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Multi-conjugated adaptive optics for intense femtosecond lasers

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Abstract content
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Many developments since the early 90's have been done on intense laser sources, in order to increase the peak power. Significant progresses were also made to obtain higher and higher average powers. Developments are still on progress especially for systems such as the ILE-Apollon program in France. The various pillars of European ELI programs in the Czech Republic, Romania and Hungary are under construction and target peak power of 10 PW with pulse durations of 15 fs and energy of 150 joules. These lasers are at the state of the art, but many other less powerful systems are now under construction by the institutions themselves or purchased from companies that are Amplitude Technologies and Thales for example. A common requirement to all these systems is to reach highest intensity in the plane of interaction, with applications both on civilian and military side.

To meet these requirements, these intense laser sources require optical components of high quality (reflectivity, flatness and damage threshold) and also of large dimension. Nevertheless despite of these efforts, the intensity on target is degraded by wavefront distortions and energy distribution modifications. This leads to a decreased intensity which is detrimental for the experiment.

Since 2000; efforts have been done by use of one adaptive optic (deformable mirror or DM) and thus correction of the wavefront. This has lead to improve the focused intensity by 30 to 40 %. For achieving this result, the DM shape is derived from the wavefront measurement obtained in the mid-field. This measurement does not take into account the propagation of the beam after the DM and especially the aberrations of the focusing system.

A collaborative French program, ILOOP, between LOA, ONERA and REOSC is aiming to measure the wavefront in the experimental plane and to improve the intensity at focus by the use of more than one adaptive optic in order to shape the energy distribution and the wavefront.

The talk will present the design of the wavefront sensor and first measurement obtained with it. An analysis as a function of the wavelength will also be presented. This point is very important for the femtosecond lasers as the spectrum is lying over 200 nm of spectral bandwidth.

The design of the multi-conjugate loop will be detailed as well as its implementation in a femtosecond laser chain.

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