X-ray astrophysics with high-power laser facility

S. Fujioka, N. Yamamoto, D. Salzmann, F. Wang[a], Y. Li[b], Y-J. Rhee[c],
H. Nishimura, H. Takabe, H. Azechi

Institute of Laser Engineering, Osaka University, Japan
[a] *National Astronomical Observatories, Chinese Academy of Science, China*
[b] *Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, China*
[c] *Laboratory for Quantum Optics, Korea Atomic Energy Research Institute, Korea*
sfujioka@ile.osaka-u.ac.jp

High-energy-density laboratory astrophysics [1, 2] is a new discipline for investigating astronomical phenomena experimentally, including fundamental properties such as opacity, equation of state, energy transport, hydrodynamics, and particle acceleration by utilizing large and extreme pulse power facilities. In addition to traditional observations and computer simulations, such laboratory experiments confirm and deepen our understanding of astrophysical phenomena, thereby enabling quantitative comparison between experimental results, astronomical observations, and model predictions under well-defined conditions. Here, we report a novel laboratory simulation of photoionized plasma generated at a high-power laser facility [3, 4].

Photoionized plasmas are encountered in astrophysics wherever low-temperature gas/plasma is bathed in a strong radiation field. X-ray line emissions in the several-keV spectral range were observed from accreting clouds of binary systems, such as CYGNUS X-3 and VELA X-1, in which high-intensity x-ray continua from compact objects (neutron stars, black holes, or white dwarfs) irradiate the cold and rarefied clouds.

X-ray continuum-induced line emission accurately describes the accreting clouds, but experimental verification of this photoionized plasma model is scarce. Here we report the generation of photoionized plasmas in the laboratory under well-characterized conditions using a high-power laser. A blackbody radiator at a temperature of 500 eV, corresponding to a compact object, was created by means of a laser-driven implosion. The emerging x-rays irradiate a low density ($n_e < 10^{20}$ cm^{-3}) and low temperature ($T_e < 30$ eV) silicon plasma.

Line emissions from lithium- and helium-like silicon ions were observed from a thermally cold silicon plasma in the 1.8 - 1.9 keV spectral region, far from equilibrium conditions. This result reveals the laboratory generation of a photoionizing plasma. Atomic kinetic calculations imply the importance of direct *K*-shell photoionization by incoming hard x-rays [5].

[1] B. Remington *et al.*, Science, **284**, 1488 (1999)
[2] H. Takabe, Prog. Theor. Phys., **143**, 202 (2001).
[3] S. Fujioka *et al.*, Nature Physics (in press).
[4] S. Fujioka *et al.*, Plasma Physics and Controlled Fusion (in press).
[5] F. Wang *et al.*, Astrophysical Journal (in press).

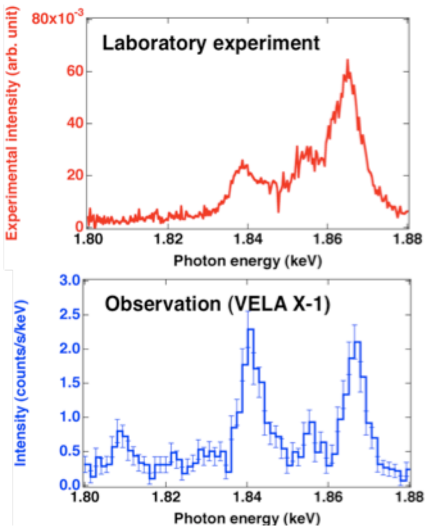

Fig. 1 X-ray spectra observed in laboratory experiment and astrophysical object (VELA X-1).