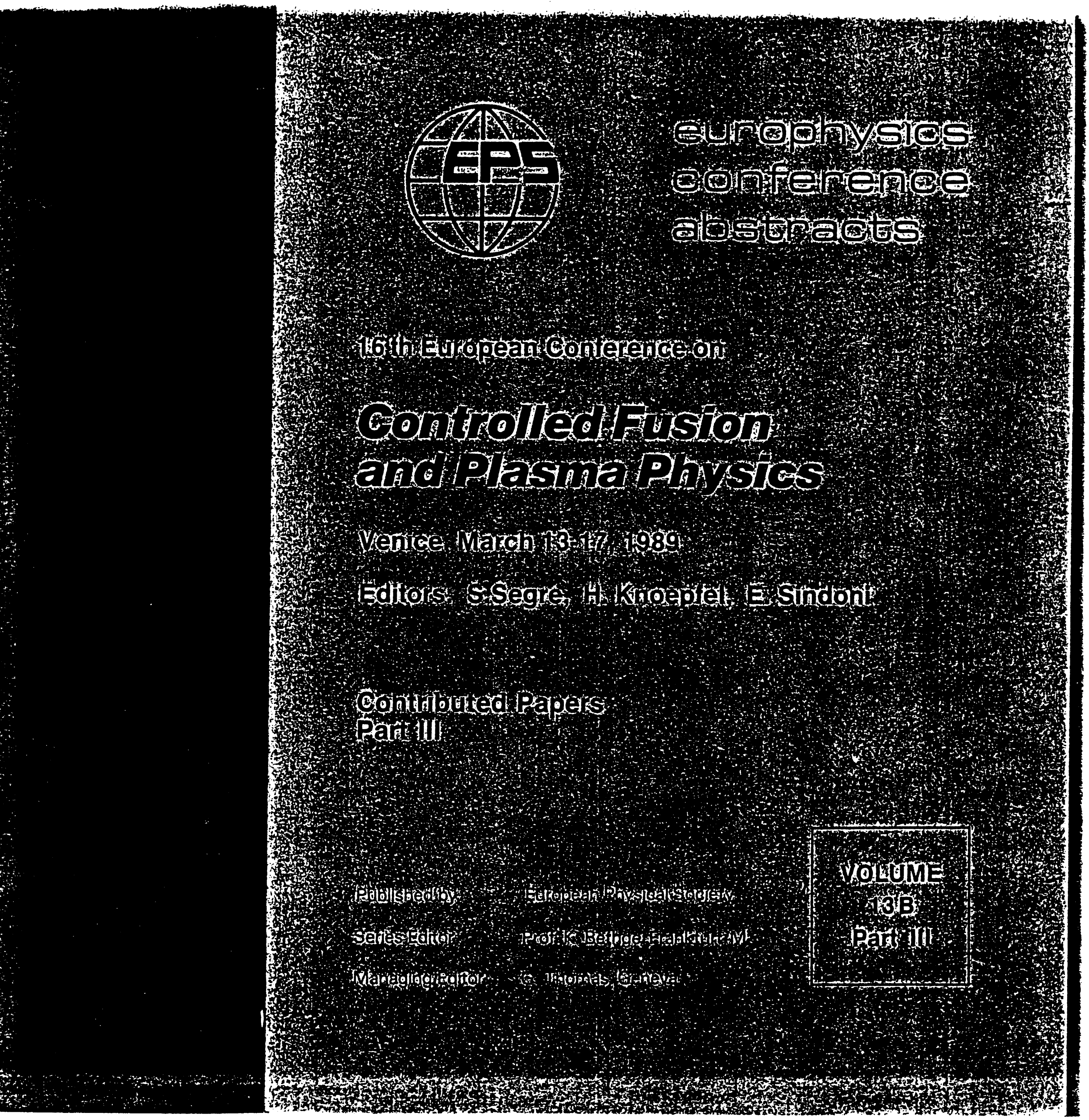

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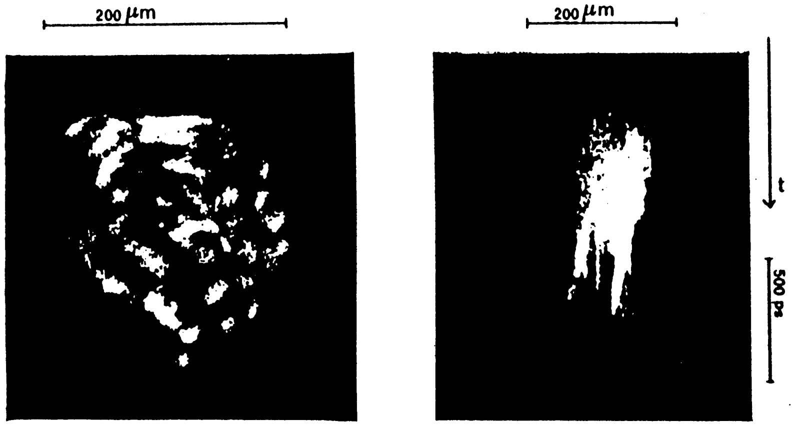

Fig.1. Pattern and evolution of the ordinary beam. Left:image of the beam pattern without target, obtained with a gated (100ps) intensifier.Irradiance 5.0 10^{14} W/cm^2. Right: beam evolution during the interaction with a pre-formed plasma from 700nm Al target. Shot# 172888.Heating-interaction delay 1.7 ns. Irrad. 7.7 10^{14} W/cm^2.

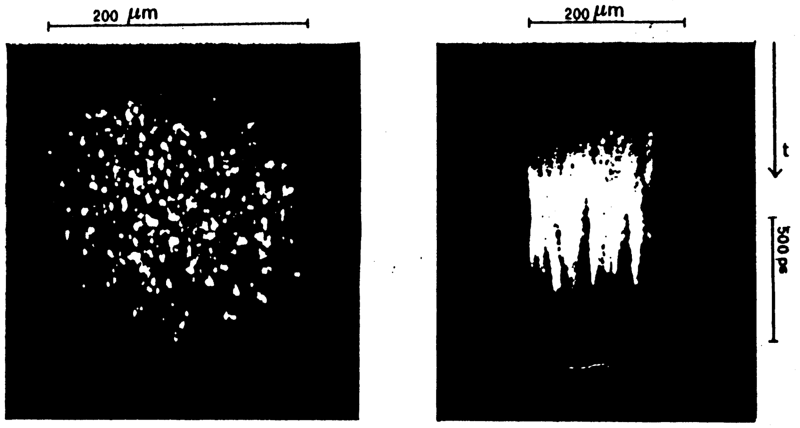

Fig. 2. Pattern and evolution of the random phased beam. Left:image from gated (100ps) intensifier. Irrad. 9.7 10^{14} W/cm^2. Right:evolution during interaction with 700nm Al target. Shot# 328788. Heating-interaction delay 1.7 ns. Irrad. 7.2 10^{14} W/cm^2.

2ω AND 3/2ω GENERATION IN LASER PRODUCED PLASMAS FROM VERY THIN PLASTIC FILMS

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The irradiation of very thin films is useful to study the laser-plasma interaction in a variety of conditions of interest for the inertial confinement fusion; these conditions can be controlled essentially through laser intensity and pulse duration, film thickness and material. In this paper we report on data from an experiment of irradiation of plastic (formvar) films 0.3 to 1.9 μm in thickness at 1.064 μm laser wavelength and 3ns FWHM pulse duration. The intensity on the target was up to 5 10^{13}W/cm^2 in a spot of 60μm in diameter. The film thickness was chosen in order to allow the plasma to become underdense during the laser pulse. In this way during the pulse, the interaction volume was extended to the whole plasma depth and several instabilities could be stimulated and studied. Of course the interaction conditions evolve in time because of the expansion of the plasma and the time-profile of the laser pulse. A first extimation of the evolution of the plasma parameters (electron temperature, density and scalelength: T, n, L) has been done using a self-similar model [1] which is in good agreement with numerical simulations.

A critical aspect of this kind of experiment is the level of pre-lasing (level of laser power before the main pulse). We have been able to achieve a pre-lasing less than 10^{-4} timesthe peak power, and the lack of any plasma formation before the main pulse have been verified shot by shot. However some shots were affected by higher pre-lasing : in these cases we found completely different behaviour. In what concerns 2ω and (3/2)ω generation, it was completely missing in case of pre-lasing because the main pulse interacted weakly with a plasma already underdense. Finally we must stress that the laser power was affected by modulations due to mode beating in the laser cavity. These modulations allowed to reach higher intesity for few tens of picoseconds, several times during the pulse.

Data on the three-halves and second harmonic emissions have been obtained at 90° to the laser beam. Both time-resolved imaging and time-resolved spectroscopy have been performed.

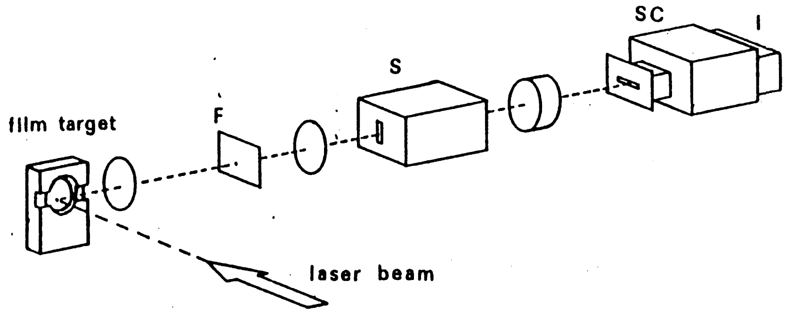

Fig. 1 Set-up for time-resolved spectroscopy at 90°.
F: filter rejecting 1.06 μm radiation; S: spectrometer; SC: streak camera; I: intensifier.

In Fig. 1 the set-up for the time-resolved spectroscopy is shown. The interaction region was imaged on the entrace slit of a spectrometer with a dispersion of 60 Å/mm. The exit plane of the spectrometer was demagnified to have both (3/2)ω and 2ω (λ=0.709 and 0.530 μm respectively) into the same streak-image. To obtain time resolved images we directely imaged the interaction region on the streak-camera slit with a magnification 10:1. A typical time-resolved spectrum is shown in Fig. 2.

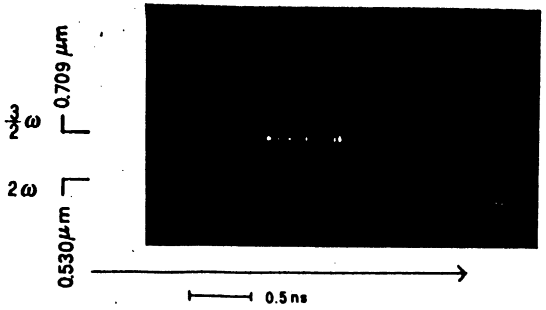

Fig. 2 Time-resolved spectrum showing both (3/2)ω and 2ω emission. Shot 061209-Laser intensity: 1.28 10^{15} W/cm^2; Formvar film thickness: 1.34 μm.

The (3/2)ω and 2ω lines are present for a time shorter than the pulse duration, and the emission shows very sharp peaks in time, following the power maxima due to the laser modulation. The (3/2)ω line originates from two-plasmon-decay instability (TPDI) in the plasma region where $n \simeq n_c/4$ [2]. The intensity threshold for TPDI, in precence of a density gradient of scalelength L at $n_c/4$, is [3] :

$$I \simeq \frac{4\ 10^{15}\ T}{\lambda_0\ L}\ (W/cm^2) \qquad (1)$$

where T is measured in KeV, λ_0 and L in μm. The threshold is exceeded for the first time when intensity and scalelength both fullfil the condition (1). If the film is thick enough, the plasma will keep a $n_c/4$ layer during the whole pulse, and (3/2)ω emission will stop when the laser intensity will drop under threshold. With thinner films, the (3/2)ω will vanish because of the plasma rarefaction below $n_c/4$. In fact we observed that the duration of the (3/2)ω emission decreased with the film thickness below 0.8 μm and no (3/2)ω emission was found with films thinner than 0.6 μm. Putting the plasma parameters given by the model in expression (1) a threshold for TPDI of the order of 10^{13} W/cm^2 is found. From this value we could expect a continuous (3/2)ω emission with targets thicker than 1 μm. On the contrary, Fig. 2 clearly shows that the threshold is exceeded only a few times for very short (tens of picoseconds) peaks. This point has to be clarified with a careful experimental study of the intensity evolution in the plasma.

Let's now consider the 2ω component of the spectrum. At early times the 2ω emission can in principle be ascribed to resonance absorption near the critical density (but 90° emission is difficult to explain). If we consider a 2ω time-resolved image, as Fig. 3, the early stage corresponds toa well localised emission close to the film position. Notice that it originates from both front and rear side, probably due to filament driven fast burn-through of the film. At later times there will be no critical layer in the plasma, and 2ω emission must be attributed to a different process. The extension of the 2ω sources in a region of the order 1 mm, perpendiculary to the film (see Fig. 3) confirms that 2ω originates from a plasma definitely underdense. A possible mechanism for 2ω generation is the sum of frequency between the laser light and the light backscattered by the plasma (stimulated Brillouin scattering) [4]. This process allows 2ω radiation at 90° due to the current

$$j_{2\omega} = (e^3/2im^2\omega^3)\ [\ \underline{E}\,\underline{E}^b + \underline{E}^b\underline{E}\ ]\cdot \underline{\nabla} n$$

where $\underline{E}^b$ is the field of the backscattered wave. In a previous experiment [5] in gas we observed 2ω emission forward but we

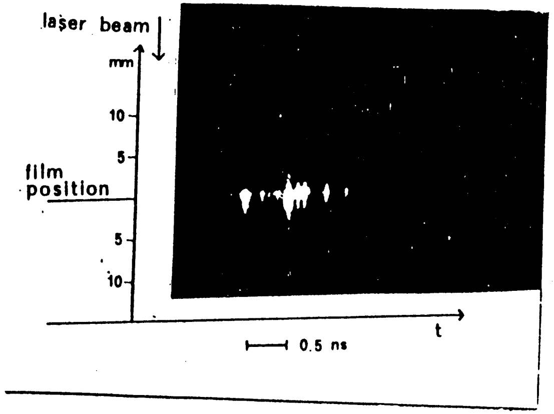

Fig. 3 Time -resolved image in 2ω light. Shot 141109- Laser intensity: 2 10^{13} W/cm^2; Formvar film thicknesss: 1.25 μm.

failed to observe 2ω at 90°.Emission was shown to mix to zero (due to destructive interference) as the detector elongated from the beam axis. The mixing effect disappears if a backscattered or reflected radiation contributes to the 2ω emission [4], this being a clear difference between experiments in gases and on solid targets. However, the formation of density gradients orthogonal to the beam axis remains a necessary requirement for 90° 2ω emission. According to [4] we can ascribe this to self-focusing which therefore remains a typical hallmark for 2ω emission.

Time-resolved spectroscopy of the two lines with higher resolution is in progress. It can give information on plasma temperature and its evolution as well as on some hydrodynamic parameters. The role played by filamentation in the interaction process have also to be clarified.

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References

[1] R.A. London and M.D. Rosen, Phys. Fluids, 29, 3813 (1986)
[2] S.J. Karttunen, Las. Part. Beams, 3, 157 (1985)
[3] W.L. Kruer in "Laser-Plasma Interaction" vol. 3 Ed. by M.B. Hooper (SUSSP Publications, Edimburg) pag 79 (1986)
[4] J.A. stamper, R.H. Lehmberg, A. Schmitt, M.J. Young, J.H. Gardner and S.P. Obenschain, Phys. Fluids, 28, 2563 (1985)
[5] D.Giulietti, G.P.Banfi, I.Deha, A.Giulietti, M.Lucchesi, L.Nocera,Z.Z.Chen, Las. Part. Beams, 6, 141 (1988)