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A Pedagogical Calculation on the Poraziation Vector in an MHD Wave

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The concept of electric polarization has been examined using an MHD (magnetohydrodynamic) wave for educational purpose. The polarization in an MHD wave can be easily derived from the basic equations, and its mechanism is transparent undergraduate students.

The polarization vector may be one of the most unclear concept in electromagnetism for students. Standard explanation of P is based on the molecular polarization of a dielectric medium, however, actual mechanism of the polarization is not consistently treated in textbooks usually. One needs to examine the molecular dynamics of the medium, which requires to solve quantum many-body problem somehow, to this end. A consistent quantum model is beyond the power of undergraduate students who are starting electromagnetism.

In the present paper, a simple and selfconsistent example of the electric polarization is introduced: an magnetohydorodynamic (MHD) wave in a collisionless plasma. The molecular polarization is not the only mechanism to cause the polarization vector. It can be the result of any current in the medium invoked by the electric field E, as long as E and P
are in linear relation.

When we examine the polarization in an MHD plasma closely, we find that the polarization vector P does not correspond to any actual physical entity. The response of the plasma as a dielectric media takes place in the form of the polarization current, and P is a convenient mathematical expression to handle the effect of the polarization current. This situation is somewhat similar to the relation of an electric potential to electric fields. What we actually observe is the electric fields, but calculations become easier when we introduce a potential function.

Keywords: MHD wave, Polarization Vector, Electric field and Electric Flux