Contribution ID: **24** Type: **Poster**

Strain Engineering of Flexo-Phonons and Flexo-Ferrons in Thin Films of Van der Waals Ferrielectrics

Tuesday, 22 September 2026 16:40 (5 minutes)

It was shown earlier that size effect of soft phonon dispersion is principally important in nanosized ferroics [1]. Also, the size and strain effects can determine the anomalous polarization reversal in strained thin films of van der Waals ferrielectrics [2]. It has been shown recently that the influence of the flexoelectric coupling (shortly "flexocoupling") on the fluctuations of electric polarization and elastic strains can lead to the principal changes of the dispersion law of soft optical and acoustic phonons (shortly "flexophonons") and ferrons (shortly "flexoferrons") in a bulk van der Waals ferrielectrics [3]. At that applied electric field influences strongly on the anisotropic dispersion of the flexocoupling induced phonons and ferrons in van der Waals ferrielectrics [4]. A strong coherent ferrons and cavity acoustic phonons is predicted in the of van der Waals ferrielectric $CuInP_2S_6$ [5].

Using the Landau-Ginzburg-Devonshire approach, in this work we reveal that the dispersion of flexophonons and flexoferrons is strongly dependent on the sign and magnitude of elastic strains originated from the lattice constants mismatch in thin strained films of van der Waals ferrielectric $CuInP_2S_6$. In particular, the frequency of acoustic flexophonons and flexoferrons tends to zero at nonzero wavevectors $k > k_{cr}$, where the critical value of the wavevector k_{cr} is determined by the mismatch strain and flexocoupling strength. Zeroing of the flexophonon frequency, that appears with increase of tensile strains, indicates a possible emergence of a spatially modulated incommensurate polar phase induced by the flexo-strain effects. Analytical results, derived in this work, open the way for strain engineering of flexophonon and flexoferron dispersion in thin films of van der Waals ferrielectrics.

Acknowledgements. The work is primary supported as part of the Computational Materials Sciences Program funded by the US Department of Energy, Office of Science, Basic Energy Sciences, under Award Number DE-SC0020145. The part of A.N.M. and E.A.E. efforts are also supported by National Academy of Sciences of Ukraine (grants No. 5.8/26-П, 1.4.B/222, III-6-26).

References

1. A. N. Morozovska, and E. A. Eliseev. Size effect of soft phonon dispersion law in nanosized ferroics. Phys.Rev. B, 99, 115412 (2019); https://link.aps.org/doi/10.1103/PhysRevB.99.115412

2. A. N. Morozovska, E. A. Eliseev, A. Ghosh, M. E. Yelisieiev, Y. M. Vysochanskii, and S. V. Kalinin. Anomalous Polarization Reversal in Strained Thin Films of CuInP2S6, Phys. Rev. B, 108, 054107 (2023); https://link.aps.org/doi/10.1103/PhysRevB.108.0

3. A. N. Morozovska, E. A. Eliseev, O. V. Bereznikov, M. Ye. Yelisieiev, G.-D. Zhao, Y. Zhu, V. Gopalan, L.-Q. Chen, J.-M. Hu, and Y. M. Vysochanskii, Flexo-coupling induced phonons and ferrons in Van der Waals ferroelectrics, Physical Review B 112, 014110 (2025); https://doi.org/10.1103/mr9v-khtj

4. A. N. Morozovska, E. A. Eliseev, Y. Zhu, Y. M. Vysochanskii, V. Gopalan, L.-Q. Chen, and J.-M. Hu, The Influence of Electric Field on the Anisotropic Dispersion of the Flexocoupling Induced Phonons and Ferrons in Van der Waals Ferrielectrics. Journal of Applied Physics, 138, 134101 (2025); https://doi.org/10.1063/5.0294057

5. Y. Zhu, Ji. Wu, A. N. Morozovska, E. A. Eliseev, Y. M. Vysochanskii, V. Gopalan, L.-Q. Chen, X. Zhang, W. Zhang, J.-M. Hu. Strong coupling between coherent ferrons and cavity acoustic phonons. Physical Review Applied (2026); https://doi.org/10.1103/q9np-lk7y

Primary authors: ELISEEV, Eugene (Frantsevich Institute for Problems in Materials Science, National Academy of Sciences of Ukraine); MOROZOVSKA, Anna (Інститут фізики НАН України); Dr ZHU, Yujie (Department of Materials Science and Engineering, University of Wisconsin-Madison); YELISIEIEV, Mykola (Institute of Semiconductor Physics, NAS of Ukraine, Kyiv, Ukraine); Prof. VYSOCHANSKII, Yulian M. (Institute of Solid-State Physics and Chemistry, Uzhhorod University); Prof. GOPALAN, Venkatraman (Department of Materials Science and Engineering, Pennsylvania State University); Prof. CHEN, Long-Qing (Department of Materials Science and Engineering, Pennsylvania State University); Dr HU, Jia-Mian (Department of Materials Science and Engineering, University of Wisconsin-Madison)

Presenter: ELISEEV, Eugene (Frantsevich Institute for Problems in Materials Science, National Academy of Sciences of Ukraine)

Session Classification: Poster Session

Track Classification: CONDENSED MATTER PHYSICS