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The interaction of multi-petawatt femtoseconds laser with nanowire target

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The interactions of petawatt ultra-intense lasers with solid targets, specifically the nanowires received a lot of attention because they appear to show the potential to increase the laser light absorption. Laser-nanowire interactions open up various applications such as attosecond bunch generation, enhanced x-ray generation, gamma-ray yield, as well as efficient micro fusion. Despite many studies on this topic, either numerically or experimentally, the electron dynamics under the action of a strong laser field across the nanowire has not yet been fully explored. We discuss the interaction of nanowire with laser pulse in the multi-petawatt laser system, with pulse duration ranging from the nanosecond pre-pulse region to the femtosecond main pulse.

We found that an array of aligned nanowires is imploded when irradiated by an Amplified Spontaneous Emission pedestal of a 1 PW laser with a contrast ratio of 10^{11} [1]. We demonstrate by using radiation hydrodynamics simulations that the electron density profile is radially compressed at the tip by the rocket-like propulsion of the ablated plasma [Fig.1a]. The mass density compression increases up to 2.9× when a denser nanowire array is used.

During the interaction with the femtosecond main pulse, we discuss our observation of the electron transport inside the nanowire [2]. We found that a plasma wakefield is excited by the double-frequency electron bunches [Fig. 1b]. This wake field has an amplitude of the order of TV/m, oscillating at the plasma frequency, and propagates into the nanowire. This strong wakefield also ionizes the atom at the core of the wire, which is opaque to the laser field [3] [Fig 1c]. We also observed that the expanded nanowire is relativistically transparent and undergoes stable density modulation [Fig. 1d] inside the laser field with simulated pressures of 40 Tbar [4]. We also observed collimated gamma-ray emission in both the direction of laser and backward direction [Fig 1e].

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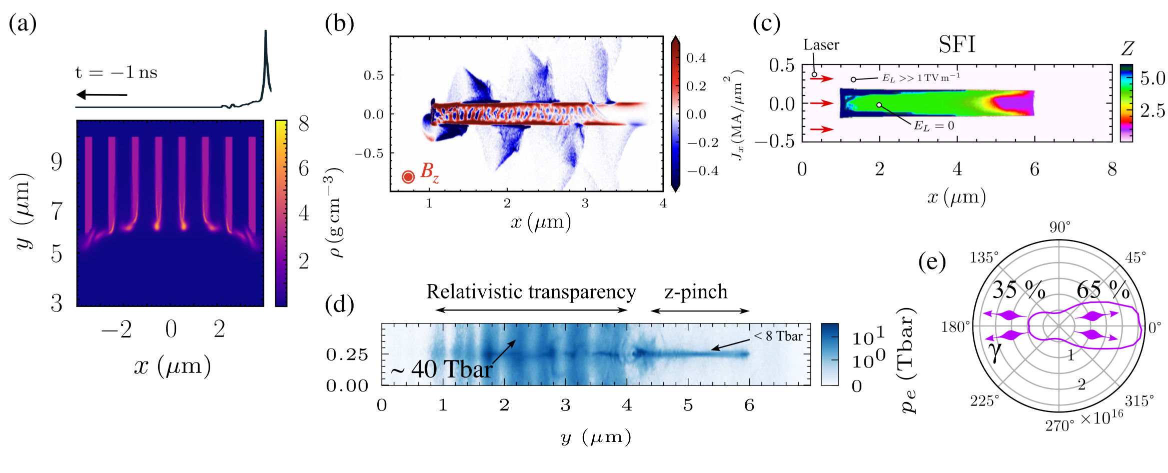

Figure 1. (a) Nanowire implosion during the interaction with the 1 ns laser Amplified Spontaneous Emission. (b) The wakefield excitation by the double-frequency electron bunches. (c) The ionisation by the Wakefield. (d) Up to 40 Tbar high pressure is generated in the relativistic transparency regime. (e) Directionality of the gamma-ray emission from the nanowire.