



KRAKOW SCHOOL
OF INTERDISCIPLINARY
PHD STUDIES

Chiral phonons

Speaker: Surajit Basak

Supervisors: Przemysław Piekarczyk, Andrzej Ptak

Department of computational material science, IFJ PAN

Date: 28/04/2023





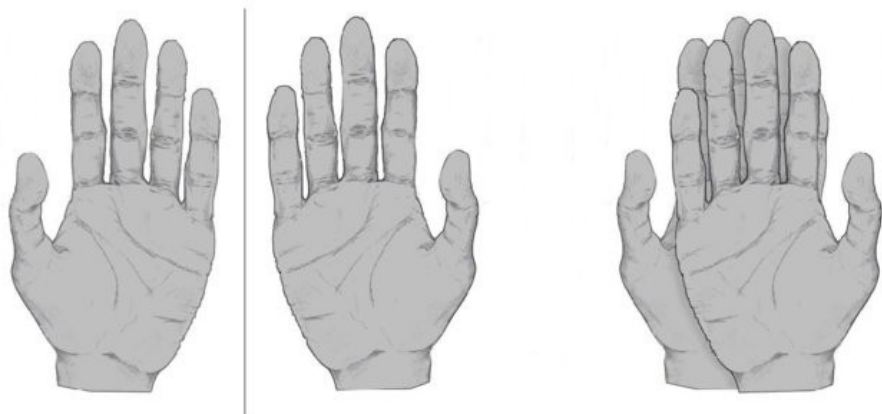
Plan

- Chirality – in nature.
- Lattice vibration and phonons.
- Systems with phonons with zero net chirality.
- Systems with phonons with non-zero net chirality.



What is chirality?

- Chirality: A property that distinguishes a system from its mirror image.

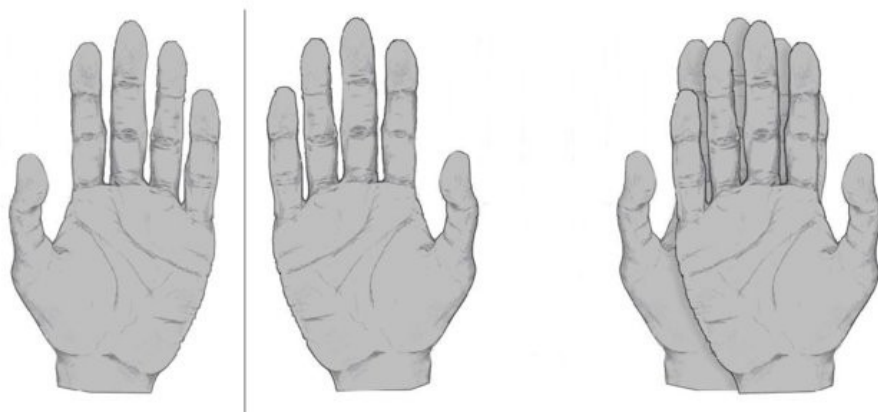


One hand is almost a mirror image of the other, but one cannot be superimposed on the other.



What is chirality?

- Chirality: A property that distinguishes a system from its mirror image.



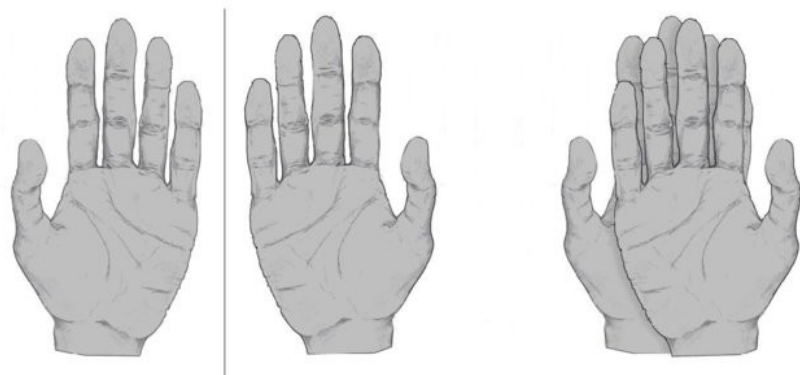
One hand is almost a mirror image of the other, but one cannot be superimposed on the other.

- Chirality gives a sense of handedness to a system.



What is chirality?

- Chirality: A property that distinguishes a system from its mirror image.



One hand is almost a mirror image of the other, but one cannot be superimposed on the other.

- Chirality gives a sense of handedness to a system.
- If your hands were not chiral, you could have wore your left glove on your right hand.

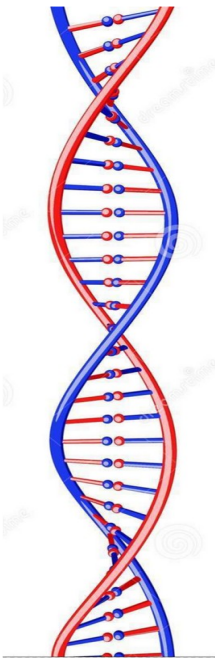


Nature's bias towards one type of handedness

- Contrary to our intuition, nature seems to prefer one type of handedness over the other.

KISI Nature's bias towards one type of handedness

- Contrary to our intuition, nature seems to prefer one type of handedness over the other.

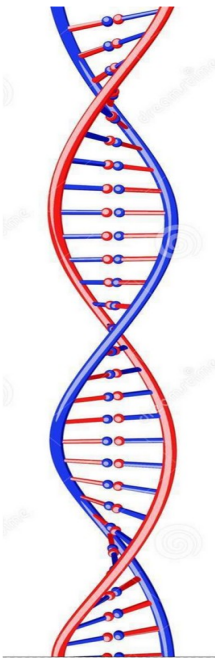


Double stranded right handed helix



Nature's bias towards one type of handedness

- Contrary to our intuition, nature seems to prefer one type of handedness over the other.



Double stranded right handed helix



Nature's bias towards one type of handedness



to prefer one



Follow

Jeremy the snail

@leftysnail

Multi award winning gastropod and shellebrity snail (RIP). The snail that keeps on giving. #snaillove. Media: our scientist @angus_davison


Nottingham, England Joined October 2016




33 Following 1,332 Followers



Nature's bias towards one type of handedness





WIKIPEDIA
The Free Encyclopedia

[Create account](#) [Log in](#) ⋮

Jeremy (snail)

[4 languages](#)

[Article](#) [Talk](#)


[Read](#) [Edit](#) [View history](#) [Tools](#)

From Wikipedia, the free encyclopedia

Jeremy was a left-coiled [garden snail](#) investigated by biologists. The snail had a rare condition which caused its shell to coil to the left; in most snails the shell coils to the right. At first it was thought to be a rare genetic mutation,^[2] although later work revealed that it was likely due to an accident in early development.^[3]

Jeremy was named after the left-wing British [Labour](#) politician [Jeremy Corbyn](#), on account of it being a "lefty" snail, but also due to Corbyn's reported love of gardening.^{[4][5][6]} The snail became

Jeremy



Jeremy [tral snails](#)

[@leftysnail](#) [lso](#)

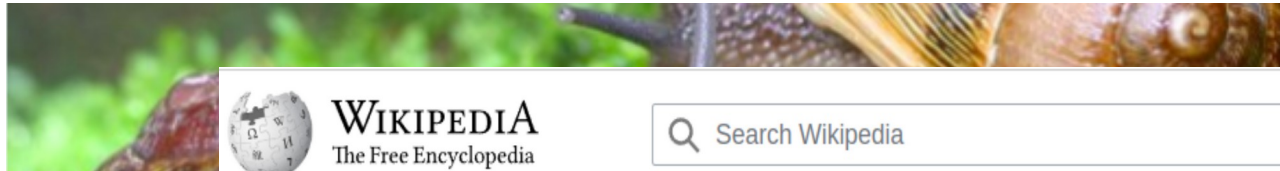
Multi award [ences](#)
giving. [#snail links](#)

[Nottingh...](#)

33 Following 1,332 Followers



Nature's bias towards one type of handedness



the Guardian

Independent, reader-funded

The Guardian

Opinion

Sport

Culture

Lifestyle

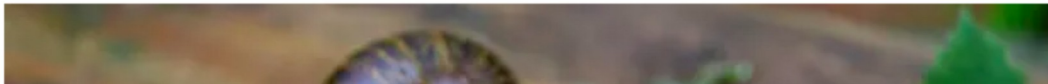
More

US Americas Asia Australia Middle East Africa Inequality Global development

This article is more than 5 years old

Snail in the coffin: left-coiling mollusc Jeremy dies after finding love

Gastropod hit headlines after his rare shell orientation prevented him from mating - but eventually found a partner and became a father



Most viewed



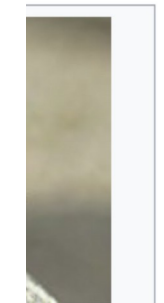
Live Russia-Ukraine war live: Ukrainian forces 'conducting raids' across Dnieper River



Tucker Carlson leaves Fox News - reportedly fired by Rupert Murdoch

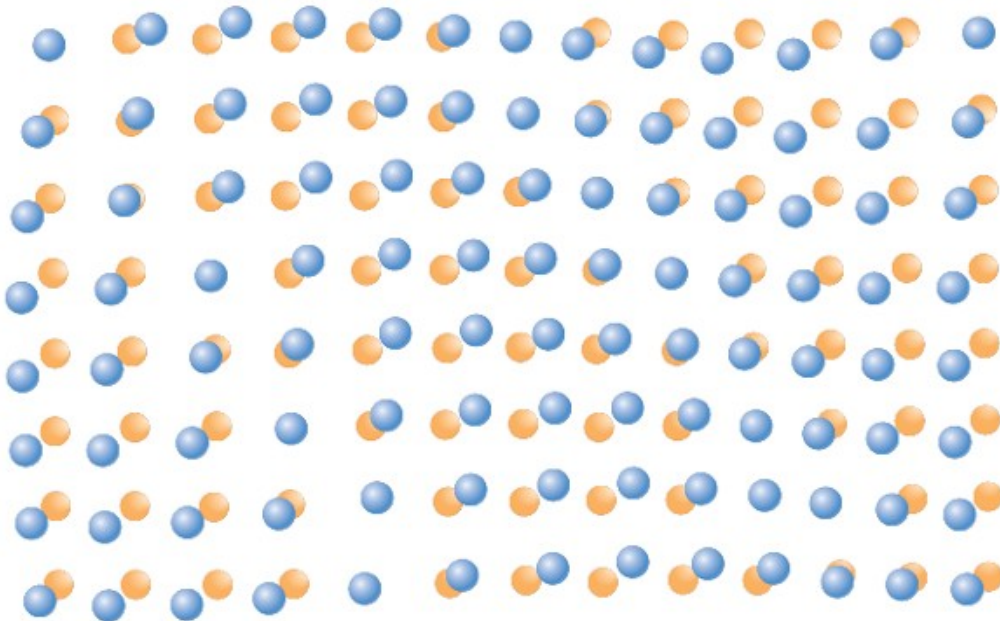


Eat fibre first - and ditch the



KISI Phonons

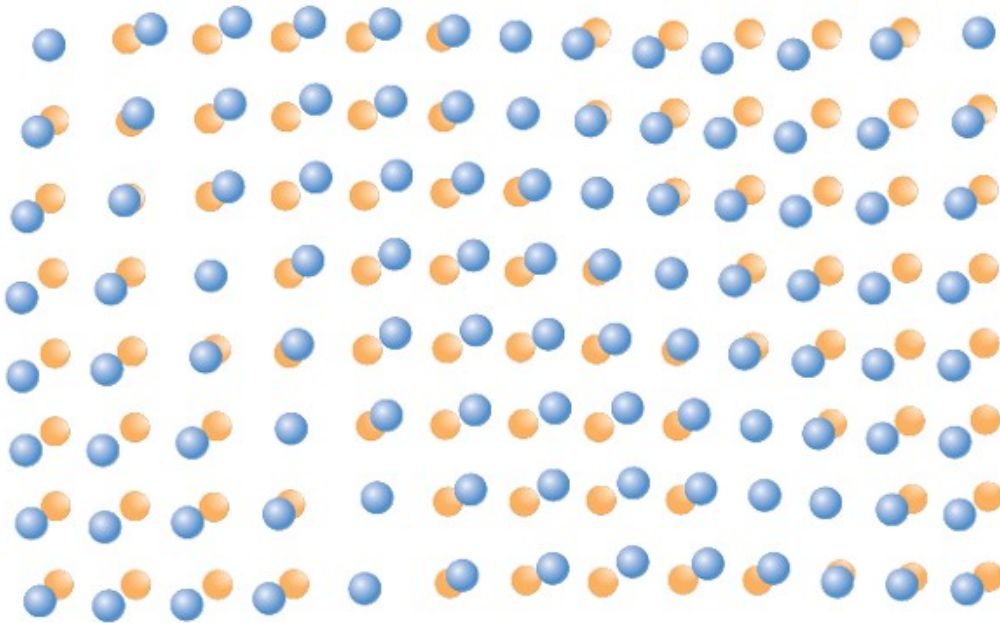
- Lattice vibration



- Normal lattice positions for atoms
- Positions displaced because of vibrations

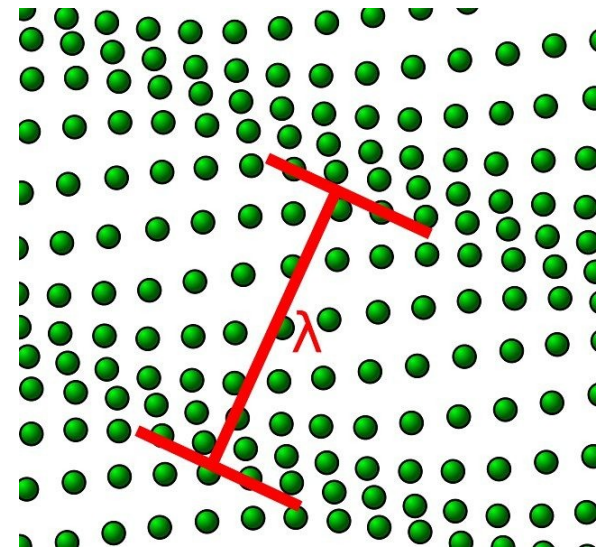
KISI Phonons

Lattice vibration



- Normal lattice positions for atoms
- Positions displaced because of vibrations

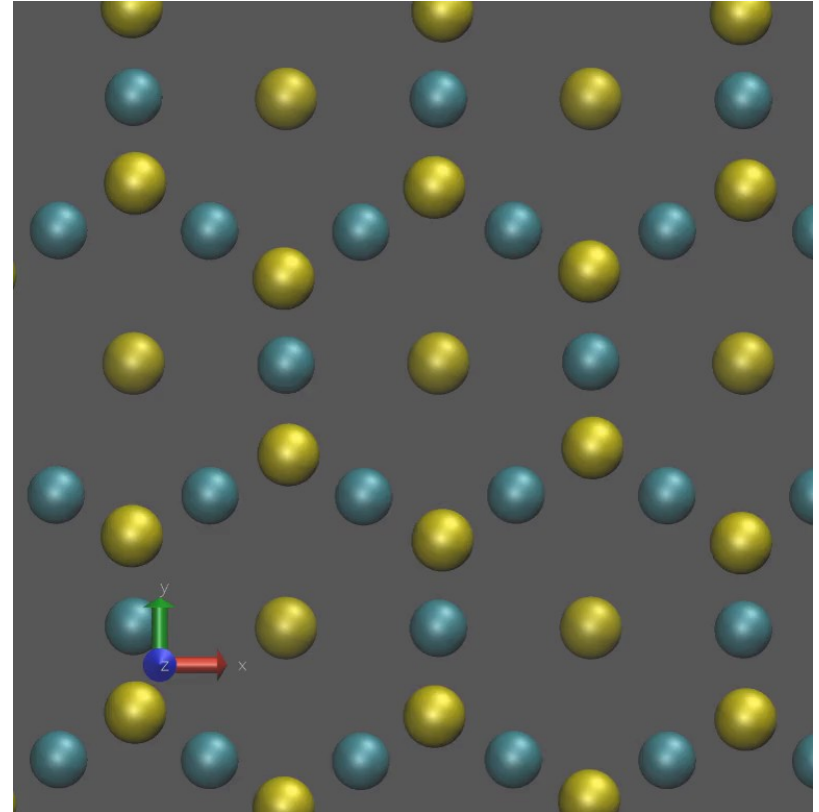
A bunch of phonons





Phonons with angular momentum

- Along with the vibration, the atoms can rotate around their equilibrium position.

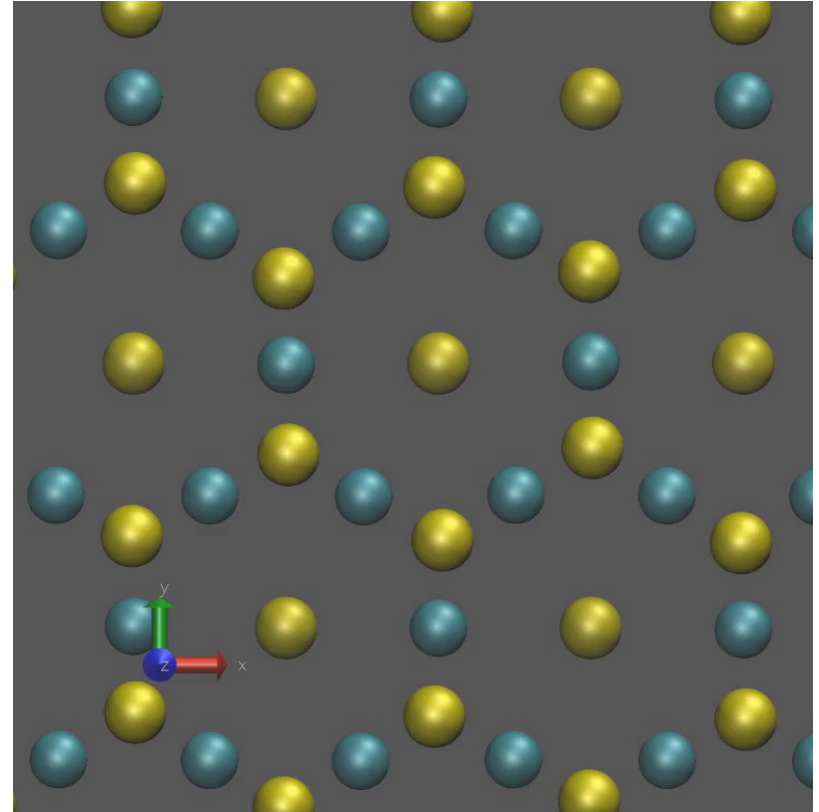


A. Ptok *et.al.*, PRB 104, 054305 (2021)



Phonons with angular momentum

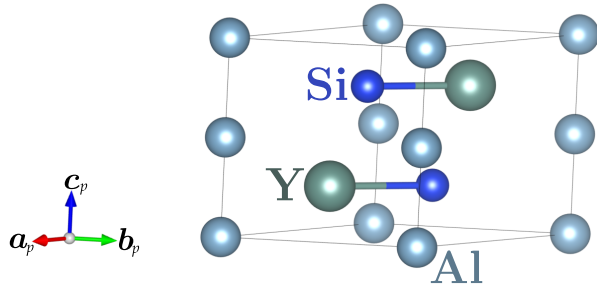
- Along with the vibration, the atoms can rotate around their equilibrium position.
- Depending on the sense of rotation {(anti-)clockwise}, the resulting phonons maybe right or left handed.



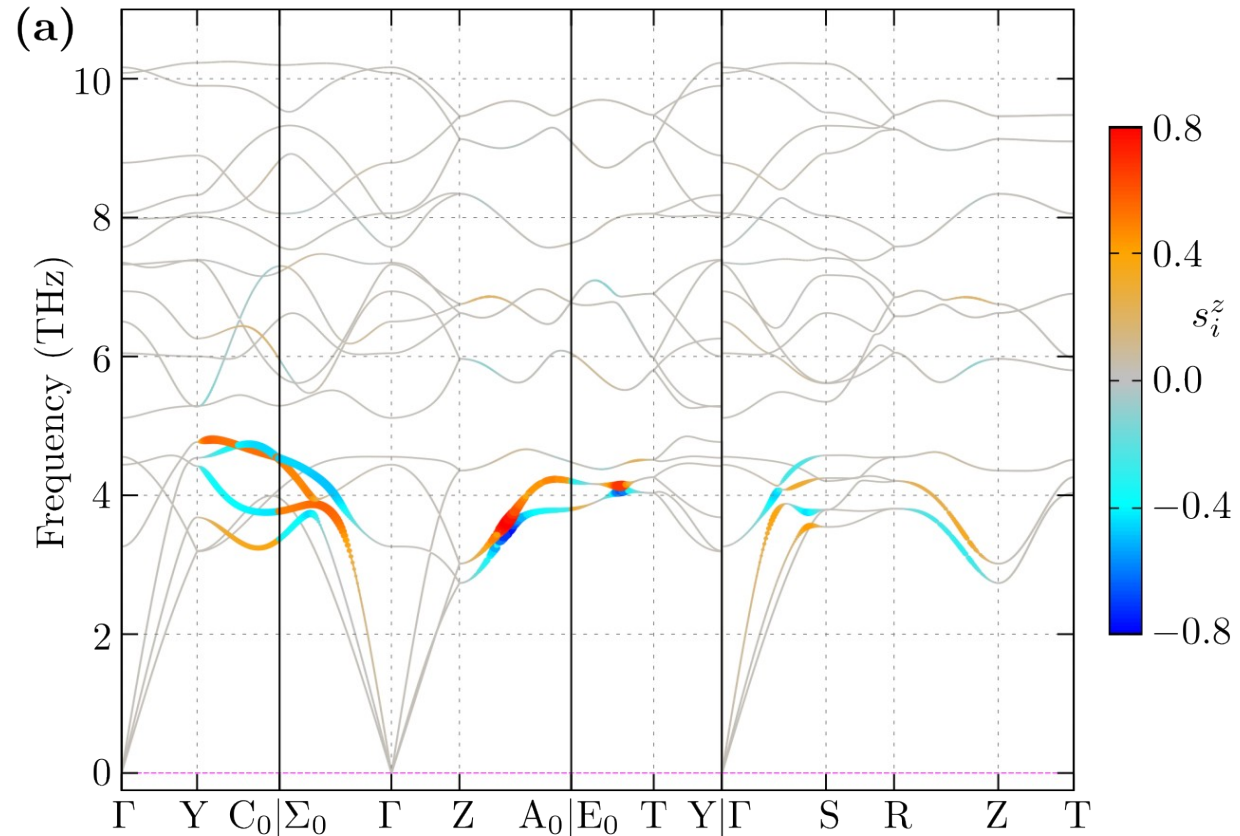
A. Ptok *et.al.*, PRB 104, 054305 (2021)



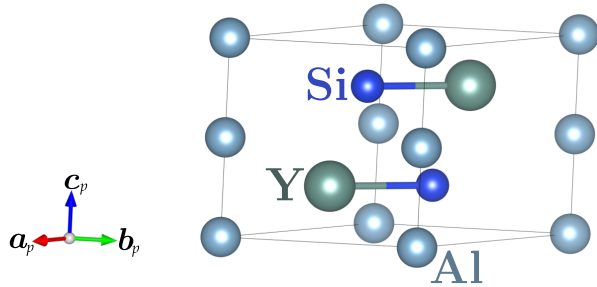
Systems with chiral phonons (YAlSi)



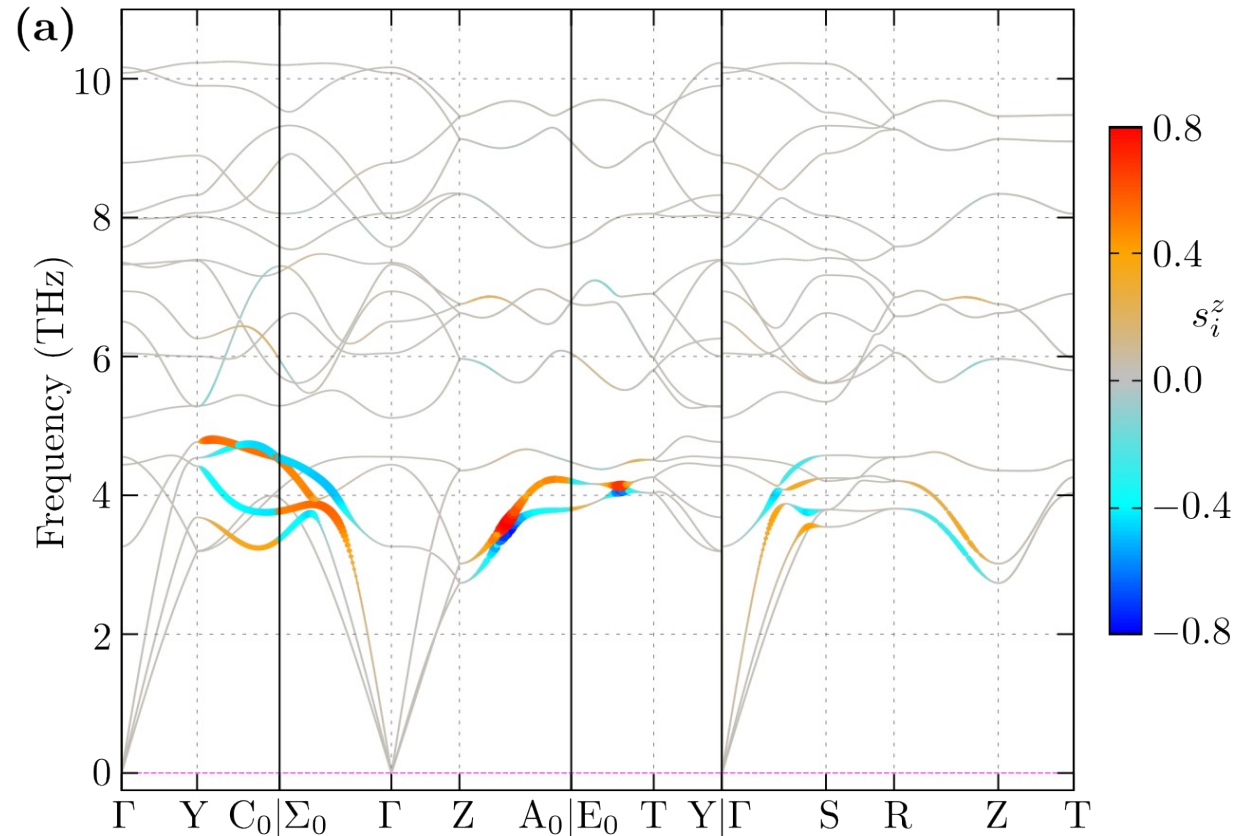
- The chiral phonon arising from Y atom of YAlSi



S. Basak, A.Ptok, Crystals 2022, 12(3), 436



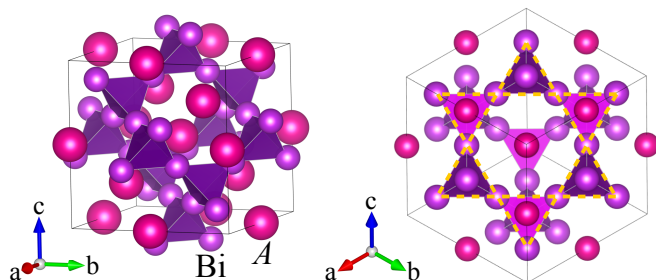
- The chiral phonon arising from Y atom of YAlSi
- **Total chirality remains zero.**



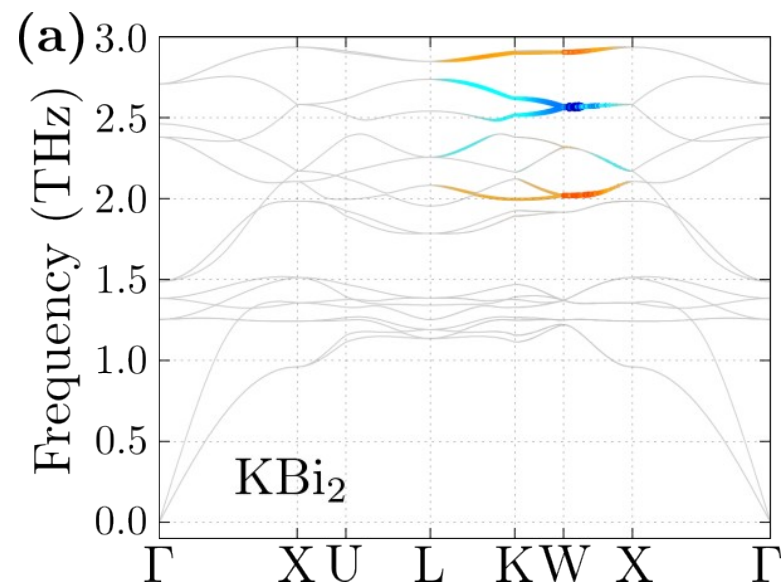


System with a non-zero net phonon chirality

KBi_2



The net chirality of the system is again zero.

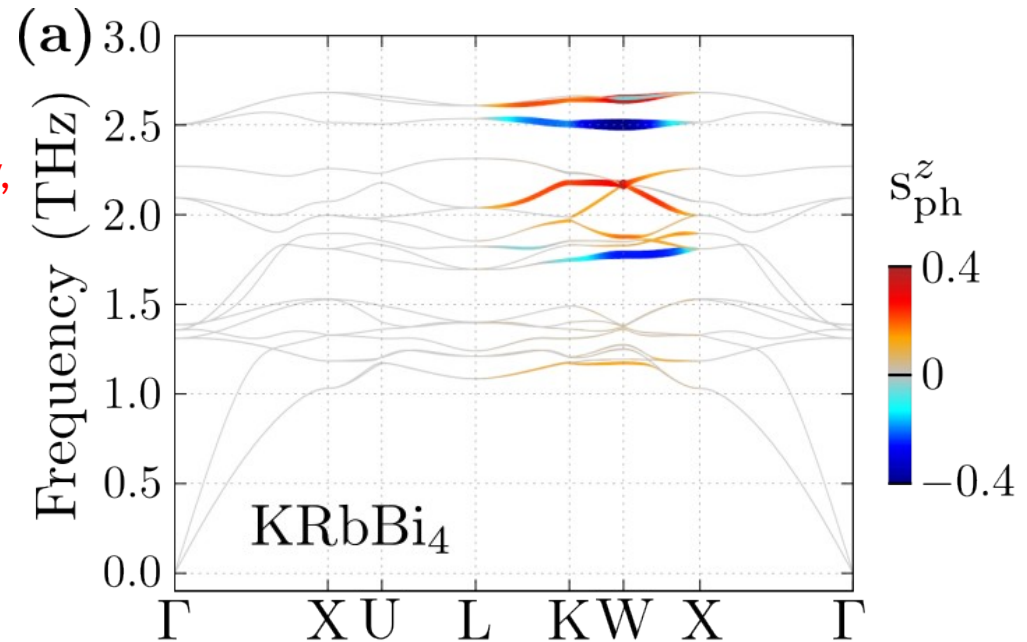




System with a non-zero net phonon chirality



Due to broken inversion symmetry,
the system now has a
a total non-zero chirality.



S. Basak, P. Piekarz, A. Ptok, arXiv:2208.14041



Conclusion

- System with a (non-)zero net chirality was discussed.
- Chiral phonons interact selectively with other chiral objects like circularly polarized light, which may help us understand the properties of system with chiral phonons.
- Chiral phonons also dictate which kind of scattering events are allowed while interacting with electrons, that can even affect the property of that system as an electronic device.



Thank You