

# The 1<sup>st</sup> Dvořák Lecture

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## Thermodynamic Approach to Nano-Inhomogeneous Ferroelectrics (Fruits from Collaboration with Vladimír Dvořák)

June 10, 2009 at 3:00 pm

Institute of Physics of the AS CR, v. v. i., Na Slovance 2, CZ-182 21 Praha 8, Czech Republic

### Annotation

Collaboration with Vladimír Dvořák started when he stayed in Nagoya for three months in 1975, and lasted until his final days. His visit to Nagoya gave me big stimuli and benefits. I could learn how to apply the group theory to phase transitions directly from him, and since then we could jointly make a certain contribution to the progress of the theory of ferroelectric phase transitions. Among our joint works, the most memorable one is the development of the theory of the incommensurate phase transitions, of which much was not known at that time. This subject had been already discussed among us during his stay, but the first joint paper reporting results of research appeared in J. Phys. Soc. Japan in January 1978, more than two years after his return to Prague. I am now reminded fondly of great patience required in Prague and Nagoya in the days of air-mail communication at the best.

Next, a theory of the morphotropic phase boundary (MPB) in the system of perovskite-type ferroelectric solid solutions will be presented.

It has turned out that gigantic electromechanical responses found in solid solutions sitting in the vicinity of MPB are all attributable to a near-isotropic potential energy expressed in terms of the order parameters, that is, the x, y and z components of the polarization in the present case. This kind of view may be applied to improve physical properties of magnetostrictive rare earth – Fe<sub>2</sub> compounds like Terfenol. Also the present idea may be utilized to produce soft magnets.

Finally, recent development of the theory of finite size ferroelectrics within the Tilley-Zeks model will be told, where the extrapolation length is introduced to specify the boundary conditions. After having been able to interpret the extrapolation length in a physically reasonable way, we could derive the exact expressions for the transition temperature, the linear and nonlinear dielectric susceptibilities, the Curie constant, the characteristic modes and frequencies for any combination of the extrapolation length at both boundaries. These exact expressions will provide firm bases when investigating systems, which consist of many different regions of finite size.



### Yoshihiro Ishibashi

Born 1935, after studying and defending his thesis at the University of Tokyo in 1963, he became assistant professor at the University of Tokyo, later at Nagoya University. 1978-1999 he took professor position at the School of Engineering, Nagoya University and 1999-2009 professor position at Aichi Shukutoku University. Presently he is professor emeritus at Nagoya University. 1966-1968 research consultant at Ford Motor

Company (USA), in 1981 guest professor at University of Dijon and 2001-2005 visiting professor at Malaysia Science University. Member of many important councils and advisory committees. Associate editor of Ferroelectrics, Ferroelectrics Letters, Ferroelectrics Reviews and Integrated Ferroelectrics. Author of more than 600 publications in peer-review journals with more than 7000 citations, h-index 39.

His main scientific achievements concern theory of ferroelectric, antiferroelectric and incommensurate phase transitions in various crystals and liquid crystals, theory of ferroelectric domain switching, thermodynamic theory of morphotropic phase boundaries in perovskite ferroelectrics etc. With V. Dvořák he published 13 highly cited papers, mainly on incommensurate phase transitions, improper ferroelectrics and antiferroelectrics.



### Vladimír Dvořák (1934-2007)

Solid state physicist, the most prominent Czech scientist in the theory of ferroelectricity and structural phase transitions, for the whole productive life affiliated with the Institute of Physics, Acad. Sci. Czech Rep. in Prague, its director in 1993-2001, member of the Learned Society since 1995. The main protagonist of the revolutionary reforms in the Institute of Physics after 1989.

His main achievement was a progress in the theory of improper ferroelectrics and incommensurate phase transitions achieved by a generalization of the group formulation of the Landau theory of phase transitions. For years he would be one of the most cited and internationally renowned scientist of the Institute. His personality has strongly influenced the scientific program and development in the Department of Dielectrics of the Institute since the late sixties up to present. Brilliant lecturer and most respected director of the Institute.

To commemorate his work and personality, the Institute of Physics of the Academy of Sciences of the Czech Republic decided to organize an annual festive Dvořák lecture, given by prominent internationally renowned scientists in the field related to the research pursued at the Institute of Physics.