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An attempt of re-defining the magnetotelluric phase tensor

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In spite of the discovery by Caldwell et al. (2004) of the way of canceling the Galvanic distortion conterminating the magnetotelluric (MT) impedance tensor for discussing the dimentionality of the electrical conductivity structure revealed by the distortion-canceled impedance tensor named as the MT phase tensor (MTPT), the features of the tensor are not evident at all from the point of view of the linear algebra. The author attempts to re-define the MTPT in the complex metric linear space, not in the real metric linear space in which Caldwell et al. (2004) attempted to define MTPT. The present author shows two ways of decomposing and interpretting re-defined two MTPTs.

The one way corresponds to an eigenspace problem of two MTPTs. Considering the eigenspace's complexity, the 3-D conductivity structure revealed by MTPTs can be classified into 2 categories: the phase-rotation-free (PRF) and the phase-rotation-necessary (PRN). The eigenspace corresponds to the characteristic direction of the magnetic field at the observation point in the period. The eigenvalues show the fundamental modes which express each element of the distortion-free MT impedance tensor as a linear combination. While in case of PRF each element of the distortion-free MT impedance tensor can be expressed with the fundamental modes as a linear combination with real coefficients, in case of PRN complex coefficients are indispensable. In addition, while in cases of 2-D conductivity structures the characteristic directions of the horizontal magnetic field which correspond to the engenspace are orthogonal to one another, they are not in 3-D conductivity structure cases. This way is after Eggers (1982).

Another way corresponds to a singular value problem of two distortion-canceled Hermitian matrices which appear in the Hermitian forms of linearly-transformed electric field with respect to the magnetic field. In case that an appropriate coordinate system is initially adopted, the two Hermitian matrices defined by two MTPTs can be decomposed with an identical unitary matrix. Since a unitary matrix can be interpretted as a linear transformation indicating a combination of coordinate-system-rotations and phase-rotations of arbitrary vectors, the resultant characteristic directions of the horizontal magnetic field are kept orthogonal even in cases of 3-D conductivity structures. This latter way which is based on the singular value decomposition is after LaTorraca et al. (1986), Counil et al. (1986) and Yee and Paulson (1987).

While the former way requires only one non-orthogonal cordinate system for expressing both the characteristic magnetic and the linearly-transformed electric fields, in the latter way, two different orthogonalcoordinate systems are required for expressing the fields due to the principle of the singular value decomposition. The discrepancy between the systems are physically discussed.