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Spectra of 2ω and 3ω/2 harmonics generated in 30 fs laser-foil interaction

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The interaction of powerful ultrashort laser pulses with thin plastic foils have been investigated experimentally. 30 femtosecond, 0.8 µm wavelength pulses, delivered by the LOA-Palaiseau laser system, were focused on plastic foil targets of 0.1 or 1.0 µm thickness at intensities up to 5 10^{18} W/cm^2. In a first experiment, where anomalous transparency has been observed [D.Giulietti et al., Phys.Rev.Lett. **79**, 3194 (1997)], the spectra of the transmitted light were found to be generally blueshifted, the amount of shift depending on the pulse intensity. The correlation between the spectral features of the transmitted light and the rapid ionisation occurring during the interaction was proved. In a second experiment the laser pulse interacted with an underdense, relatively cold plasma preformed by the ASE. Space-resolved spectra of second harmonic and three-halves harmonics were obtained an intensity on target of 10^{18} W/cm^2 in two different conditions:

1. target irradiation at an angle of 20 degrees; the light reflected specularly was analysed;

2. target irradiation at normal incidence; the light scattered at 40 degrees was analysed.

These spectra were found to be quite complex. and can provide interesting information on the propagation of femtosecond pulses in preformed plasmas.

Both 2ω and 3ω/2 emissions were much more intense in condition 1., buth spectral features were similar in the two conditions. 3ω/2 spectra are very broad and spatially well localised on the main peak of the laser spot on target. Both red and blue components are present. This latter feature is in contrast with the typical structure of common 3ω/2 spectra detected in other experimental conditions and usually explained in terms of two plasmon decay. Further investigation may give information on the $n_c/4$ layer in the preformed plasma, as "scanned" by the 30 fs (10 µm length) "probe" pulse. Also the 2ω spectra show both blue and red shift, but, surprisingly, in complementary spatial regions that are roughly modulated in space like the interference rings of the laser spot on target. While the blue shift may be attributed to self phase modulation due to further ionisation of the regions corresponding to the intensity maxima, the red shifted part of the spectrum suggests that part of the pulse could be refracted out by the regions of higher degree of ionisation to the regions of lower plasma density and penetrate deeply into the forward expanding plasma. In this case the very low level of transmission observed in the solid angle of the focused pulse may be also due to diffraction from such "filaments" produced between pairs of intensity maxima.