Relativistic mirror made of plasma at kilohertz repetition rate

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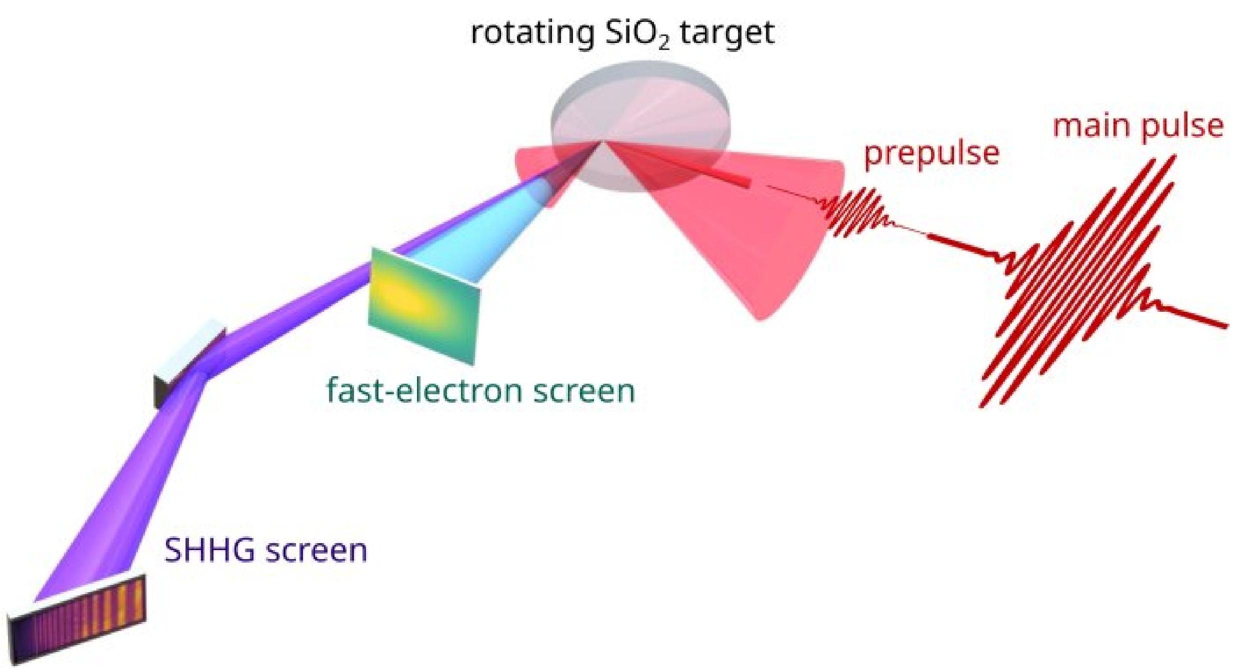

Schematics of the experimental setup for SHHG and electron acceleration on a kHz plasma mirror. Credit: *Ultrafast Science* (2022). DOI: 10.34133/2022/9893418

Scientists at the LOA (Laboratoire d'Optique Appliquée) in France succeeded for the first time to drive at a thousand shots per second a so-called plasma mirror in the relativistic regime (i.e., with a laser-field so strong that it hurls the plasma-electrons back and forth at nearly the speed of light.

When an intense laser pulse ionizes the surface of a solid target, it creates plasma so dense that it is impenetrable to the laser, even if the target was initially transparent. The laser now gets reflected off this "plasma mirror". In the relativistic regime, the mirror surface no longer just sits stills but is driven to oscillate so fast that, through a process called relativistic surface high-harmonic generation (SHHG), it temporally compresses the laser's electro-magnetic field cycles.

This concentrates the laser energy further in time and makes plasma-mirrors a promising path for the generation of ever more intense and shorter laser pulses.

Their use and fine control does however place extremely high demands on the driving laser such as pristine spatiotemporal pulse quality and temporal contrast, as well as a huge peak power of terawatts. This had only been achieved in single-shot experiments made with much bigger lasers that operate at ≤ 10 Hz repetition rate.

The team around Stefan Haessler and Rodrigo Lopez-Martens now report evidence for relativistic SHHG driven at kilohertz repetition rate. Simultaneously with the SHHG emission, a correlated beam of relativistic electrons is observed. This is a major step from hitherto few-shot exploratory experiments towards a usable secondary radiation and particle source for applications.

A key element for this progress is the in-house developed kilohertz repetition rate terawatt laser, providing pulse durations down to