

1. Product Description

DOE Award Number: DE-SC0012444

Recipient/Contractor: The University of Texas at Austin; Tech-X Corp.

STI Product Type: Final Technical Report

Intellectual Property/Distribution Limitation: Unlimited

2. Product Type Info

STI Product Title: Collaborative Research: Tomographic imaging of laser-plasma structures

STI Product Date: 01/18/2018

3. Authors

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4. Content

Report/Product Number: DOE-UT-12444-1

Sponsoring DOE Program Office: USDOE Office of Science (SC), Fusion Energy Sciences (FES)(SC-24)

Description /Abstract (5000 characters max):

The interaction of intense short laser pulses with ionized gases, or plasmas, underlies many applications such as acceleration of elementary particles, production of energy by laser fusion, generation of x-ray and far-infrared “terahertz” pulses for medical and materials probing, remote sensing of explosives and pollutants, and generation of guide stars. Such laser-plasma interactions create tiny electron density structures (analogous to the wake behind a boat) inside the plasma in the shape of waves, bubbles and filaments that move at the speed of light, and evolve as they propagate. Prior to recent work by the PI of this proposal, detailed knowledge of such structures came exclusively from intensive computer simulations. Now “snapshots” of these elusive, light-velocity structures can be taken in the laboratory using dynamic variant of holography, the technique used to produce ID cards and DVDs, and dynamic variant of tomography, the technique used in medicine to image internal bodily organs. These fast visualization techniques are important for understanding, improving and scaling the above-mentioned applications of laser-plasma interactions. In this project, we accomplished three things: 1) We took holographic pictures of a laser-driven plasma-wave in the act of accelerating electrons to high energy, and used computer simulations to understand the pictures. 2) Using results from this experiment to optimize the performance of the accelerator, and the brightness of x-rays that it emits. These x-rays will be useful for medical and materials science applications. 3) We made technical improvements to the holographic technique that enables us to see finer details in the recorded pictures. Four refereed journal papers were published, and two students earned PhDs and moved on to scientific careers in US National Laboratories based on their work under this project.

5. Related Documents

Related Document Information:

Zhengyan Li, Hai-En Tsai, Xi Zhang, C.-H. Pai, R. Zgadzaj, X. Wang, V. Khudik, G. Shvets and M. C. DOWNER,” Single-shot optical visualization of evolving laser wakefields using an all-optical streak camera,” *Phys. Rev. Lett.* **113**, 085001 (2014). DOI: 10.1103/PhysRevLett.113.085001

H.E. Tsai, X. Wang, J. M. Shaw, Z. Li, A. V. Arefiev, X. Zhang, R. Zgadzaj, W. Henderson, V. Khudik, G. Shvets, and M. C. DOWNER, “Compact tunable Compton x-ray sources from laser-plasma accelerator and plasma mirror,” *Phys. Plasmas* **22**, 023106 (2015). DOI: 10.1063/1.4907655

N. H. Matlis, A. Maksimchuk, V. Yanovsky, W. P. Leemans, and M. C. DOWNER, “Analysis of sinusoidally-modulated chirped laser pulses by temporally-encoded spectral shifting,” *Optics Letters* **41**, 5503-06 (2016). DOI: 10.1364/OL.41.005503

Hai-En Tsai, A. V. Arefiev, J. M. Shaw, D. J. Stark, X. W. Wang, R. Zgadzaj, and M. C. DOWNER, “Self-aligning concave relativistic plasma mirror with adjustable focus,” *Phys. Plasmas* **24**, 013106 (2017). DOI: 10.1063/1.4973432

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