

# Comment on “Interaction of Ion Cyclotron Electromagnetic Wave with Energetic Particles in the Existence of Alternating Electric Field Using Ring Distribution” by Shukla KN, Kumari J, Pandey RS

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It is already discussed categorically and in detail that for the alternating current (AC) electric field parallel to the magnetic field, the dispersion relation is too complicated and cannot be expressed through a simple expression. As they claim to use a simple relation, which cannot be applicable, the results of Shukla et al. (2022) are not reliable.

Propagation of waves through a magnetized plasma having AC electric field has been discussed in detail in literature. For propagation of waves in plasma, the dielectric tensor is expressed by Summers et al. (1994), where  $\epsilon_{ij}$  are (nine) elements of dielectric tensor  $\epsilon$ , and the wavevector is  $\mathbf{k} = k_{\perp} \hat{i} + k_{\parallel} \hat{k}$ , where  $\hat{i}$  and  $\hat{k}$  are, respectively, unit vector along the x-axis and z-axis of Cartesian coordinate system.

Let us review our earlier work in brief. We have investigated two cases: (i) the magnetic field is perpendicular to the AC electric field (Chandra & Sharma 2020a), and (ii) the magnetic field is parallel to the AC electric field (Chandra & Sharma 2020b).

Chandra & Sharma (2020a) considered the case of AC electric field  $\mathbf{E}_0 = E_0 \sin vt \hat{i}$ , and ambient magnetic field  $\mathbf{B} = B_0 \hat{k}$ , i.e., the direction of the electric field is perpendicular to the direction of the magnetic field. For the propagation of wave parallel to the magnetic field (i.e., along the z-axis), we have  $k_{\perp} = 0$ ,  $k_{\parallel} = k$ ,  $N_{\perp} = 0$  and  $N_{\parallel} = N$ . Therefore,  $\epsilon_{13} = \epsilon_{31} = \epsilon_{23} = \epsilon_{32} = 0$ , so that, we have

$$\epsilon_{11} \pm i\epsilon_{12} = N^2 \quad (1)$$

Chandra & Sharma (2020b) considered the case of AC

electric field  $\mathbf{E}_0 = E_0 \sin vt \hat{k}$ , and ambient magnetic field  $\mathbf{B}_0 = B_0 \hat{k}$ , i.e., the direction of the electric field is parallel to the direction of the magnetic field. For the propagation of wave parallel to magnetic field, all nine elements are non-zero, and the dispersion relation would be too complicated and its solution may not be feasible.

Chandra & Sharma (2020a) wrote that Kumari et al. (2018), Kumari & Pandey (2018) and many more coauthors with Pandey used the relation

$$\epsilon_{11} \pm \epsilon_{12} = N^2 \quad (2)$$

irrespective the electric field is perpendicular or parallel to the ambient magnetic field (see, Chandra & Sharma 2020a, b). Chandra & Sharma (2020b) explicitly showed that for the case of parallel electric and magnetic fields, even the relation (1) cannot be used. Now, Shukla et al. (2022) said that they have used equation (1) for parallel electric and magnetic fields. Such use is obviously not valid, and the results of Shukla et al. (2022) cannot be reliable. Further, Shukla et al. (2022) said that they have got this expression from Kumari et al. (2018), Kumari & Pandey (2018), many others (coauthors of Pandey). Chandra & Sharma (2020a, b) have categorically said that Kumari & Pandey (2018), Kumari et al. (2018), many others (coauthors of Pandey) have used the relation (2) and not relation (1). Shukla et al. (2022) can see that the difference between the relations (1) and (2) is similar as between a real number and a complex number.

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Chandra & Sharma (2020b) have explicitly showed that for the case of parallel electric and magnetic field, the dispersion relation would be too complicated and cannot be expressed in the form of an expression. Shukla et al. (2022) said that they have used equation (1). Consequently, the results of Shukla et al. (2022) cannot be reliable.

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