Plasma density jump for the control of coherent x-ray emission via BISER mechanism

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We have discovered Burst Intensification by Singularity Emitting Radiation (BISER) [1], a new phenomenon which in particular results in bright coherent x-ray generation by relativistic plasma singularities driven by a multi-terawatt femtosecond laser focused onto a gas jet target [2], [3]. Singularities are produced in plasma by the laser pulse which pushes electrons creating an electron-free cavity and bow wave [4]. The singularities at the joining of the cavity wall and bow wave manifest themselves as point-like coherent x-ray emitters. A spontaneous BISER regime realized in previous experiments exhibits relatively large shot-to-shot fluctuations of the x-ray source position and low overall stability because the emission occurs after the relativistic self-focusing. However, stability is desirable for prospective applications of the new coherent x-ray source.

A tailored plasma density profile can help to control the BISER, as shown by our simulations with the PIC REMP code [5]. Here, we present an experiment with the plasma profile tailoring, where a shock in supersonic gas flow generates a sharp density up-jump. We demonstrate the BISER control using this density jump scheme and the J-KAREN-P laser [6]-[7]. In contrast to the spontaneous regime, here we obtain low-jitter x-ray source position and higher x-ray yield. Moreover, these advantages are achieved simultaneously in an optimized case. Our results represent a crucial step towards implementation of the next-generation bright compact coherent x-ray source. Further, they demonstrate the new technique of relativistic self-focusing control and its diagnostics.

We thank the J-KAREN-P laser operation group. We acknowledge the financial support from JSPS Kakenhi JP 25390135 and JP 26707031.

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