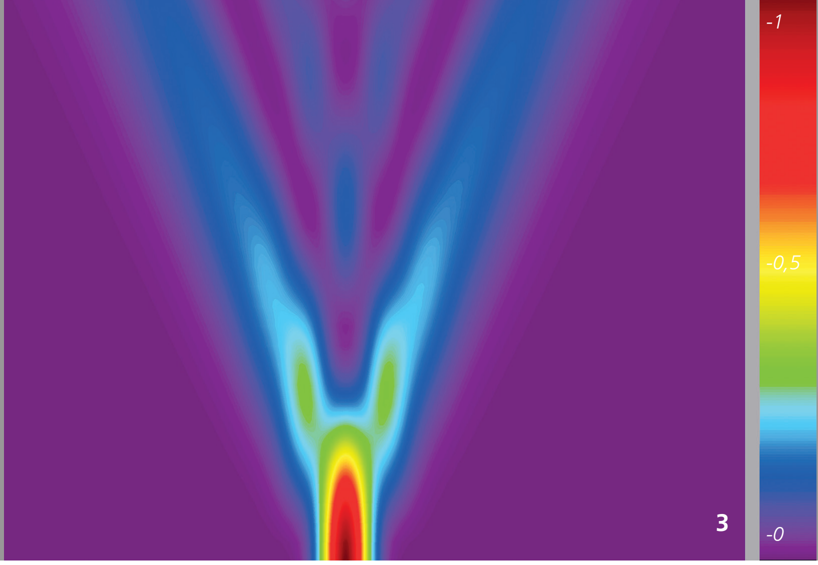

FREQUENCY COMB IN THE VACUUM ULTRAVIOLET FOR OPTICAL EXCITATION OF THE NUCLEAR TRANSITION IN 229-THORIUM

Task

229-Thorium is the only element that has a nuclear transition in the optical spectral region suitable for operating a nuclear clock. To drive this transition optically, a tunable frequency comb in the vacuum ultraviolet (VUV) will be constructed, combining a large amount of power per comb mode (nW/mode) and an extremely small linewidth (kHz). Furthermore, its spectrum shall cover the range around 150 nm based on current knowledge of the transition wavelength.

Method

The process of high harmonic generation (HHG) has a very small conversion efficiency, but allows a coherent conversion that preserves the comb modes and reaches wavelengths in the 10 - 200 nm range. Laser amplifiers with high power are available for generating the 7th harmonic of a frequency comb in the infrared (IR). To achieve the required VUV power, Fraunhofer ILT uses a laser with up to 400 W average power, a nonlinear pulse compression to about 50 fs to increase the HHG efficiency, and an enhancement resonator with a circulating power of 10 kW. One challenge this poses is the output coupling of the harmonics from the resonator, which is done geometrically here.

Results

Fraunhofer ILT has worked out and designed the concept of the VUV frequency comb with the relevant specifications in detail. It has also begun to build the setup and completed building the first components.

Applications

The laser system will be an essential building block for a thorium nuclear clock, which can achieve a much higher accuracy than previous atomic clocks. A frequency comb in the VUV or EUV will also make further applications in spectroscopy possible. In addition, spatially coherent sources in the VUV to the XUV range, which can be built with HHG, can be used in numerous applications in science and industry, for example, in photoemission spectroscopy, microscopy, lithography and metrology.

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3 Simulation of the spectral intensity (abscissa) over the round trips in the MPC (ordinate) at nonlinear spectral broadening for pulse compression.