# ION-CRYSTAL RAINBOW INTERACTION POTENTIAL IN CHANNELING

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**Abstract.** One of the most important effects in the movement of positive ions through oriented crystals relative to an ion beam is the rainbow effect. The problem of accurate ion - atom interaction potential is one of the fundamental problems in describing ion - crystal interaction. It is assumed that ion - atom interactions can be treated as an two - particle collision process and that the interaction potential is a screened Coulomb potential. Construction of an accurate interaction potential of the channeled ion in the crystal is the main goal of this work. The effect of the crystal rainbow is predicted in the theoretical analysis of the transmission of positive ions through axial channels of thin crystals using a so-called impulse approximation model, which is valid when the ion energy is large enough or the crystal thickness is small enough that the trajectories of transmitted ions can be described by straight lines. After that, the crystal rainbow theory was formulated including curved trajectories or thicker crystals. Experimental measurements have shown that the predictions of the crystal rainbow model and theory are correct. It was shown that the rainbow lines represent the „skeleton" of the angular distributions of the channeled ions. The crystal rainbow theory was used for the morphological method to construct ion - atom interaction potentials in the sequence analysis of experimentally obtained high - resolution angular distributions of protons with energy of 2 $MeV$ and a $Si^{14}$ crystal membrane in the (001) orientation. The construction of the rainbow interaction potential is obtained by modifying the Moliere interaction potential so that it becomes precise in the whole space of the crystal channel, i.e. near the channel axis and near the atomic strings defining the channel. This modification was performed by adjusting the shape of the rainbow lines in a way that the corresponding theoretical angular distributions of the transmitted protons were in excellent agreement with the corresponding experimental distributions for proton energies of 2 $MeV$, 1.5 $MeV$, 1 $MeV$ and 0.7 $MeV$. In this way, the rainbow proton - silicon interaction potential for channeling was successfully obtained. After that, a universal axial (001) and (111) rainbow ion - atom interaction potential was constructed for the case of proton channeling in the following 28 cubic crystals: $FCC$ crystal structure: aluminum, calcium, nickel, copper, strontium, rhodium, palladium, gold, lead and thorium; $BCC$ crystal structures: vanadium, chromium, iron, niobium, molybdenum, barium, europium, tantalum and tungsten; and with diamond crystallographic structure: carbon, silicon, germanium and tin. Furthermore, the analysis of the proton channeling in the case of the above mentioned 28 cubic crystals was extended and improved by considering two orientations (001) and (111) simultaneously. As a result, the two axial channeling directions could be treated with the same physical arguments, leading to consistent values of the interaction potential fitting parameters.

## References

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