

Recent experiments at NovoFEL user stations

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The Novosibirsk free-electron laser (NovoFEL) is a source of monochromatic frequency-tunable radiation [1]. This facility belongs to the Siberian Synchrotron and Terahertz Radiation Center, which is open for Russian and foreign users. The NovoFEL consists of three laser oscillators, the supposed generation regions of which cover three regions of the spectrum, shown in Fig. 1 (a) with light rectangles. The spectral ranges of generation currently available to users are marked with darker rectangles. The first laser system of the facility, generating terahertz radiation in the range of 90 – 240 μm , was commissioned in 2003, and most studies performed by users to date relates to this range. Experiments using radiation of 40-50 μm have been started recently. The studies that had been performed at the first six workstations by 2015 are described in the review [2]. Since then, the facility was signifi-

cantly upgraded, and now 11 workstations, the location of which is shown in Fig. 2, are in operation. Several more stations are under construction. The directions of research conducted at the stations are understandable from their names, but are not limited by them.

The laser beams at the inputs to the user stations are Gaussian beams (Fig. 1(b)). The radiation is an infinite sequence of 30-100 ps pulses with a standard repetition rate of 5.6 MHz and average power of up to 100-200 W. Regimes in which the radiation is coherent are described in [3]. Such parameters enabled the development of several superfast and high-resolution techniques of molecular spectroscopy [4,5], and the high pulse power allowed ignition of a continuous optical discharge in gases at the atmospheric pressure [6].

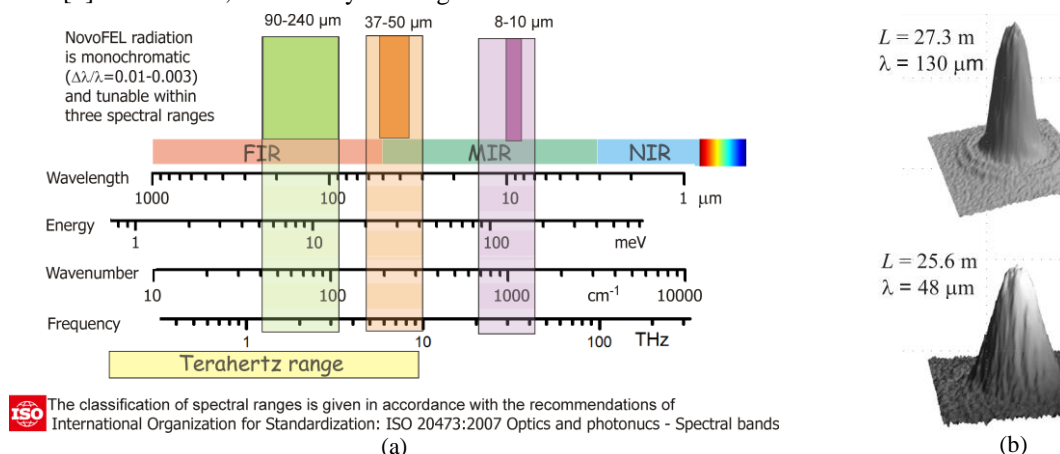


Fig. 1. (a) Generation ranges of the Novosibirsk free electron laser; (b) beam shapes at the inputs to workstations (L is the distance from the laser oscillator).

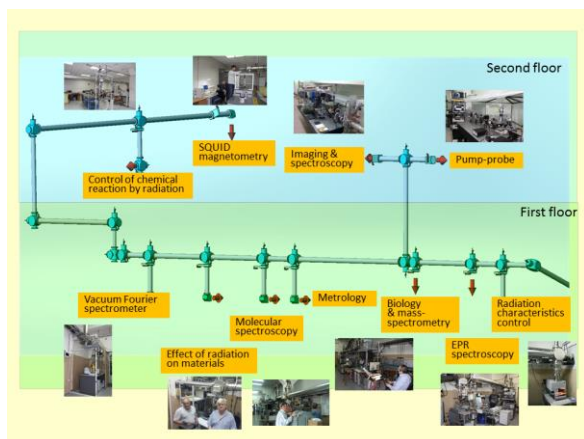


Fig. 2. Beamline (filled with dry nitrogen) and workstations at the Novosibirsk free electron laser facility.

Many applications require transformation of a Gaussian laser beam into beams of different mode structure or concentration of radiation in a predetermined volume or on an area. A number of diffractive optical elements made of diamond or high-resistivity silicon have been designed and fabricated for this purpose [7-8]. In particular, using diffractive optics made it possible to transform the laser radiation into Bessel beams with an orbital angular momentum ("vortex beams") [9-10]. The latter were converted into arrays of vortex beams via their diffraction on a 2D amplitude array of circular openings [11]. Acousto-optical deflection of a terahertz vortex beam was demonstrated in [12], and production of nanosized metal particles by acoustic waves generated in liquids by the NovoFEL pulsed-intermittent radiation was described in [13].

Classical holography with a monochromatic terahertz radiation source was first demonstrated in [14]. The NovoFEL radiation enabled achievement of record resolution for the terahertz range in the internal reflection ellipsometry [15]. Studies of terahertz surface plasmon polaritons on metal-dielectric-air interfaces revealed their particularities in comparison with the visible range plasmons [18-20].

The effect of THz radiation on biological objects, from cells to organisms, is under investigation at the biological station of NovoFEL (see, e. g., [21]). Two new workstations have been commissioned at the facility. A one-color pump-probe setup was applied to research on the relaxation time in semiconductors with shallow donors at cryogenic temperatures [22]. The electron paramagnetic resonance station [23] enables exploration of the influence of high-power THz or mid-IR radiation on spin systems.

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