

*Theoretical seminar*  
(22 December, 16:00 Conference Room)

Closure relations for electromagnetism

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December 22, 2011

**Abstract**

The electromagnetic response of a local and linear medium is described by a  $6 \times 6$  constitutive matrix  $\kappa$ , which includes four familiar  $3 \times 3$  blocks: the permittivity, the permeability, and the electromagnetic/magneto-electric couplings. It is often useful to demand that  $\kappa$  is invariant under the transformation  $(\mathcal{H}, \mathcal{D}) \rightarrow \zeta(E, B)$  and  $(E, B) \rightarrow -\zeta^{-1}(\mathcal{H}, \mathcal{D})$ , where  $\{\mathcal{H}, \mathcal{D}, E, B\}$  are the fundamental fields of electrodynamics. When the medium is indeed endowed with this symmetry, that is, when the medium is “electric-magnetic reciprocal”, one can show that  $\kappa$  obeys closure relation [see the book by Hehl and Obukhov (Birkhäuser, 2003)]. In the present talk, the transposed constitutive matrix  $\kappa^{\dagger}$  is introduced to construct the generalisation of the closure relation. The solutions of the generalised closure relation are derived explicitly. As a consequence, the *previously unknown* roots of the usual closure relation are obtained. The discussion is finally applied to two specific problems.