Ultraintense ultrashort laser - plasma interaction

P. Mulser, TQE: Theoretical Quantum Electronics, Tech. Univ. Darmstadt, Germany

1st Lecture

Some of the most prominent features of laser beam-plasma interactions from 1D, 2D and 3D Vlasov and PIC simulations are introduced, like fast electron generation and the formation of filaments in overdense matter. Laser light absorption in the intensity regime from to W is noncollisional. Starting from considerations on the compulsory phase shift between laser field and induced current the main proposals on absorption from the literature are presented. Owing to its significance Brunel's model is analyzed in detail and its pros and cons are discussed with the aid of concomitant 1D PIC simulations. Surprising enough, at the relativistic threshold a non-Maxwellian structure in Brunel's universal fast electron spectrum is confirmed in PIC simulations.

2nd Lecture

The fully developed absorption dynamics is characterized by quasi oscillatory motions of the electrons in the weak field region of the skin layer and their stochastic diffusion into the target interior. They represent the non-Maxwellian low energy bulk of the spectrum. The residual fraction of highly relativistic Maxwellian electrons is shown to be generated by anharmonic resonance at the vacuum-plasma interface and in the skin layer. The fundmentally different behavior of an anharmonic, highly nonlinear oscillator in comparison to harmonic motion, in particular the existence of an attractor and its absence in harmonic motion, is elucidated by model calculations. The fast electrons emit Cherenkov radiation of plasmons in the target interior thereby heavily perturbing the smooth return current. In 1D collisionless absorption and energetic electron production decrease with growing intensity, reach a minimum at 3 – 5 times W and then increase rapidly again. The partition of absorbed energy between slow and fast electrons, ions and plasmons is presented, te significance of scaling laws is discussed.