Research (What is it about?)	**Ionization-induced multiwave mixing and terahertz generation**
UNN authors	*Vvedenskii N.V., Kostin V.A., Laryushin I.D., Silaev A.A.*
We find (The result)	Ultrafast strong-field ionization is shown to be accompanied by atypical multiwave mixing with the number of mixed waves defined by the dependence of the ionization rate on the field strength. For two-color laser pulses of ***various frequency ratios*** this results in the excitation of a free-electron current at laser combination frequencies and possibly in the excitation of terahertz (THz) generation with uncommon laser frequency ratios
Abstract	The existing method of THz generation employs ionizing pulses that originate from a one-color ultrashort laser pulse passing through a frequency-doubling crystal, i.e. a two-color pulse containing a strong main field along with a weak additional field tunable near the half value of the main frequency. It provides THz pulses with a very broad spectrum. The main contribution to low-frequency THz radiation is defined by the free-electron response in the formed laser plasma. We examine for the first time how the intrinsic nonlinear features of this response lead to THz generation. We answer the question by justifying these processes to be ionization-induced multiwave mixing when considering ionizing two-color laser pulses with various frequency ratios. The main differences between the ionization-induced multiwave mixing and well-known Kerr-like wave mixing caused by a nonlinear response of bound charges in neutrals originate from the essentially high-order character of nonlinear ionization and the associated strong nonlinear dispersion. Therefore, ionization-induced wave mixing is an almost unique example of when the high-order nonlinear effects (multiwave mixing) dominate over the low-order ones (three- and four-wave mixing) in a natural way. The energy of a generated THz pulse increases with the square of the zero-frequency plasma-current density or, in other words, of the residual current density (RCD) that is left in the plasma after the ultrashort laser pulse has passed. We use semiclassical and oquantum-mechanical approaches to calculate this RCD, assuming single ionization of an atom. The concept of nonlinear ionization-induced multiwave mixing should allow one to design schemes and methods for the generation of radiation in the THz and other frequency ranges in a sensible and targeted way.

Representative articles 2016-2017, quartiles	1. *Kostin V.A., Laryushin I.D., Silaev A.A., Vvedenskii N.V.* Ionization-induced multiwave mixing: Terahertz generation with two-color laser pulses of various frequency ratios. Phys. Rev. Lett. **117**: 035003 (2016).	Q1
	Q-index (Qi) of the result	**4**

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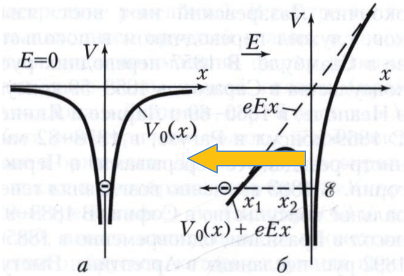
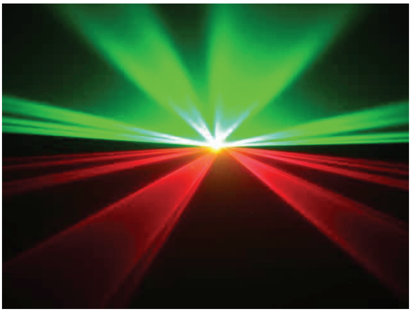
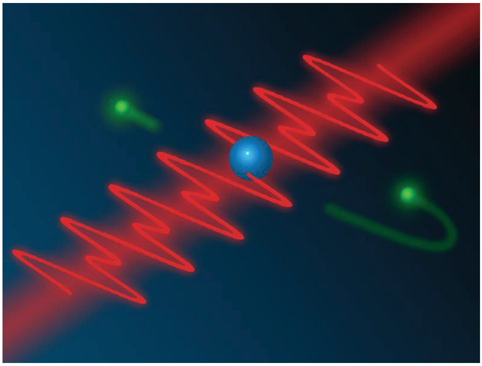


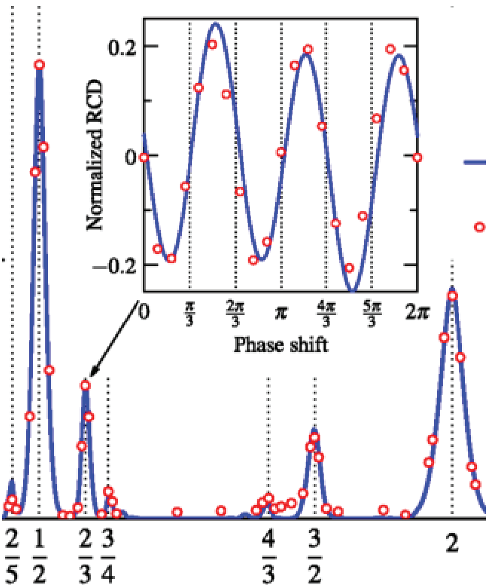
An electron in Coulomb hole of the hydrogen nucleus (*а*). The change of potential shape in the strong external electric field ***E*** and the possibility of tunnel ionization of atom (*б*).

An ionization in the strong laser pulse field.





The two-color laser field (frequency ratio $\omega_1/\omega_2 \approx 4/3$).



The maximum value of the residual current density (RCD) in dependence of the frequency ratio of ionizing pulse

Semiclassical calculation

The numerical integration of the three-dimensional time-dependent Schrödinger equation for an electron acted upon by the Coulomb field of the hydrogen nucleus and the laser field ***E***

The inset illustrates the dependence of the RCD on the phase shift at $\omega_1/\omega_2=2:3$