Adaptive Optics on Dielectric Gels

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Introduction:
Adaptive Optics is common sense, since many people use digital cameras with electromechanical iris actors on elastic autofocus lenses.
This project tries to create a Comsol Multiphysics based mathematical model of adaptive optics with electrostatically induced deformation of dielectric gels. Upper and lower sides of a lens (dielectric conductive gel) are coated by transparent conductive films, i.e. TCO (transparent conductive oxides). These "film electrodes" could have any shape, like concentric rings or an array of hexagonal patches, and controlled by microcontrollers. So different electrical charges can be placed on the surface, inducing arbitrary electric homogeneous or heterogeneous fields in the gel. The electric fields cause deformations in the lens, while any aspherical optics are imaginable.

Computational Methods:
The Comsol Model couples electrostatic fields with elastic structure mechanics on elastic materials. Here we used a rotation-symmetric plano-convex lens (Figure 1) as primary shape. The film electrodes can be considered as concentric rings, while voltage and surface charge only depend on the radius of the lens. Example electric potential with deformation of this lens (i.e. Figure 4) and deformation of this lens, caused by an electric field (Figure 2) depending on radius of the lens.

$$\left.\begin{array}{l} E = -\nabla V \\ -\nabla(\varepsilon_0\, \varepsilon_r E) = \rho \end{array}\right\}$$ **electrostatic field**

$$\nabla S + F_V = 0$$ **structural mechanics, elastic material**

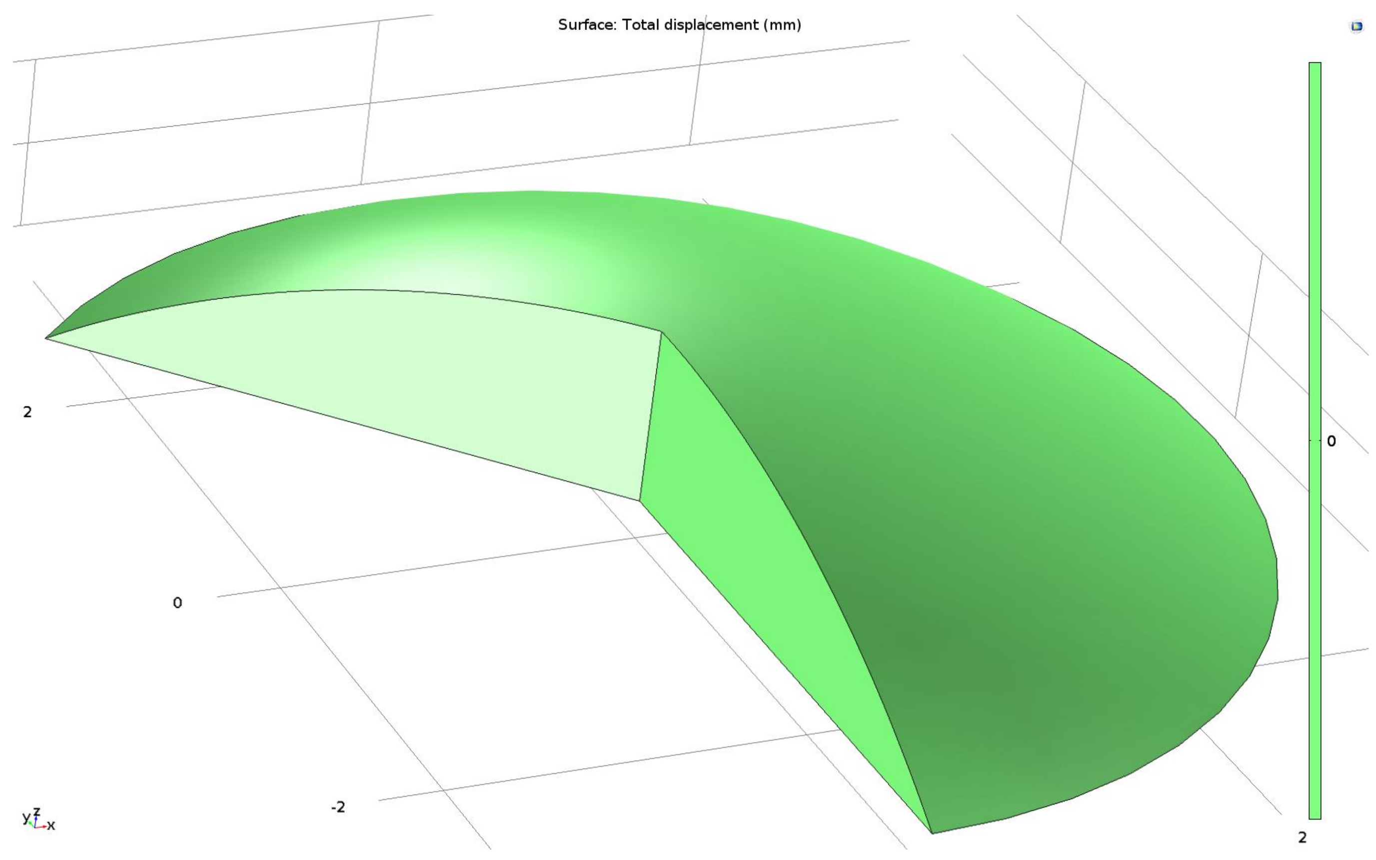

Figure 1. Primary shape of the dielectric lens

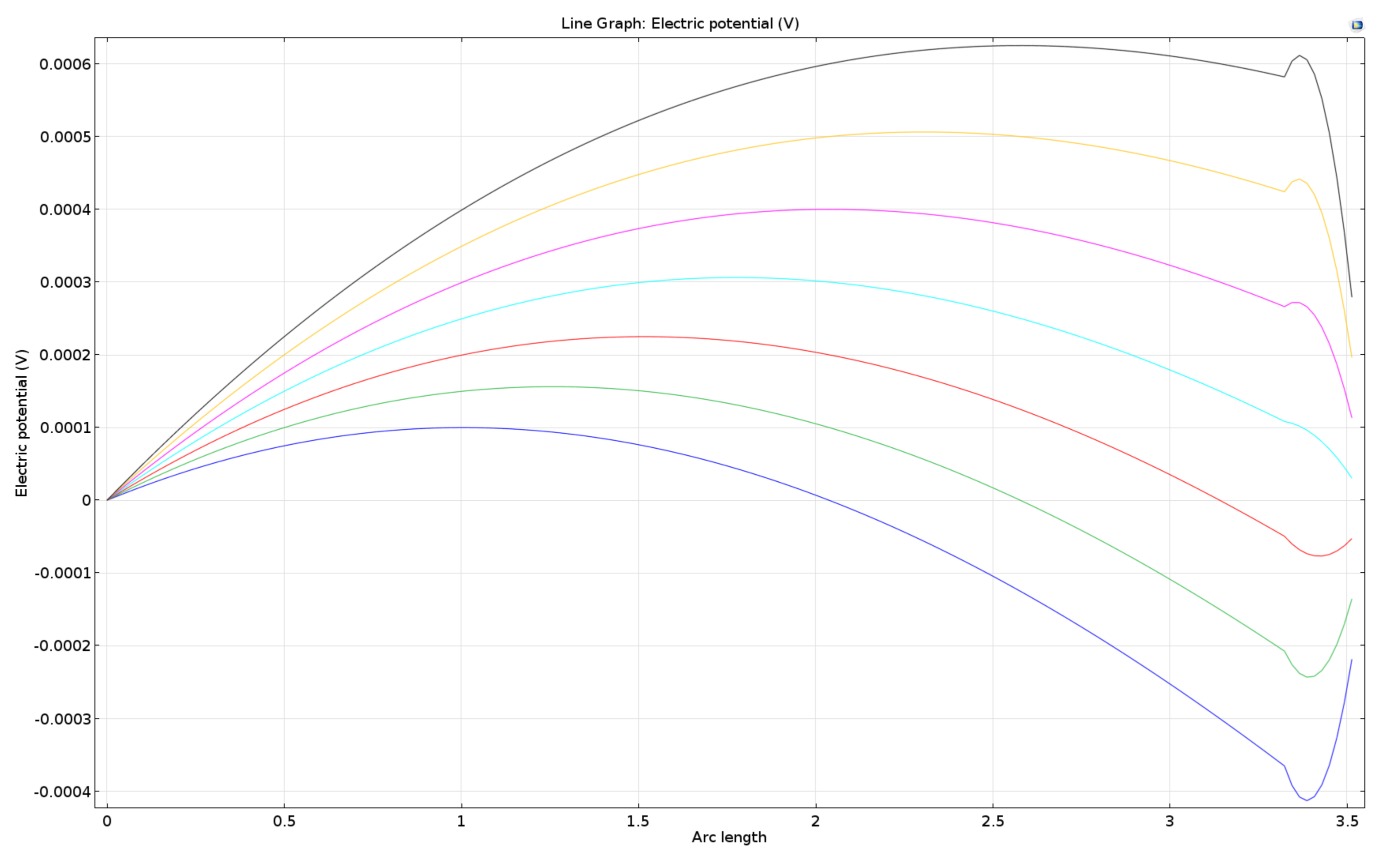

Figure 2. Maxima of the electric potentials depending on radius

Results:

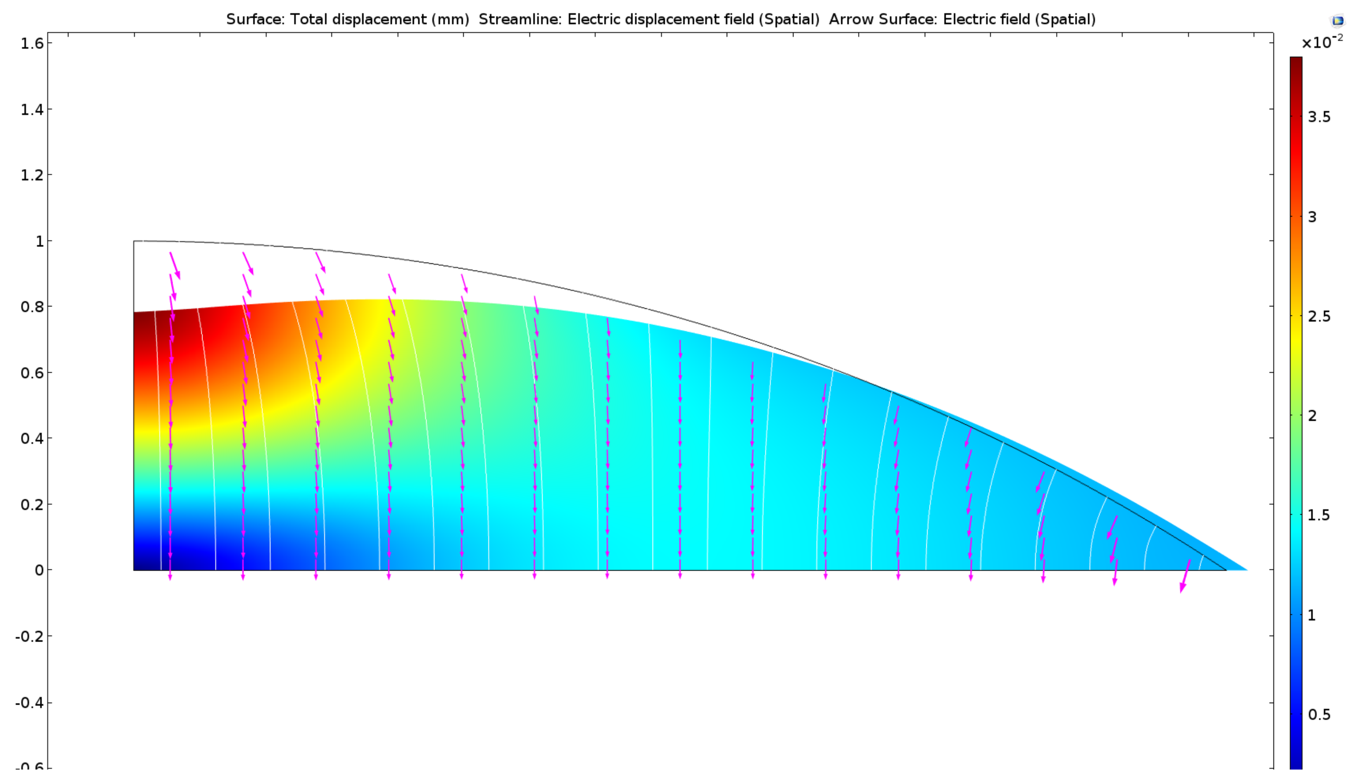

Figure 3. Deformation and electrical displacement, sectional view

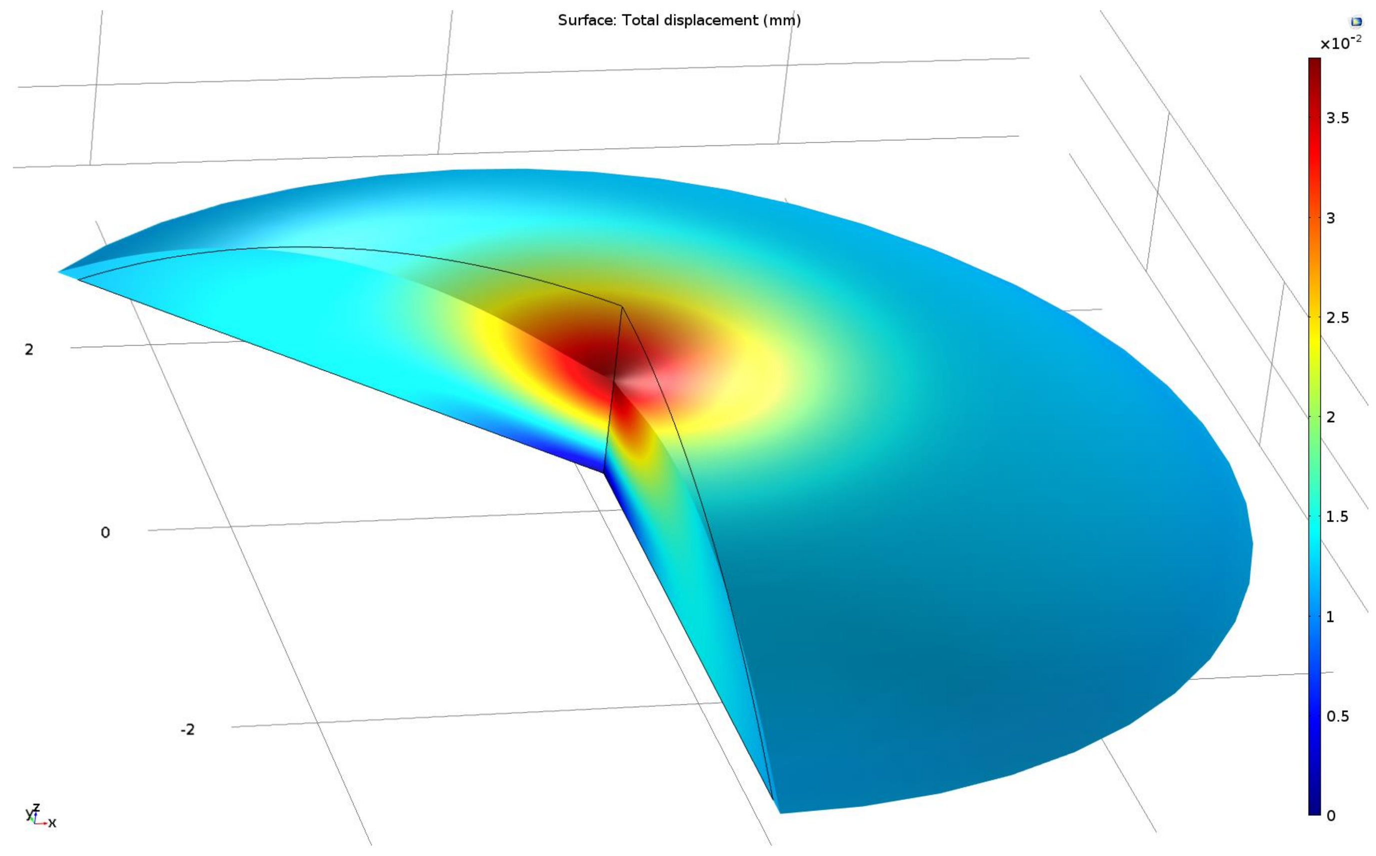

Figure 4. Maximum of electrical field in center of the lens

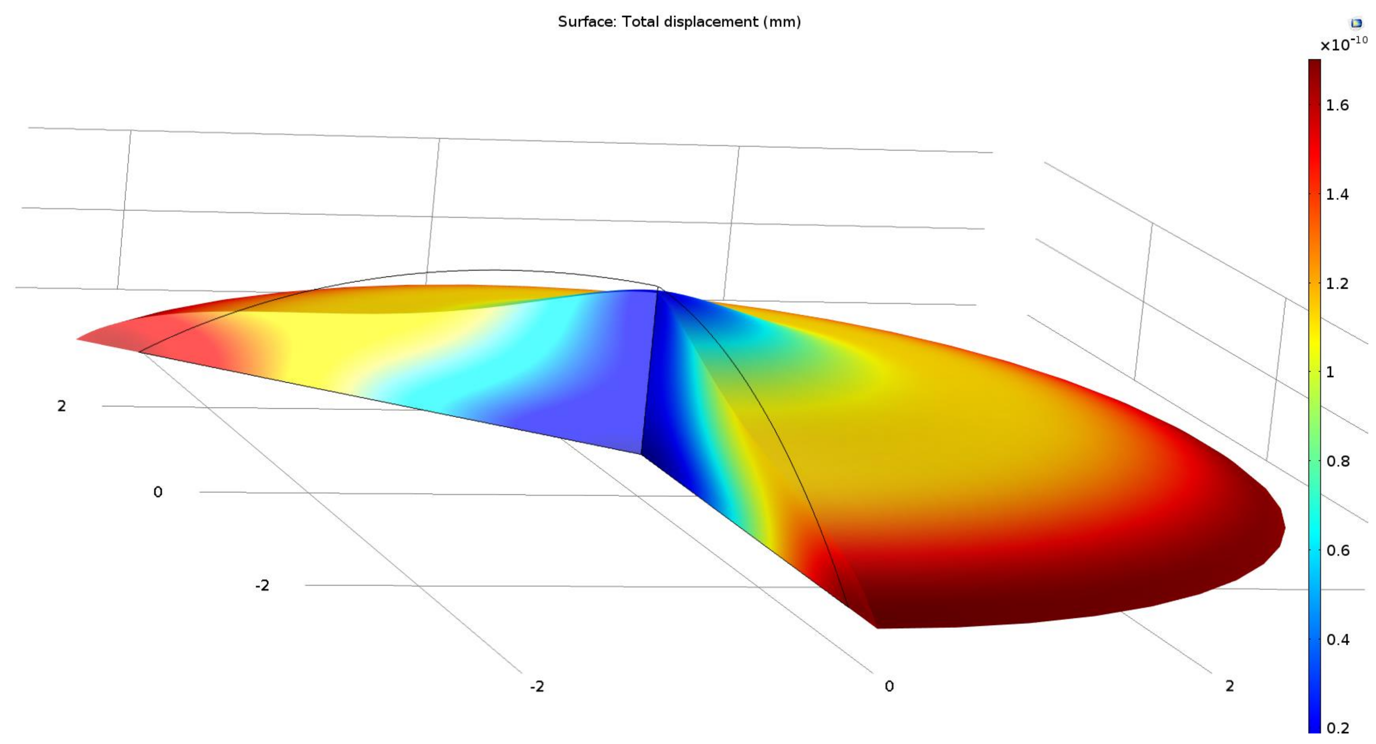

Figure 5. Maximum of electrical field in periphery of the lens

Conclusions:
Comsol Multiphysics is a convenient tool modeling this kind of coupled physics. This approach also can be used for design of adaptive reflectors, i.e. for telescopes or spotlight illumination.

References:

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