

**Problem 1. Functional Perovskite materials.**

Describe functional elements of the Perovskite crystal unit cell and explain how it allows multiple electronic phases in the same material.

**Problem 2. Two-dimensional electron system at the  $\text{LaAlO}_3\text{-SrTiO}_3$  interface.**

What is the main difference between 2-dimensional electron gases at oxide interface  $\text{LaAlO}_3/\text{SrTiO}_3$  and semiconducting  $\text{GaAs}/\text{AlGaAs}$  heterointerface?

**Problem 3. Magnetoelectric effect in multiferroic materials**

Magneto-electric effect is as a dependence of ferroelectric (ferromagnetic) polarization on the applied magnetic (electric) field. Give at least two reasons why there are so few multi-ferroic materials exist in nature that also show a significant magnetoelectric effect. How the effect can be enhanced on a nanoscale?