Active control for hard x-ray lasers with high energy density matter

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Recently, at Japanese x-ray free electron laser facility, extreme high intensity condition of hard x-ray inside solid density matter. The ionization speed of K-shell electrons is faster than the following relaxation process such as rate of Auger decay and rate of the fluorescence emission. That intense fluence can make particular high energy density matter in which almost all the atoms have single vacancy in K-shell electron orbit. Using such an extreme condition, it is possible to observe several nonlinear optics and quantum optics phenomena which are new for the hard x-ray region. In this talk, our recent experiments will be reviewed. Those include nonlinear transmission, phase front reshaping, saturable absorption[1], and laser-pumped inner-shell lasers.
By using a high density of single K-shell vacancy atoms at solid density, the K-shell absorption edge shifts toward higher energies and that results in the nonlinear transmission phenomena. Similar to the optical science, due to Kramers-Kronig relation, the real part of optical constant also changes along the path of the incident x-rays. It means we expect the light induced guiding channel in hard x-ray region. These media can also make an extreme high gain Kalpha laser. With this conversion scheme, we expect a large improvement of coherency from SASE x-rays to atomic inner-shell x-ray lasers.
These active devices for hard x-ray make new type of xray laser pulse and start new coherent x-ray science.

[1] H. Yoneda, et. al., Nature Communication, in printed (2014)