

Transmission of the unit of length to modern lasers and laser measuring systems

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Introduction

In the modern world, laser technologies are widely used in various fields of science and technology. Increasingly, in the domestic innovative production of such industries as aircraft and rocket building, shipbuilding, machine tool building, etc., laser-based measuring instruments are used. These measuring instruments are also used to solve many scientific problems.

Problem

In recent years, there has been a significant increase in interest in the metrological support of laser radiation sources not only at a wavelength of 633 nm, but also in a wider range, because a large number of laser radiation sources, as well as laser measuring systems, with different nominal wavelengths appeared (Fig. 1 and Fig. 2). Since, in accordance with the Federal Law of June 26, 2008 No. 102-FZ "On Ensuring the Uniformity of Measurements", traceability to the State Primary Standard must be guaranteed for measuring instruments used in the field of state regulation of ensuring the uniformity of measurements. Therefore, the tasks of expanding the functionality of the State Primary Standard have become extremely urgent.



Fig.1. Modern sources of laser radiation

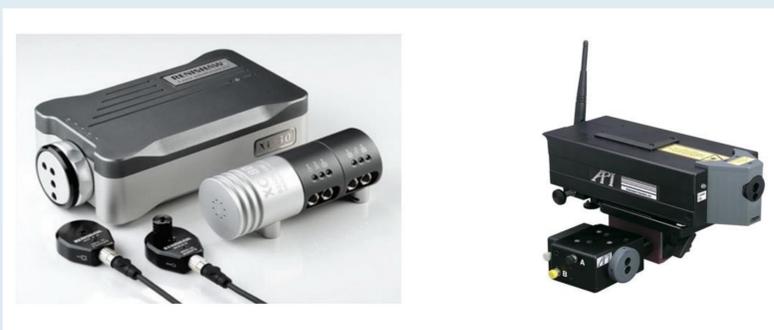


Fig.2. Modern laser measuring systems

In this connection, from 2017 to 2020 in the research department of geometric measurements of the Federal State Unitary Enterprise VNIIM named after D.I. Mendeleev, work was carried out to improve the State primary standard of the unit of length - the meter GET 2 (next GET 2).

Results

As a result, the reproduction of a unit of length became possible at two wavelengths of laser radiation: 633 nm and 532 nm. These lines are recommended for the practical implementation of a unit of length - a meter in accordance with the BIPM recommendation. The structure of GET 2 also included a transportable source of laser radiation for transmitting a unit of length to permanently installed lasers and laser measuring systems at the customer's site.

The transfer of a unit of length to laser radiation sources is carried out using an installation for measuring the difference in frequencies of laser radiation sources, as well as a set of equipment included in GET 2 for measuring the frequency (wavelength in vacuum) of lasers in the wavelength range from 500 to 1050 nm, complete with a standard frequency and time hydrogen Ch1-1003M. The main component of the complex is an optical frequency comb.

The external view of the laser radiation sources and the GET 2 complex are shown in Figures 3 и 4.

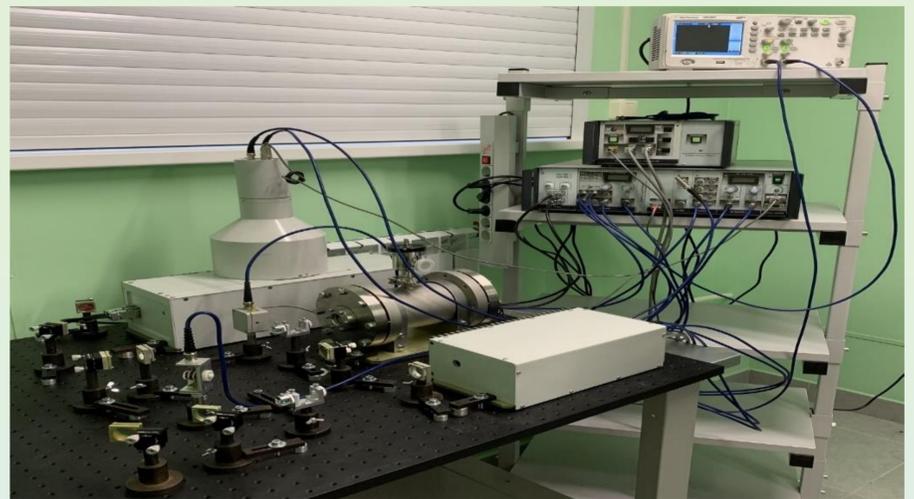


Fig.3. Nd:YAG laser stabilized along the saturated absorption line in molecular iodine 127



Fig.4. A complex of equipment for measuring the frequency (wavelength in vacuum) of lasers in the wavelength range from 500 to 1050 nm

The main metrological characteristics of GET 2 are shown in Table 1.

Table 1

Characteristic	Meaning
Nominal wavelengths at which unity is reproduced	633 nm 532 nm
Standard deviation of the reproduction of a unit of length (with 100 independent measurements) at a wavelength:	
633 nm	$1,6 \cdot 10^{-12}$
532 nm	$1,3 \cdot 10^{-12}$
Non-excluded systematic error of reproduction of a unit of length at a wavelength:	
633 nm	$1,9 \cdot 10^{-12}$
532 nm	$1,6 \cdot 10^{-12}$
Expanded uncertainty at wavelength:	
633 nm	$3,6 \cdot 10^{-12}$
532 nm	$3,0 \cdot 10^{-12}$
Transmission range of a unit of length to laser radiation sources	from 500 to 1050 nm

Conclusion

The implemented expansion of the functionality of the State primary standard of the unit of length - the meter GET 2 made it possible to provide metrological support for modern lasers and laser measuring systems in the range from 500 to 1050 nm on the territory of the Russian Federation.