Temporal and Spectral Control of the X-ray Pulses in a Resonant Medium with a Modulated Transition Frequency

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We discuss a method for controlling the spectral/temporal characteristics of an X-ray radiation produced by the X-ray plasma lasers, X-ray free electron lasers (XFELs), synchrotron or radioactive sources via variation in time/space of the parameters of its resonant interaction with a medium (atomic or nuclear transitions in gases, plasmas or solids). In the case of an active medium of the plasma based X-ray lasers a modulation of the resonant transition frequency can be achieved under the action of sufficiently strong IR/optical field via the sub-cycle Stark shift of the energy levels of the resonant ions. In the case of the nuclear gamma-ray transitions it was realized via the Doppler frequency shift in the vibrated recoilless absorber.

Several applications of this technique are considered, including

(i) an amplification and/or formation of the intense attosecond pulses in the active medium of plasma based X-ray lasers (promising for dynamical microscopy and imaging of materials and biological nano-structures) [1],
(ii) a spectral enhancement of an XFEL's radiation (promising for development of long-lived quantum nuclear memory, ultrahigh resolution nuclear spectroscopy, and nuclear frequency standards) [2],
(ii) a control of single X-ray photon waveform and realization of quantum interfaces between single photons and nuclear ensembles [3,4].

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