# High-Intensity / Relativistic Optics

**Problem set 5—Self-focusing effects in a plasma**

1. **Exercise:** A plasma comprising free electrons of density $n_{\mathrm{e},0}$ exhibits different interactions with a laser pulse propagating through it. Discuss in a qualitative way how ponderomotive self-focusing as well as relativistic self-focusing occur. How do ionization effects influence the propagation of the laser pulse?

2. **Exercise:** Taking into account the natural diffraction of a focused laser pulse which might be compensated by the relativistic self-focusing effect discussed in the 1. Exercise, it becomes important to know whether any intensity or power threshold exists for the occurrence of self-guiding of the laser pulse.

   - Describe the wavefront tilt inside the plasma due to the influence of $\langle\gamma(\boldsymbol{r})\rangle$ on the index of refraction $\eta(\boldsymbol{r})$. Assuming that the energy transport of the pulse is given by the group velocity one again finds a description of the wavefront tilt. After expressing $\langle\gamma(\boldsymbol{r})\rangle$ as a function of the intensity $I_{\mathrm{L}}$ or the vector potential $a_0$ the curvature induced by relativistic self-focusing is found.
   - The curvature due to natural diffraction of the beam follows a focused Gaussian beam with a beam waist $w(x) = w_0(1 + x/x_{\mathrm{R}})^{1/2}$.

   Only small scale changes must be considered.