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A nugget from FOCUS:

HERCULES laser contrast reaches eleven orders of magnitude

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The HERCULES laser has recently reached record intensities, as high as 10^{22} W/cm^2 [1]. Such ultrahigh intensities create exciting opportunities for experiments in the ultra-relativistic and radiation dominated [2] regime of laser-matter interactions. Laser contrast, defined as the ratio of the peak intensity of the pulse to the prepulse intensity, must be at least 11 orders of magnitude to restrict destructive preplasma dynamics. This estimate is valid for transparent targets with a high damage threshold (fused silica for example) - otherwise higher contrast is required. If the contrast is smaller, a preplasma is created before the main pulse by pre-pulses, thus significantly complicating the experiments and interpretation of the results. In order to reach ultrahigh intensities, sharp focusing is required [1]. However, beam break-up into multiple filaments in an expanding pre-plasma may preclude achieving the necessary intensity on a target.
In order to make experiments at 10^{22} W/cm^2 possible, we have improved the HERCULES contrast dramatically from 10^8 to10^{11}. This result is based on two major developments. First, the contrast without a pulse cleaner is relatively high (10^8 comparing to common values of 10^6–10^7) due to the use of a long cavity-ring-resonator regenerative amplifier that was developed [3] for HERCULES. This contrast level is achieved with nano-joule pulses injected into the resonator. Injecting a clean pulse (contrast ~10^{11}) of micro-joule, instead of nano-joule of energy, allows for the pump fluence to be lowered to achieve the same output energy. This results in a concomitant decrease of ASE generation. We developed and implemented a simple cleaner based on direct amplification to micro-joule energy and on a modified XPWmethod [4]. The contrast was directly measured to be at least 10^{11} (limited by the autocorrelator sensitivity) with the third order autocorrelator. To our knowledge HERCULES is currently the highest-contrast multi-terawatt laser system.

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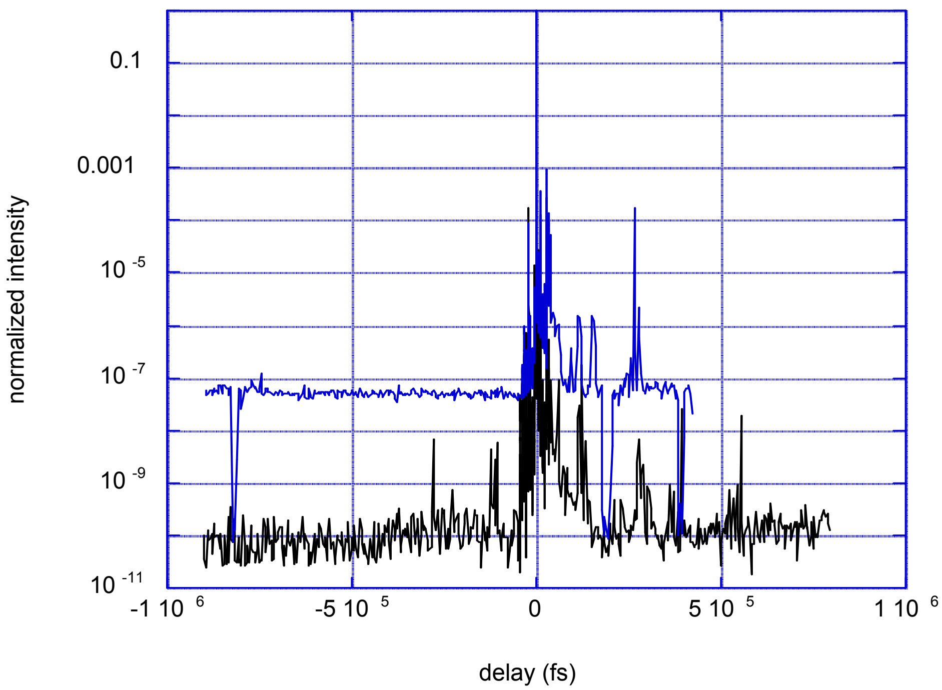
[2]. A. Zhidkov, J. Koga, A. Sasaki, and M. Uesaka, Phys. Rev. Lett. **88**, 185002 (2002) .

[3]. V. Yanovsky, C. Felix, G. Mourou, IEEE J. Select. Topics Quant. Electr. **7**, 539 (2001)

[4]. A. Jullien, F. Auge-Rochereau, G. Cheriaux, J. P. Chambaret, P. d'Oliveira, T. Augusta, and F. Falcoz, Opt. Lett. **29**, 2184 (2004)



Third-order autocorrelation with (black) and without (blue) cleaner. In order to get a contrast value, the intensity from the third-order autocorrelation has to be divided by 4- a ratio of the temporal resolution of the autocorrelator to the pulsewidth. The signal without cleaner, at about –800ps, was intentionally blocked to check the noise level. The signal with cleaner between 900ps and 50 ps is photomultiplier noise and does not change when the light is blocked. The short pulses in the lower curve, before the main pulse (between -300ps and -100 ps) are artifacts of the detection system