Electric-magneto-optical Kerr effect in a hybrid organic-inorganic perovskite

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Abstract

Hybrid organic-inorganic compounds attract a lot of interest for their flexible structures and multifunctional properties. For example, they can have coexisting magnetism and ferroelectricity whose coupling gives rise to magnetoelectricity. Here we show that, in a perovskite metal-organic framework (MOF), the magnetic and electric orders are further coupled to optical excitations, leading to an electric tuning of the Magneto-Optical Kerr effect (MOKE). Moreover, the Kerr angle can be switched by reversal of both ferroelectric and magnetic polarization only. The interplay between the Kerr angle and the organic-inorganic components of MOFs offers surprising unprecedented tools for engineering the Kerr effect in complex compounds.

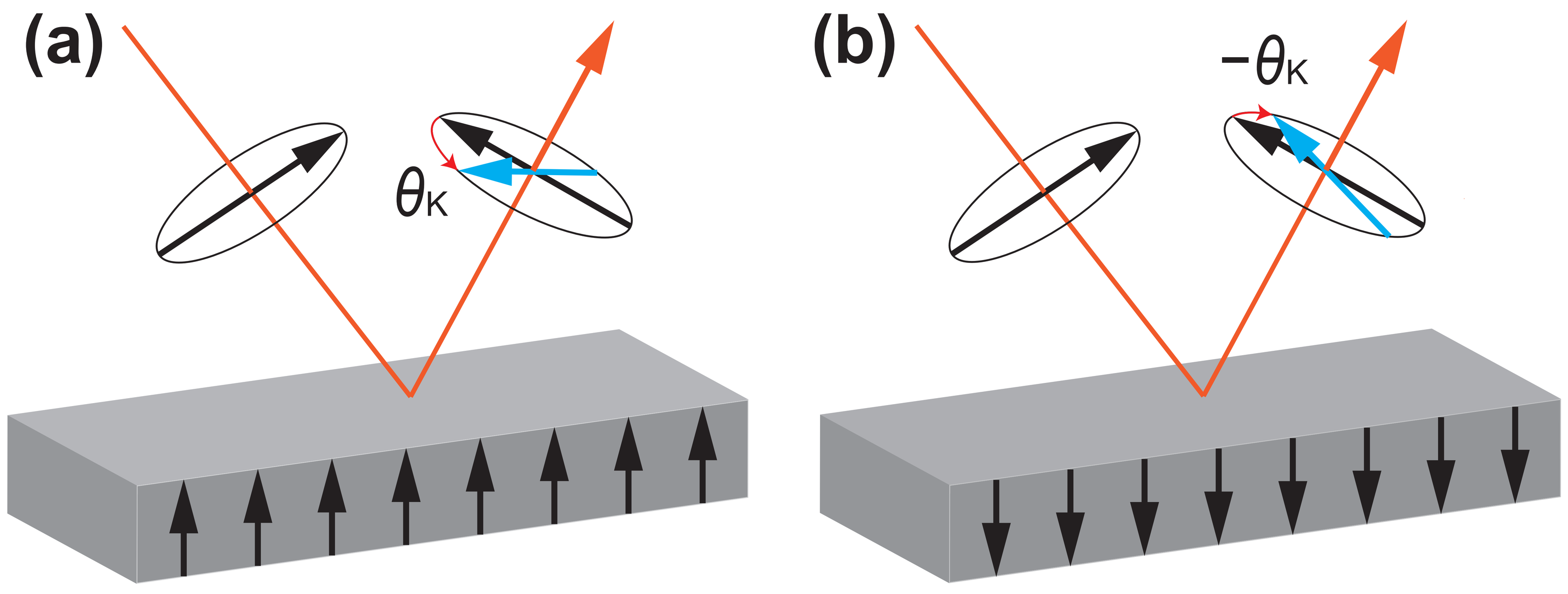

Figure 1: Schematic diagram of the Kerr effect and its switching upon reversal of the magnetization in a ferromagnetic(FM) sample. Very often, a FM material is metallic and thus has no electric polarization. Therefore, an electric tuning of MOKE has long been overlooked.

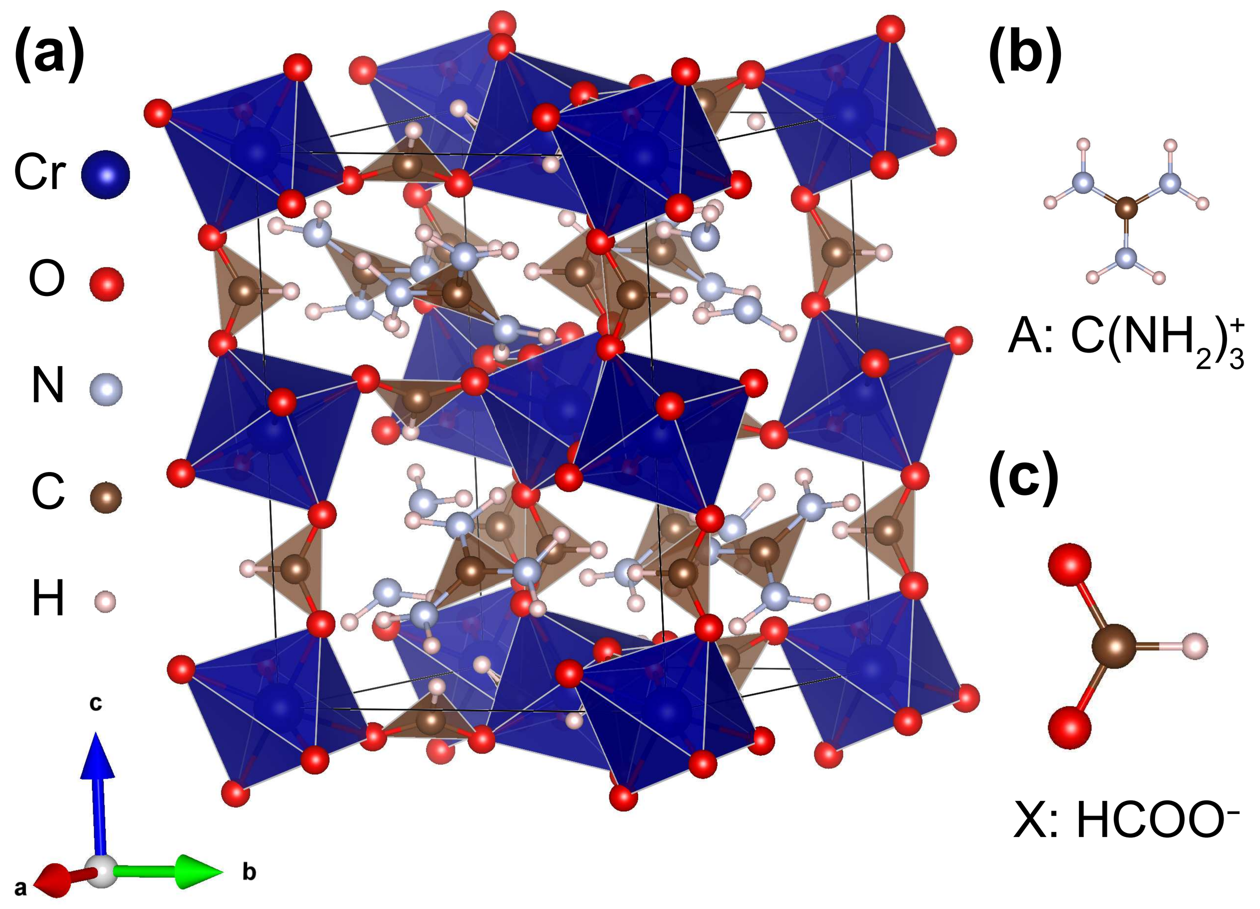

Figure 2: Crystal structure of $[C(NH_2)_3]Cr[(HCOO)_3]$, *i.e.*, a perovskite ABX_3-type Cr-MOF, blue octahedrons are CrO_6 units. It is a multiferric material, and the cross coupling between electric polarization and magnetism enables an electric tuning of MOKE.

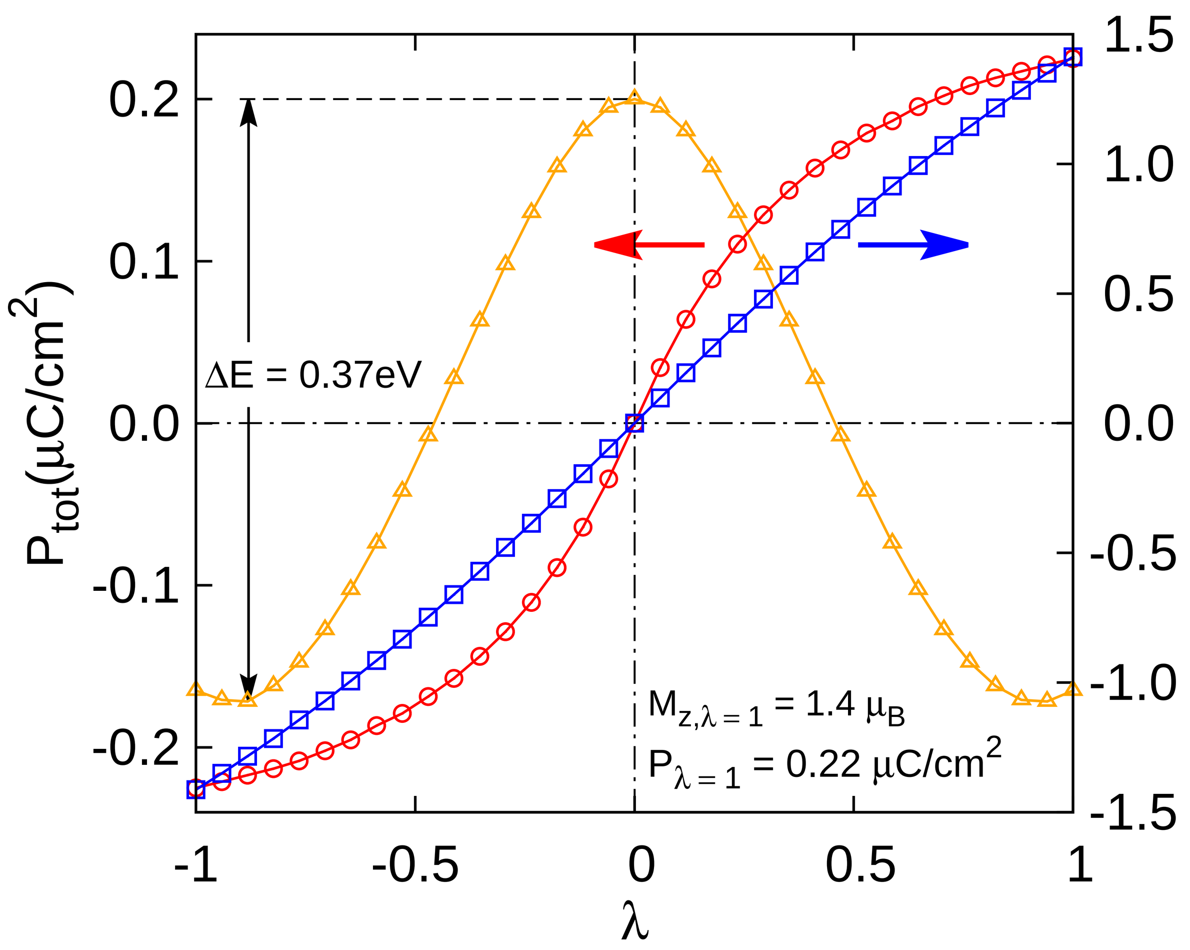

Figure 3: Variation of the total energy (orange triangles), the ferroelectric polarization P (red circles) and magnetism M_z component (blue squares) as a function of normalized amplitude of the polar distortion λ. There is a one-to-one correspondence say λ-P-M_z.

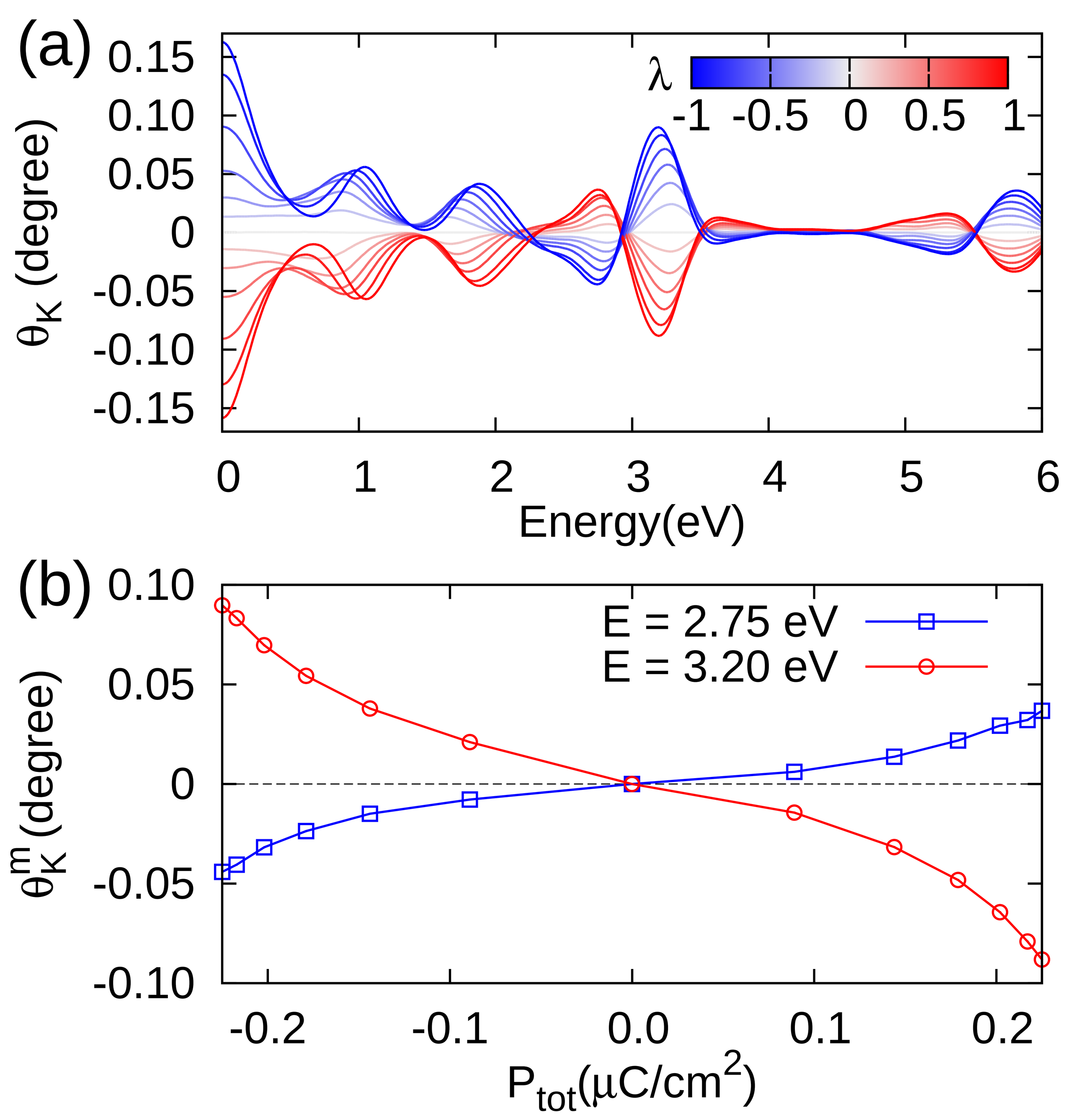

Figure 4: (a) Variation of the Kerr rotation as a function of the incident photon energy at different values. (b) Some maxima and minimum are shown as a function of ferroelectric polarization. The sign of the Kerr rotation can be switched by the ferroelectric polarization via an external electric field.

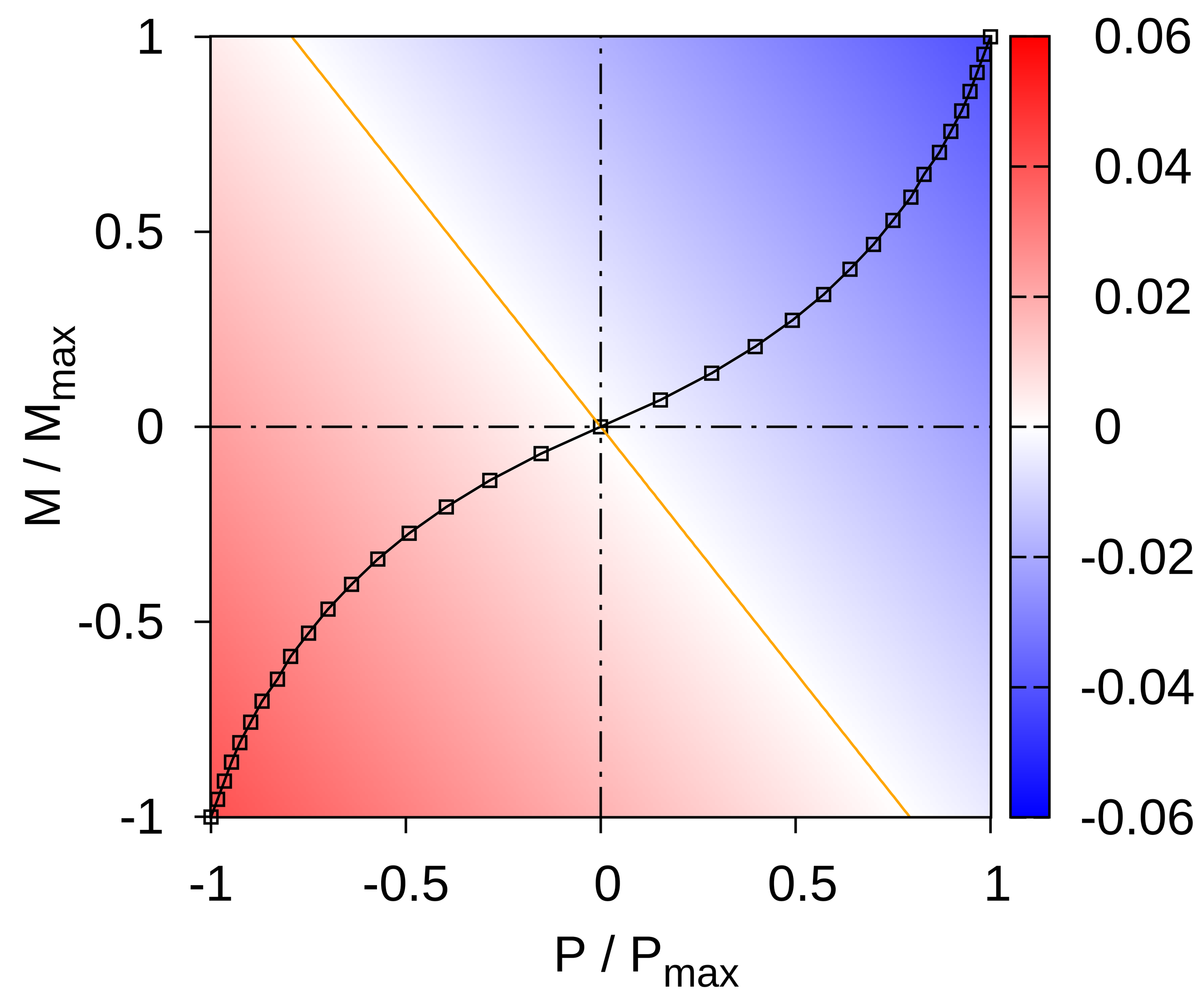

Figure 5: Kerr rotation as a function of both the normalized P and M at E = 3.82 eV. The solid orange line represents the locus of points in the (P, M) space having zero Kerr angle. The solid black curve is the magnetoelectric curve, showing an cooperative electric-magneto-optical Kerr effect(EMOKE).

Conclusions

- The Kerr angle in Cr-MOF can be swtiched by external electric field;
- Only when both electric and magnetic polarizations are reversed, can the Kerr angle be reversed;
- A ferroelectric antiferromagnetic may be useful for data storage with electric writing and optical reading.