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Short-pulse laser cluster interaction: unification of resonances

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In the conventional scenario of laser-driven nano-clusters, a pronounced maximum absorption of laser light is widely expected during the linear resonance (LR) when Mie-plasma wavelength λ_M of electrons equals the laser wavelength λ. On the contrary, by performing molecular dynamics (MD) simulations of an argon cluster irradiated by short 5-fs (fwhm) laser pulses it is found that, for a given laser pulse energy and a cluster, at each laser intensity there is a λ – shifted from the expected λ_M – that corresponds to a unified dynamical LR at which evolution of the cluster happens through very effective unification of possible resonances in various stages, including (i) the LR in the initial time of plasma creation, (ii) the LR in the Coulomb expanding phase in the later time and (iii) anharmonic resonance (AHR) in the marginally over-dense regime. This unification of resonances (LR and AHR) leads to maximum laser absorption accompanied by maximum removal of electrons from cluster and also maximum average charging for argon cluster. With increasing laser intensity, the absorption maximum is found to systematically redshift (see Fig. 2) to a higher wavelength in the band of $\lambda \approx (1-1.5)\lambda_M$ than permanently staying (vertical dashed line in Fig. 2) at the expected λ_M. This study may find importance for guiding an optimal condition laser-cluster interaction experiment in the short pulse regime where maximum energy is required to transfer from laser to charge particles.

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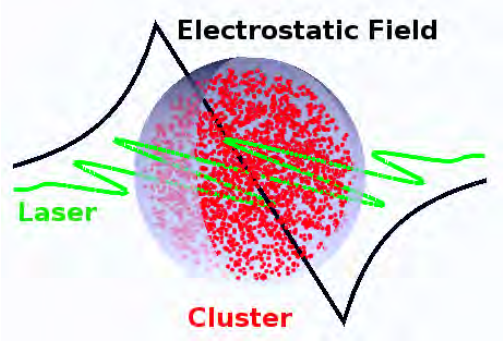

Figure 1: Schematic of laser interaction with a solid density spherical nano-plasma, e.g., argon cluster.

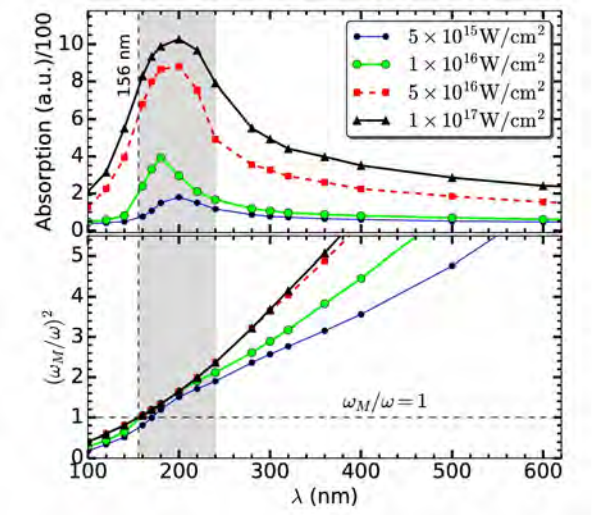

Figure 2: Laser absorption in an argon cluster versus laser-wavelength at different laser intensity. Absorption maxima (top panel) is found to be shifted from the expected 156 nm in the marginally over-dense band of wavelength where Mie-plasma frequency is (1-1.5) times the laser frequency (bottom panel) [see Ref. 5].

References

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