Comment on "Magneto-Optical Kerr Effect, Enhanced by the Plasma Resonance of Charge Carriers"

In a recent Letter Feil and Haas[1] present a simple model calculation for the Kerr effect metals and claim that this calculation proves that certain assignments of magneto-optical structures in *f* materials[2-4] are not warranted. In this Comment we will show that both the model and the conclusions are incorrect.

Feil and Haas (FH) consider the equation for the complex Kerr effect

$$\tilde{\phi}_K = \phi_K + i\epsilon_K = \tilde{\epsilon}_{xy}/\tilde{\epsilon}_{xx}^{1/2}(1-\tilde{\epsilon}_{xx}), \tag{1}$$

where $\tilde{\epsilon}_{xj} = \epsilon_{1xj} - i\epsilon_{2xj}$ with $j = x$ or y. Using for $\tilde{\epsilon}_{xx}$ the sum of a Drude and a Lorentz term and setting $\tilde{\sigma}_{xy} = \omega \times \tilde{\epsilon}_{xy}/4\pi i = \text{const}$, FH conclude that "a large resonance-like enhancement of ϕ_K and ϵ_K is expected in the frequency range where $\epsilon_{1xx} = 1$." This conclusion is incorrect as one can easily show by performing the same calculation as FH, but with different parameters. If we take, for example, $\hbar\omega_p = 7$ eV and $\hbar/\tau = 1$ eV for the Drude term and $\hbar\omega_1 = 3$ eV, $\hbar/\tau_1 = 3$ eV, and $\hbar^2 A_1 = 140$ eV^2 for the Lorentz term, no resonance occurs in the Kerr effect, although $\epsilon_{1xx} = 1$ near 1.6 eV. Equation (1) is not suited for the discussion of the Kerr effect because of its complex denominator. Removing the complex denominator leads to

$$\tilde{\phi}_K = \frac{(A\epsilon_{2xy} - B\epsilon_1 xy) + i(A\epsilon_{1xy} + B\epsilon_{2xy})}{A^2 + B^2}$$

with $A = 2n^2k + (n^2 - k^2 - 1)k$ and $B = (n^2 - k^2 - 1) - 2nk^2$. One now recognizes that $\epsilon_{1xx} = n^2 - k^2 = 1$ is neither a necessary nor a sufficient condition to produce a peak in ϕ_K or ϵ_K, but that A and B should be small to enhance $\tilde{\phi}_K$.

Besides this basic error in the discussion of Eq. (1) we note that the model of FH is also by itself unphysical. The assumption of frequency-independent and equal real and imaginary parts of $\tilde{\sigma}_{xy}$ $(=1+i)$ is incompatible with the Kramers-Kronig relation. A constant σ_{1xy} leads to $\sigma_{2xy} = 0$. In addition, because $\tilde{\sigma}_{xx}$ and $\tilde{\sigma}_{xy}$ rely on the same optical transitions, these functions of ω are interdependent. The assumption of a Drude and Lorentz term for $\tilde{\sigma}_{xx}$ but a constant $\tilde{\sigma}_{xy}$ violates the self-consistency requirement.

In the second half of their Letter Feil and Haas question our assignments of $f \rightarrow d$ transitions in CeSb[2] and uranium monochalcogenides[3] and of intraband transitions in TmS and TmSe.[4] In particular, FH claim that in CeSb ϕ_K peaks for $\epsilon_{1xx} = 1$. This is incorrect. $\epsilon_{1xx} = 11$ at $\hbar\omega = 0.5$ eV where we observe 14° Kerr rotation. The determination of an $F \rightarrow d$ transition energy of 0.4 eV in this compound is based on the occurrence of peaks in σ_{1xx} and σ_{1xy} at this energy and not on the basis of any peak in ϕ_K or ϵ_K.

FH also suggest that uranium chalcogenides have a steep plasma edge which might enhance the Kerr signal. This is again incorrect. In US, for example, $\epsilon_{2xx}(\omega)$ always exceeds 3.5.[5] ϕ_K does not peak at the energy of the maximum in the energy-loss function at 4.25 eV. The $f \rightarrow d$ transition is assigned to a strong negative peak in σ_{1xy} at 1 eV.

Only TmS and TmSe display a steep plasma edge and we have been the first[5] to show that this steep plasma edge gives rise to a strong resonance-shaped magneto-optical effect. As evidenced by σ_{1xx} and photoemission no $f \rightarrow d$ interband transition is expected in the neighborhood of this plasma edge and could thus possibly interact with magnetic-optically inactive intraband transitions as FH like to suggest.

We summarize: The model of FH is incorrect from first principles and $\epsilon_{1xx} = 1$ is not equivalent to a resonance peak in ϕ_K or ϵ_K. We emphasize that assignments to electronic transitions can be and have been made by us only on the basis of $\tilde{\epsilon}_{xy}(\omega)$ or $\sigma_{xy}(\omega)$ spectra and not on $\tilde{\phi}_K(\omega)$. To make such assignments even more reliable, comparison to $\tilde{\epsilon}_{xx}(\omega)$ or $\tilde{\sigma}_{xx}(\omega)$ spectra has always been made.

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Received 20 February 1987
PACS numbers: 78.20.Ls, 71.45.Gm

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