at a zero angle regarding [100] axes (Fig. 11a) and [110] axes (Fig. 11b) of ZnS crystal at Lorentz-factor  $\gamma = 5$  (angular dispersions by x and y axes have zero values).**

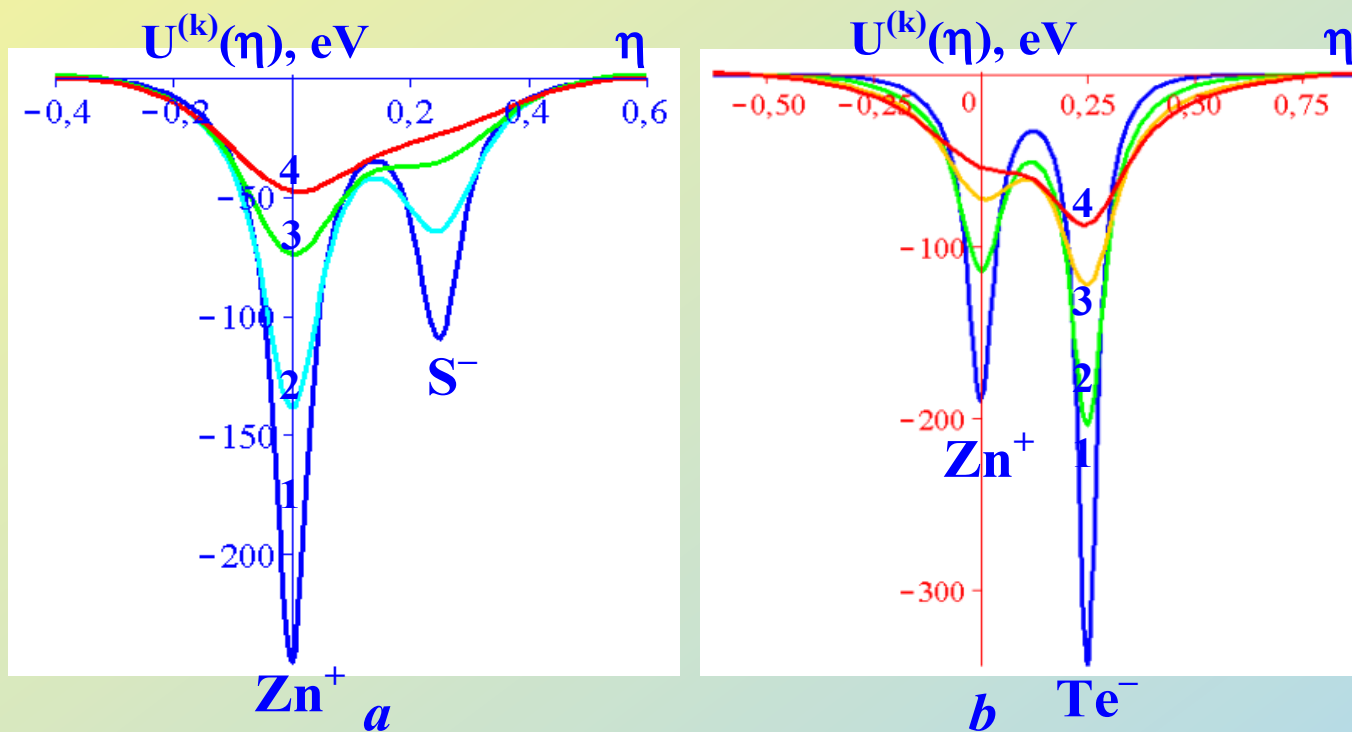
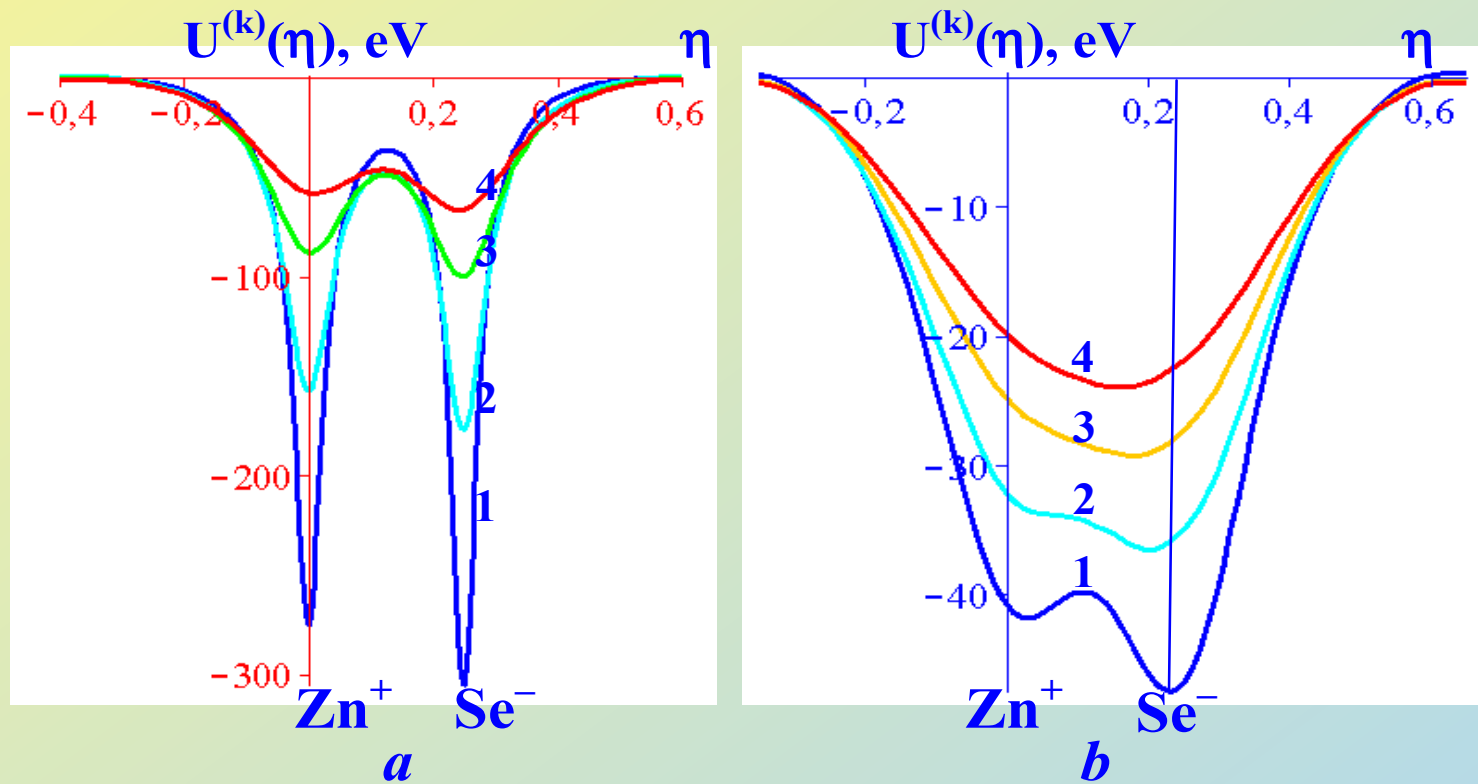
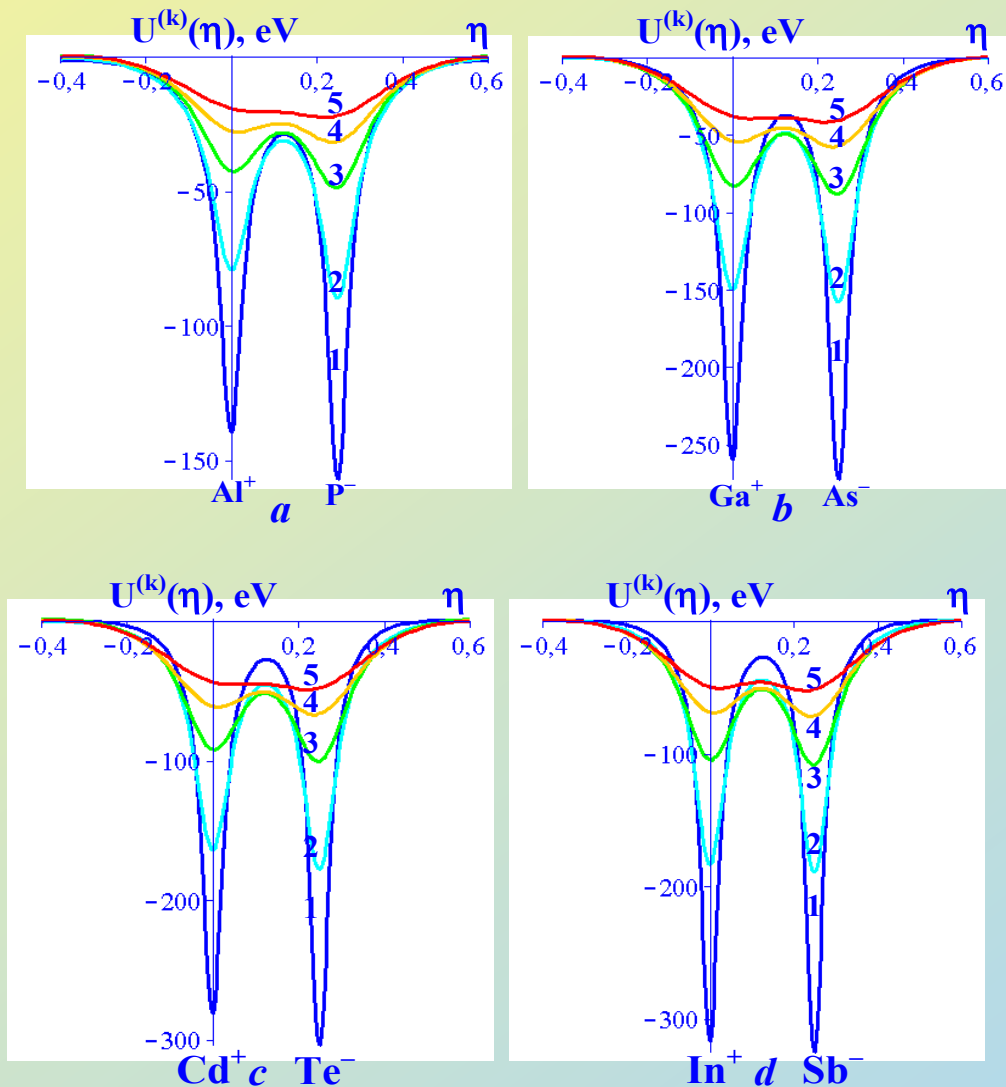


Fig. 19. The graphs of the interaction potentials of the electrons with [110], [112], [114], [116] axes (correspondingly 1, 2, 3, 4 curves) in crystals: (a) – ZnS, (b) – ZnTe.



**Fig. 20.** The graphs of the interaction potentials of the electrons in ZnSe crystal: (a) – with [110], [112], [114], [116] axes (correspondingly 1, 2, 3, 4 curves), (b) – with [118], [1,1,10], [1,1,12], [1,1,14] axes (correspondingly 1, 2, 3, 4 curves).



**Fig. 21.** The graphs of the interaction potentials of the electrons with [110], [112], [114], [116], [118] axes (correspondingly 1, 2, 3, 4, 5 curves) in crystals: (a) – AIP, (b) – GaAs, (c) – CdTe, (d) – InSb.

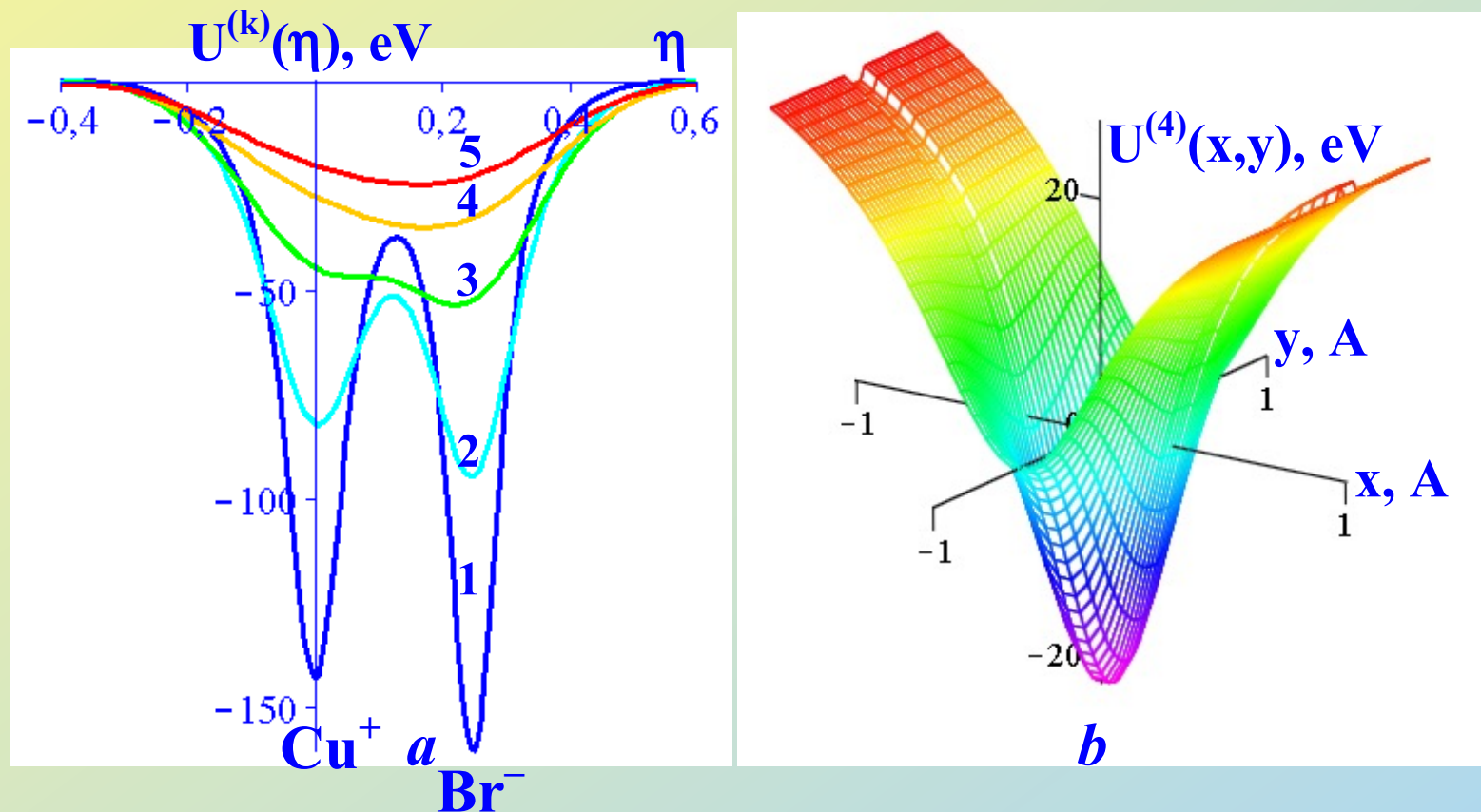


Fig. 22. (a) – graphs of the interaction potentials of electrons with [110], [112], [114], [116], [118] axes (correspondingly 1, 2, 3, 4, 5 curves) in CuBr crystal, (b) – 3D – graph of the interaction potential of electrons with [118] axes of CuBr crystal.



## CONCLUSION

1. The paper deals with the interaction potentials of electrons with the charged [100] and [110] axes for ionic ZnS, ZnSe crystals and then the spectra of transverse energies and corresponding to them wave functions for Lorentz-factors  $\boxed{?}$  = 2 – 10 were found numerically.
2. The spectra of quasi-characteristic radiation for these crystals in a dipole approximation were calculated with the use of these data. It was shown that even a small increase of Lorentz-factor causes an abrupt increase of QCR intensity which explains the presence of a great number of energy levels nearby.
3. The interaction potentials of electrons with high-indexed [11n] axes in different crystals with a zinc blende. In this case different anomalous potential relieves may occur.

**THANKS  
FOR THE  
ATTENTION**