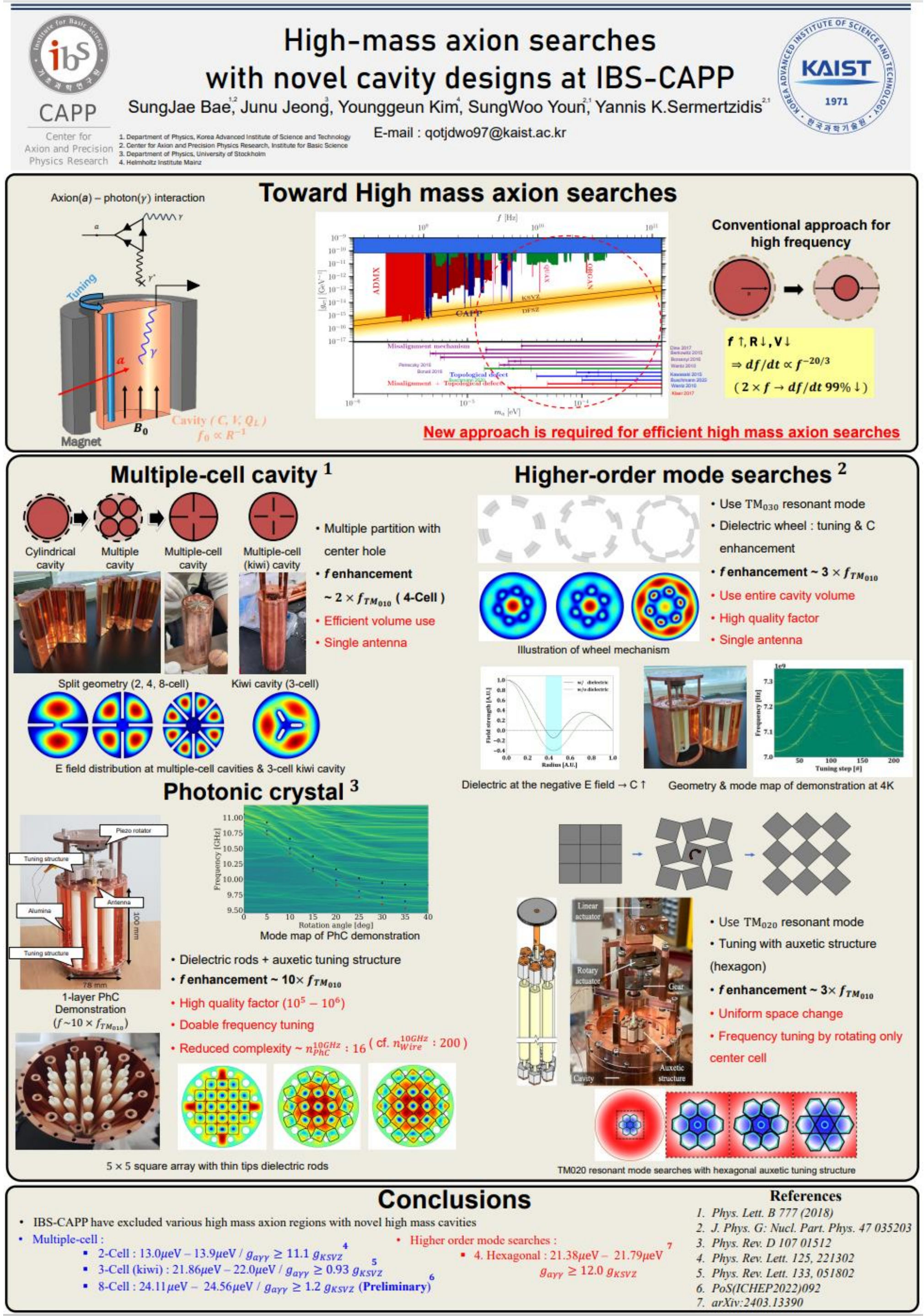


High-mass axion searches with novel cavity designs at IBS-CAPP

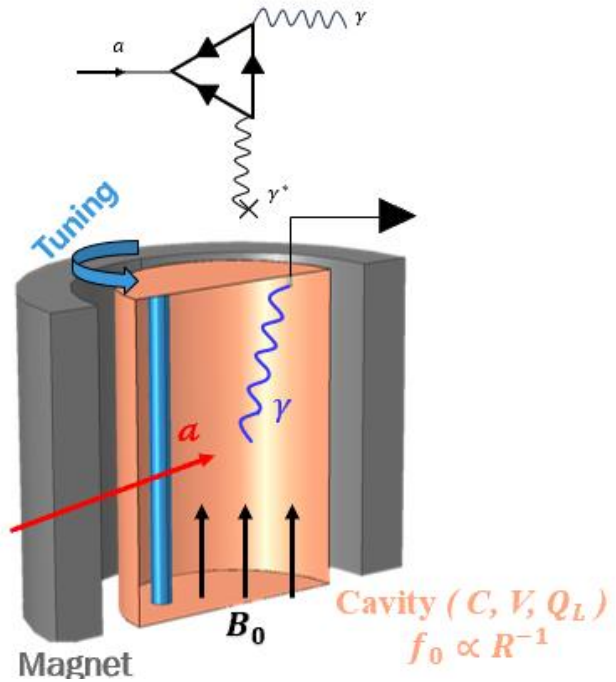
SungJae Bae

Behalf of CAPP-HF team

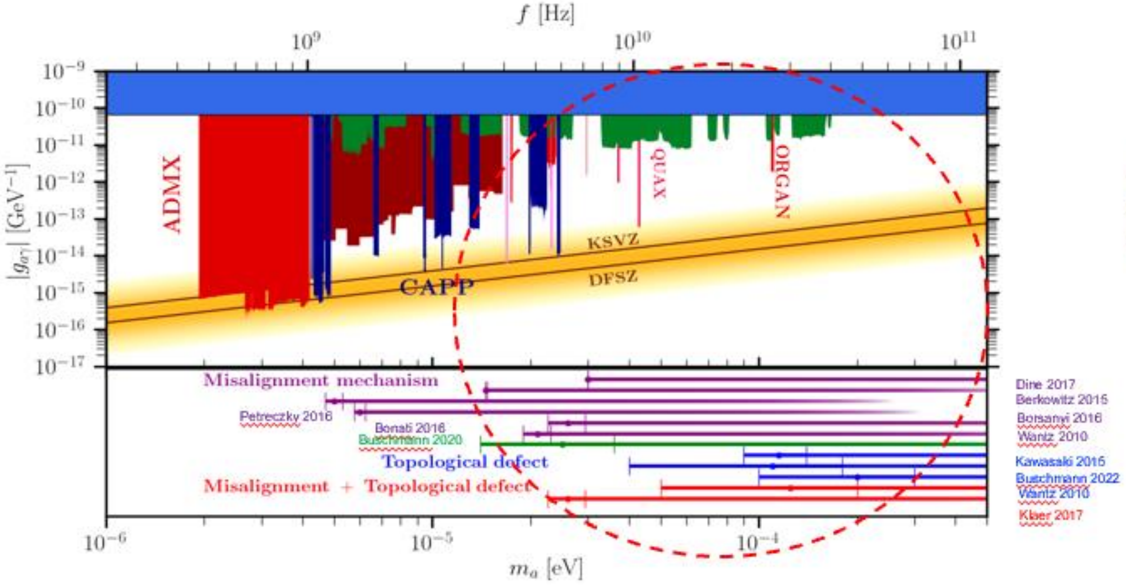
19th PATRAS workshop

Motivation

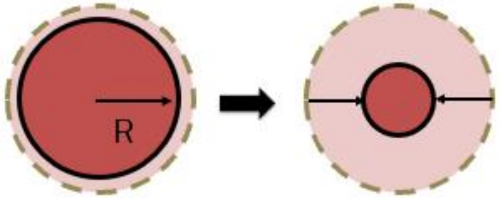
Axion(a) – photon(γ) interaction



Toward High mass axion searches



Conventional approach for high frequency searches

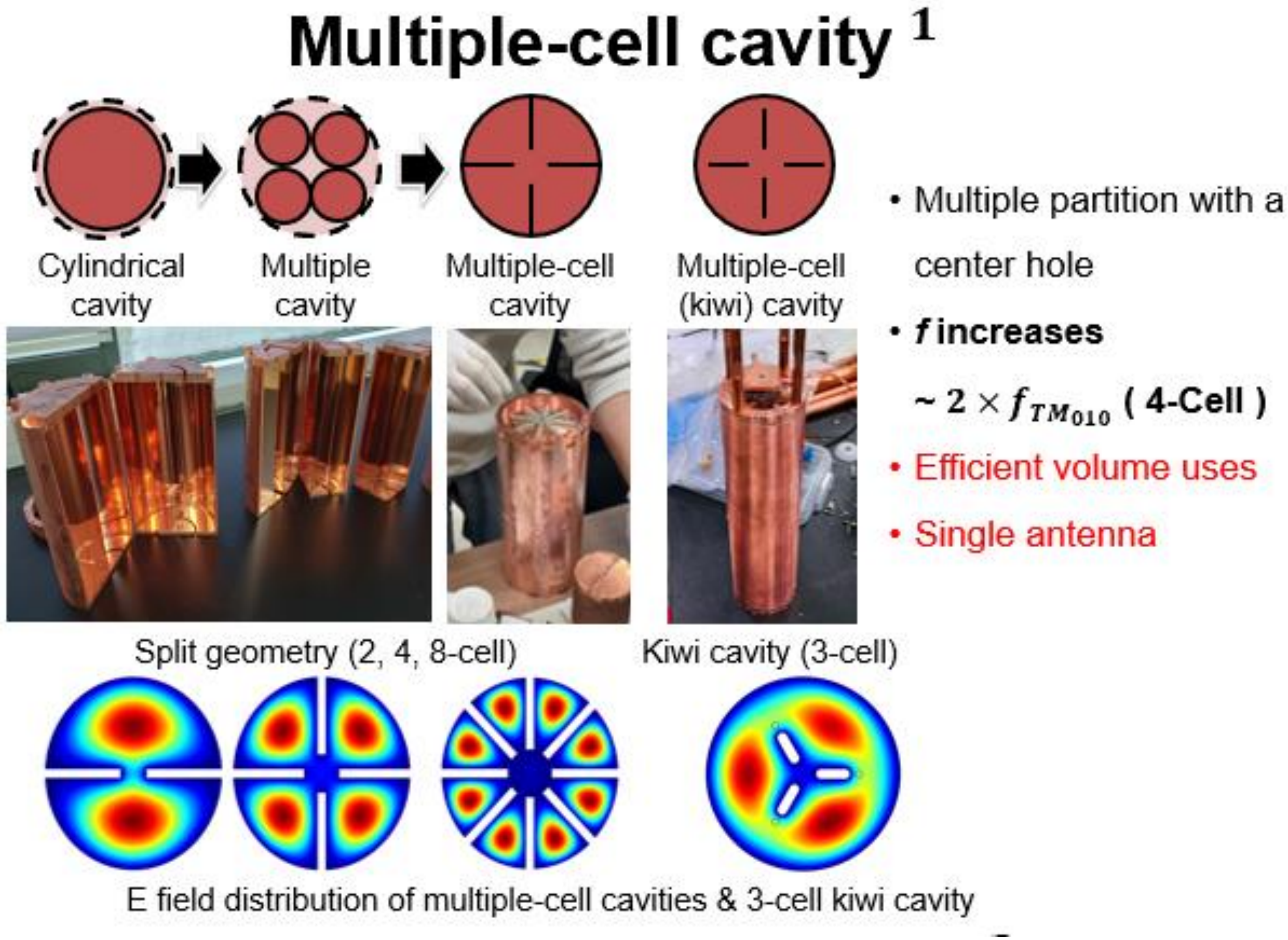


$f\uparrow$, $R\downarrow$, $V\downarrow$

$\Rightarrow df/dt \propto f^{-20/3}$

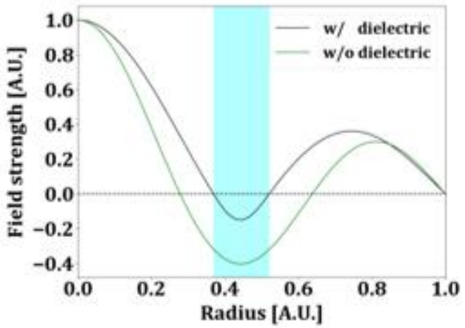
New approach is required for efficient high mass axion searches

Novel high frequency cavity designs at IBS-CAPP



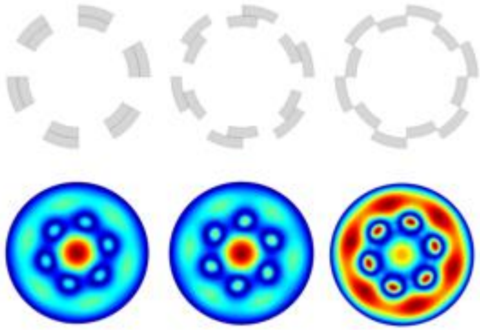
Novel high frequency cavity designs at IBS-CAPP

Higher-order mode searches [2]

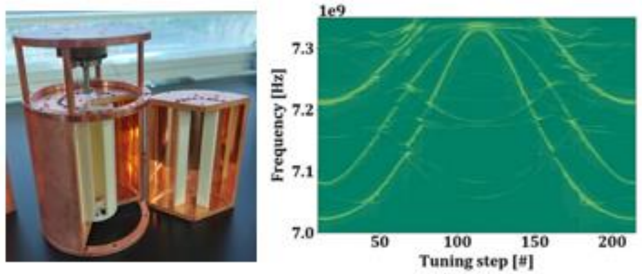


C enhancement using dielectric

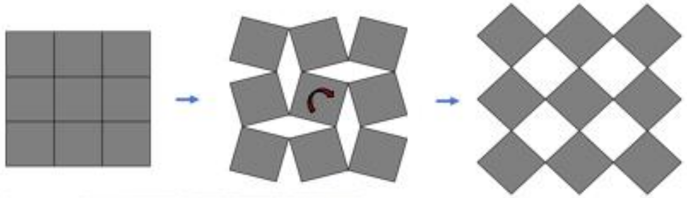
- Use TM_{030} resonant mode
- Dielectric : tuning & C enhancement
- ***f* increases ~ 3 × $f_{TM_{010}}$**
- Use entire cavity volume
- High quality factor
- Single antenna

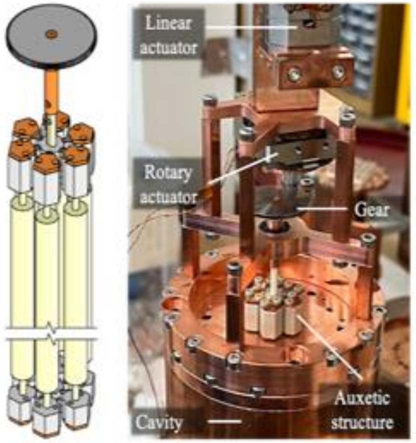


Wheel tuning mechanism

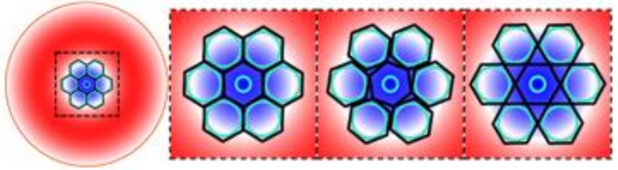


Demo cavity & mode map at 4K





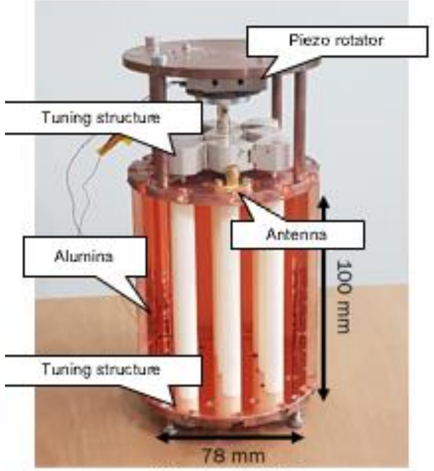
- Use TM_{020} resonant mode
- ***f* increases ~ 2× $f_{TM_{010}}$**
- Tuning with auxetic structure (hexagon)
- Uniform space changing
- Frequency tuning by rotating only center cell



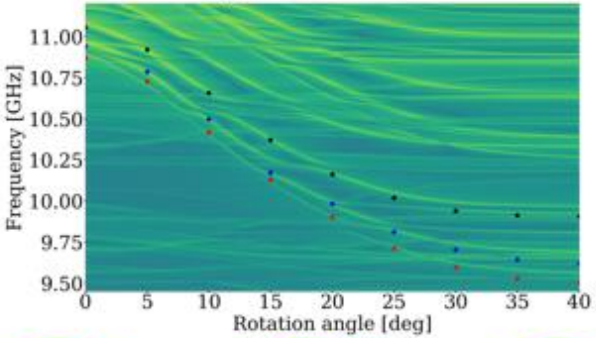
E field distribution of TM_{020} with auxetic tuning structure

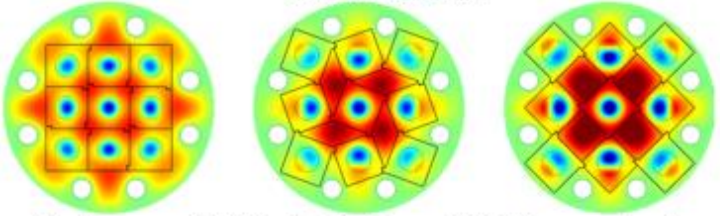
Novel high frequency cavity designs at IBS-CAPP

Photonic crystal [3]



1-layer PhC Demonstration





Mode map & field distribution of PhC demonstration

5 × 5 square array on planning

- Dielectric rods + auxetic tuning structure
- ***f* increases ~ 10×** $f_{TM_{010}}$
- High quality factor ($10^5 - 10^6$)
- Doable frequency tuning
- Reduced complexity ~ n_{PhC}^{10GHz} : 16

  (cf. n_{Wire}^{10GHz} : 200)

Conclusions

- IBS-CAPP have developed various novel high mass cavities and implemented in axion searches
- Multiple-cell :
  - 2-Cell : 13.0μeV – 13.9μeV / $g_{a\gamma\gamma} \geq 11.1\, g_{KSVZ}$ [4]
  - 3-Cell (kiwi) : 21.86μeV – 22.0μeV / $g_{a\gamma\gamma} \geq 0.93\, g_{KSVZ}$ [5]
  - 8-Cell : 24.11μeV – 24.56μeV / $g_{a\gamma\gamma} \geq 1.2\, g_{KSVZ}$ **(Preliminary)** [6]
- Higher order mode searches :
  - 4. Hexagonal : 21.38μeV – 21.79μeV [7]
    $g_{a\gamma\gamma} \geq 12.0\, g_{KSVZ}$

References

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2. *J. Phys. G: Nucl. Part. Phys. 47 035203*
3. *Phys. Rev. D 107 01512*
4. *Phys. Rev. Lett. 125, 221302*
5. *Phys. Rev. Lett. 133, 051802*
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7. *arXiv:2403.13390*