LASER GYROSCOPES

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Laser gyroscopy in the journal *Kvantovaya Elektronika*

The application of lasers in the measurement of linear and angular displacements arose historically at the instant of the appearance of lasers themselves (1961 – 62). The idea of using an optical beam in a ring laser cavity instead of rotating mechanical masses proved extremely fruitful from both scientific and practical points of view. A whole series of fundamental advantages of optical, and in the first place laser, gyroscopes over mechanical ones were very rapidly discovered: a virtually unlimited dynamic range of the measurement of angular velocities, a short warm-up time after switching on, immunity to considerable mechanical overleads (owing to the absence from the laser gyroscope of mechanically moving or rotating units and components), the possibility of the precise measurement of the number and phase of the revolutions of the rotating object, etc. Together with the potentially lower cost and considerable prospects for the improvement of laser gyroscopes (far from fully realised), these advantages have led to the discovery of ways in which these gyroscopes can be applied in practice in devices for controlling the movement of a wide variety of objects: automobiles, sea and river vessels, as well as all types of aircraft and spacecraft, and in measuring apparatus — for the monitoring of the parameters of movement in railways transport, metros (urban railways), robotics, etc.

Naturally, the vigorous development of laser gyroscopy does not imply that laser gyroscopes have fully displaced mechanical ones. The latter, which have a history longer than 100 years, have attained an extremely high technical level and continue to be actively improved. For this reason, in many cases their replacement by gyroscopes of another type is undesirable from both technical and economic points of view. At the same time, one cannot fail to recognise that, for example, virtually all modern and probable future navigation systems for civil passenger and cargo air transport are in fact designed to employ laser gyroscopes; it is sufficient to point to the laser-gyroscopic strapdown inertial navigation systems (SDINS) of the American companies Litton (LTN-92, LTN-101) and Honeywell (Lasernav), a whole series of new systems from European companies, and Russian laser-gyroscopic SDINS-type I-42-1-S, BINS-85, and NSI-2000 systems designed for use in piloting and navigational systems of existing and future aircraft.

It is useful to stress that, whereas mechanical gyroscopes have now reached the limit of their development and each new step in their improvement is achieved at the expense of considerable scientific-engineering and economic efforts, laser gyroscopes are in fact passing nowadays through the period of their youth and the widest possible pathways leading to their development and improvement are open before them.

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Laser gyroscopy deals fundamentally with coherent laser radiation, i.e. not only with light amplitudes (intensities) but also with the phases of optical waves or, in other words, a laser gyroscope is a precision laser-interferometric instrument. Laser gyroscopy is therefore in the same class as modern applications of quantum electronics based on coherent phenomena, such as holography, interferometry, optical heterodynes, generation of optical harmonics, etc. There is also a purely physical difference between mechanical and laser gyroscopes; whereas a mechanical gyroscope is in essence a vibrorotational system or a system with lumped constants, a laser gyroscope is a wave ('distributed') system. Extensive possibilities therefore arise for the use of purely wave methods in the monitoring of the parameters of a laser gyroscope and for the correction of errors up to the employment of phase conjugation.

For a number of reasons, among which those associated with special applications of laser gyroscopes are notable, laser gyroscopy has been neglected, with rare exceptions, by Russian academic science and science in higher educational establishments. A large proportion of the fundamental and applied research in this field of laser gyroscopy has therefore been concentrated in specialised industrial research institutes, which has had both positive and negative aspects.

At the same time, laser gyroscopy, based on the coherent properties of laser radiation and being therefore 'at the top' of modern quantum electronics, requires extensive fundamental and applied theoretical and experimental research in order to discover all the physical processes and mechanisms in gas, solid-state, and diode ring lasers on the basis of which laser gyroscopes have been constructed (or will be constructed in the immediate future).

The editors of Kvantovaya Élektronika welcome articles on this topic aimed at the solution of the fundamental problems of laser gyroscopy and the search for new ways leading to its development. The first topical selection of papers on optical, including laser, gyroscopy presented in this issue of the journal comprises a review on gas and solid-state ring lasers as well as a series of communications on frequency, polarisation, and diffraction nonreciprocities in ring-laser cavities and passive fibre optic interferometers, communications on polarisation losses in prism cavities, etc. Naturally, by no means all the problems of modern laser gyroscopy are covered here, but the editors hope that this issue will bring these problems, which are of exceptionally great scientific and explicit practical interest, to the notice of the Ministry of Science of Russia and the scientists in the Russian Academy of Sciences, higher educational establishments, and all interested institutions. There is no doubt that laser gyroscopy has a direct bearing on those 'critical technologies' which constitute the basis of the national security of our country.

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