Laser plasma acceleration of electrons: towards the generation of high quality, monoenergetic, relativistic beams

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The results of laser plasma electron acceleration experiments are discussed for a wide range of conditions. Using the VULCAN PetaWatt laser at an intensity of $3x10^{20}$ W/cm^2, energetic electrons have been observed to be accelerated up to 350 MeV with a broad energy distribution. The acceleration mechanism is unlikely to be due to relativistic plasma waves because of the low sideband emission observed in the transmitted laser spectrum. Rather these electrons result from a direct laser acceleration process. These experiments are compared to lower intensity interactions in which the mechanism is clearly that of Self-Modulated Laser Wakefield Acceleration (SMLWA). For interactions using much shorter pulses (40 fs) and lower intensities, it is shown that the interaction becomes fundamentally different and that mono-energetic electron beams can be produced from the breaking of large amplitude plasma waves.