Responses to the Reviewers

Thank you for reviewing carefully our manuscript (Manuscript ID : crystals-2479825).

Your advice is very helpful to us.

According to your comments, we are revising the manuscript as follows.

Reviewer #1

The submitted paper “Electromagnetically-induced transparency analog of asymmetric perovskite metamaterial in THz spectral region” by T.-H. Kim, B. W. Lee and F.J. Seo is devoted to simulations of electromagnetic response of a perovskite metamaterial composed of the cut wire and ring resonators. The terahertz transmission is modeled using the CST MWS code. The features of transparency spectra are explained by destructive interference of two different quantum excitation paths in a three-level system. The high group refractive index of the structure is reported, up to 3100 at the distinct frequencies. The coupling between electromagnetic modes in the structure is analyzed employing Lorentz harmonic oscillator model. This provides confirmation to the outcomes concerning the mechanisms of transparency. The presented results are investing and original. The comprehensive simulation and modeling are provided. The text is well written. In my opinion the paper could be accepted for publication in Crystals in its present form.

⇨ Thank you for the good comments from the reviewer.

Reviewer #2

1. What are the specific applications of the proposed structure in this frequency band, such as what substances can be sensed?

⇨ Thanks for comments from the reviewer. According to the Reviewer's comments, we have revised the description in Introduction. The related sentences were written in lines 43-48.

Controlling the electromagnetic properties makes metamaterials useful for a variety of applications, including sensing and detection in the ~650 GHz frequency band [4, 13, 14]. Particularly, THz communication is a new field, and metamaterial structures can play an essential role in designing compact and efficient terahertz antennas and imaging devices for future communication systems. In addition, perovskite metamaterial-based sensors can be employed for non-destructive imaging and analysis of biological samples.

2. The article only focuses on the asymmetry parameter, what is the basis for choosing the size parameters of the resonators?

⇨ The related sentences were written in lines 81-85 (red).

Electromagnetic metamaterials are well known to consist of artificially designed units with electromagnetic resonant structures that exhibit strong dispersion and subwavelength properties. In the proposed metamaterial (MM) structure, the size parameters of the resonators are smaller than the wavelength ($\lambda = 440$ μm at 0.68 THz) of the incident electromagnetic wave.

3. In Equation (11), FOM value is defined as FOM=S×Q, while in other relevant literature, FOM is defined as FOM=S/FWHM. Please explain the difference.

⇨ The two different definitions of FOM are based on different considerations. The first definition of FOM, FOM = S × Q, emphasizes both sensitivity (S) and the quality factor (Q). On the other hand, the second definition of FOM, FOM = S / FWHM, focuses on the sensitivity-to-bandwidth ratio without explicitly considering the quality factor.

In the first definition of FOM, the Q represents the sharpness of the resonance peak. A higher Q value indicates the resonance peak is sharper, indicating that the resonator has lower losses and higher energy storage capacity. In the second definition of FOM, the FOM value represents the ratio of sensitivity to the bandwidth of the resonance peak.

In addition, related sentences were written in lines 308-310 and 344-346.

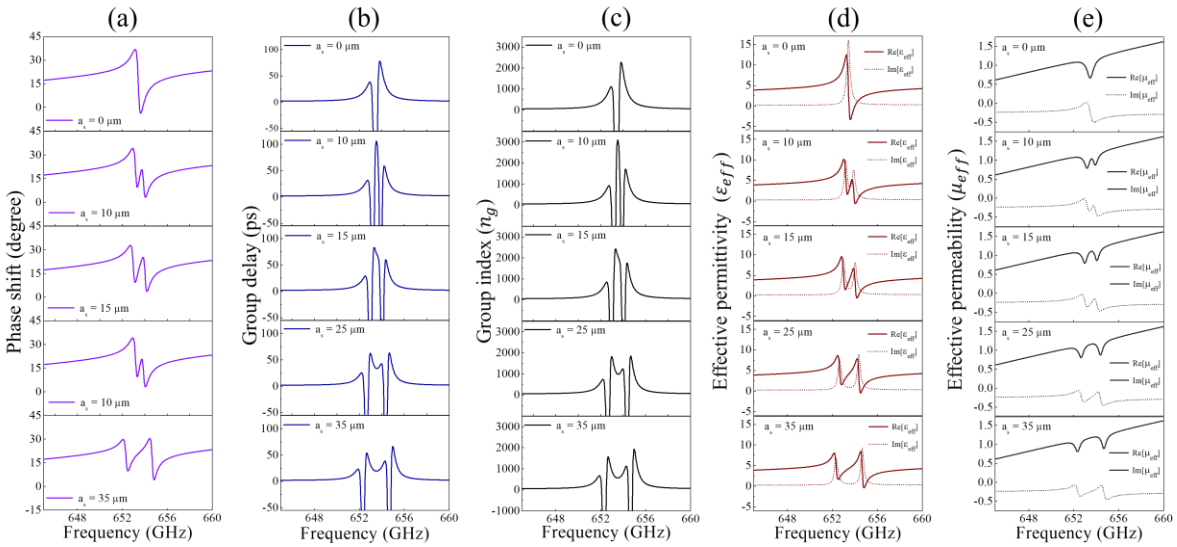
4.There is a rapid development in the aspects of electromagnetically induced transparency, some articles in recent years had better be cited for example: Design and prediction of PIT devices through deep learning, Optics Express 30 (9), 14985-14997

⇨ The reference recommended by the reviewer (Ref. 58) was added.

5. Whether the choice of substrate and resonant material can be realized in the experiment? The article can add the analysis of the feasibility of the experiment.

⇨ In this study, we used a linear effective medium approach (EMA) for perovskite metamaterial (MM) structures, which can provide important information in the search for experimentally applicable substrates and resonant materials.

Specifically, by being able to control the effective permittivity and effective permeability, metamaterials may be showing great potential for practical applications such as slowing light devices, sensors, and modulators. Two figures (d) and (e) are shown in Figure 8 were added, and related sentences were written in lines 291-292 and 297-298.

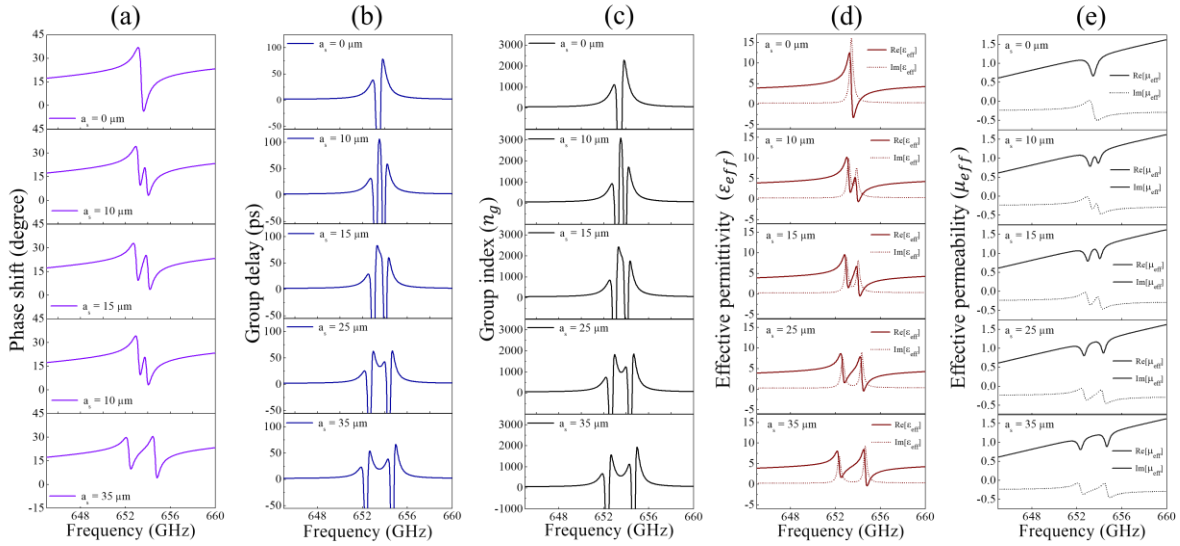


Reviewer #3

The paper "Electromagnetically-Induced Transparency Analog of Asymmetric Perovskite Metamaterial in THz Spectral Region" need minor revision to process to next level.

1) The evidence of metamaterial property with respect to the permittivity or permeability are missing in the paper at basic design analysis i.e Unite cell analysis

⇨ To accommodate the reviewer's comments, the results of the effective permittivity and the effective permeability perovskite MM structure are shown in figure below. Two figures (d) and (e) are shown in Figure 8 were added, and related sentences were written in lines 291-292 and 297-298.



2) What is the targeted application in specific to the designed model?

⇨ We have added applications for the proposed perovskite MM structure in lines 43-48 and 373-375.

3) FDTD technique means which tool was used? Why not FEM based analysis was not considered in this work?

⇨ In our article, the main reasons for using FDTD techniques over FEM-based analysis are as follows:

1. FDTD involves discretizing space and time, making it conceptually simple and easier to implement from scratch. On the other hand, FEM can be more complex, particularly for problems involving complicated geometries.
2. FDTD is a time-domain method, which makes it well-suited for simulating transient and time-varying phenomena.
3. FDTD simplifies the meshing process, particularly for regular structures. In contrast, FEM may require a more refined mesh to accurately capture complex geometries.
4. FDTD can be extended to handle frequency-domain simulations using techniques like

the Fourier Transform. For high-frequency electromagnetic simulations, FDTD may be more efficient.

Our numerical analysis utilized a 3D FDTD solver, specifically the commercial CST Microwave Studio 2022.

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4) Check grammatical mistakes while submitting the revision.

⇨ Checked for grammatical errors.

Reviewer #4

The paper under consideration reports on a numerical study of the electromagnetic response of a dielectric metasurface base on low loss dielectric material. The results are interesting, but the authors present them in a confusing manner.

1. The abstract states that "The analogy of EIT in perovskite metamaterials is characterized using a finite-difference time-domain (FDTD) technique". Not all of the Crystal journal readers are supposed to recognize that the paper describes NUMERICAL simulations, not a real experiment. Abstract and conclusion should begin with an unambiguous statement that results presented are those of simulations.

⇨ Thank you for the comments from the reviewer. According to the Reviewer's comments, we have revised the description in abstract and conclusion.

(Abstract in lines 19-22)

The numerical simulation analysis revealed the characteristic dynamics of the electromagnetic field, the near-field couplings of CWRs and DR, and the EIT-like spectral features of perovskite metamaterials as functions of the asymmetry parameter and polarization direction.

(Conclusion in lines 356-358

The bright-dark mode coupling of perovskite metamaterials displayed an EIT-like transparency with a high Q-factor and slow light in the THz spectral region by numerical simulation.

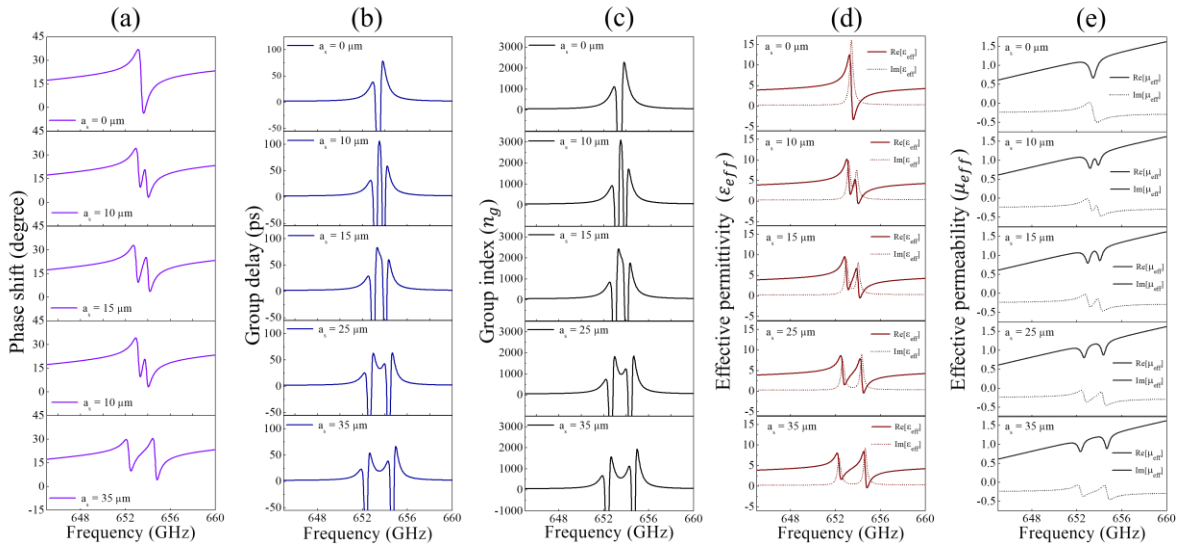
2. A specific materials – a perovskite (CsPbBr3) – is mentioned in the title and introduction. Still it remains unclear what material characteristics are important for the reported results. Authors only mention the permittivity and loss tangent. Optical anisotropy and other characteristics intrinsic to this material are not discussed. Therefore, authors should clearly specify the properties of the chosen material that are important for the study.

⇨ In this study, we employed the linear effective medium approach of perovskite MM structures. Based on the effective medium approach, our focus was on the effective permittivity and permeability of the perovskite MM structure, rather than the optical anisotropy and other intrinsic properties of the material. In addition, related sentences were written in lines 36-37 and 291-292.

3. If the only material parameters that are essential for the metamaterial response are the permittivity and loss tangent this should stated unambiguously. Importantly the authors REDUCE possible citations of the work by reducing the possible material choice for those who may want to realize the structure in an experiment.

⇨ In this study, we used a linear effective medium approach (EMA) for perovskite metamaterial (MM) structures, which can provide important information in the search for

experimentally applicable substrates and resonant materials. Specifically, by being able to control the effective permittivity and effective permeability, metamaterials may be showing great potential for practical applications such as slowing light devices, sensors, and modulators. Two figures (d) and (e) are shown in Figure 8 were added, and related sentences were written in lines 291-292.



The statement: “The transmission window has an amplitude of about 95% in the 630 GHz to 670 GHz band [14].” Cannot be correct as the radiation attenuation in atmosphere depends on the optical path. 95% for 1 meter distance corresponds to much less than 1% transmission for 1km.

⇨ Thanks for pointing our introduction. According to the Reviewer's comments, we revised the description in Introduction (in lines 43-48).

Controlling the electromagnetic properties makes metamaterials useful for a variety of applications, including sensing and detection in the ~650 GHz frequency band [4, 13, 14]. Particularly, THz communication is a new field, and metamaterial structures can play an essential role in designing compact and efficient terahertz antennas and imaging devices for future communication systems. In addition, perovskite metamaterial-based sensors can be employed for non-destructive imaging and analysis of biological samples.