MAGNETOELECTRIC PROPERTIES OF JAHN-TELLER CRYSTALS

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Recent discovery of a new group of materials with strong magnetoelectric effects revived the interest to multiferroics - crystals with coexisting magnetic and electric dipole moment orderings. The interest to these materials is caused by their importance for various industry applications related, in particular, to the possibility of modifying the electric properties by external magnetic field. On the other hand, many of newly discovered multiferroics are chiral materials with unexpected magnetooptical properties. Understanding these properties as well as chirality itself is one of fundamental problems of physics, chemistry, and biology.

The mechanism of the strong magnetoelectric coupling in above mentioned crystals becomes therefore of a great importance and has already generated a number of ideas mostly based on a phenomenological or semi phenomenological approach to the problem. At the same time it is clear that as a rule the crystal polarization is the result of the displacement of the atoms from the equilibrium positions in the high symmetry crystal phase. That means that strong magnetoelectric coupling is caused by strong electron-phonon interaction typical for the Jahn-Teller systems.

In this presentation the magnetoelectricity of Jahn-Teller crystals is discussed. It is shown that the cooperative Jahn-Teller effect is responsible for structural phase transitions accompanied by the electric dipole ordering. In combination with the antiferromagnetic ordering these phase transitions are leading to the multiferroic phases with anti- or ferrotoroidal ordering. In the last case that means that the multiferroic phase is magnetoelectric and chiral at the same time.

Rare-earth and transition metal ion compounds are considered as examples of multiferroics. The main attention is paid to the magnetoelectric properties of manganites with perovskite structure. Some recent experimental results are discussed.

The theoretical approach proposed in this presentation is compared to the recently developed theories of magnetoelectric coupling in multiferroics. In particular, it is shown that the Dzialoshinski-Moriya interaction is not the only possible driving force of magnetoelectricity and of the canting of the magnetic moment in the crystals under discussion. On the contrary, both phenomena and the Dzialoshinski-Moriya interaction itself are the consequence of the Jahn-Teller distortion ordering. As a result of this ordering the crystal symmetry lowers and the Dzialoshinski-Moriya interaction constant becomes different from zero.