Scientific session of the Division of General Physics and Astronomy, USSR Academy of Sciences (June 29–30, 1977)

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The Joint Scientific Session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences took place on June 29–30, 1977 in the Conference Hall of the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following papers were read:

1. *N. V. Karlov,* Laser separation of isotopes.
2. *V. V. Smirnov,* Coherent Raman spectroscopy of gases.
3. *V. V. Korobkin, B. M. Stepanov, S. D. Fanchenko, and M. Ya. Shchelev,* Pico-femtosecond electron-optical photography.
4. *A. A. Kolomenskiĭ,* Collective methods of particle acceleration.
5. *Ya. B. Faĭnberg and N. A. Khizhnyak,* Plasma methods of acceleration.
6. *V. P. Sarantsev,* Acceleration of ions in electron storage rings.

Brief accounts of five of the papers presented are given below.

N. V. Karlov, *Laser Separation of Isotopes.* The high spectral intensity of laser radiation can be used in the selective initiation of photoionization, photodissociation, photochemical processes, and so on. The resonance effect of laser radiation on matter can also be used for isotope separation. The separation of isotopes with the aid of optical radiation produced by lasers makes this method sufficiently universal and, at least in principle, highly productive. In contrast to all other methods of isotope separation, all laser methods have the unique ability to affect only the required isotopes in a natural mixture, and not the mixture as a whole. Selective excitation of the required isotopic components by laser radiation and the spatial separation of the excited isotopes is a common feature of all methods of laser separation of isotopes. Physical or chemical processes corresponding to the second stage should then proceed with a minimum loss of selectivity.

Since the quantum yield of a selective photoprocess cannot exceed unity, it is clear that the production of one gram-mole of the required material per minute corresponds to not less than 10^{22} laser photons incident per second.

An analysis of laser methods for the separation of isotopes can provide the answer to the question as to which particular laser photons are required. Three laser methods for the separation of isotopes have now been developed, namely, selective photoionization of atoms, multistep selective dissociation of polyatomic molecules by infrared radiation, and selective heterogeneous processes.

Two-step selective photoionization of atoms is the most general method of laser separation of isotopes. It can be used to extract any isotope of any element in the Mendeleev periodic table, provided the necessary atomic vapor pressure can be established. This method has been successfully used to separate the isotopes of all the elements of the rare-earth group which have stable isotopes. The necessary high atomic vapor pressures were produced by electron-beam evaporation without the use of a crucible. Two-frequency selective excitation has been found to be a powerful tool in spectroscopic studies. It can be used in the accurate recording of hyperfine structure spectra of odd isotopes, and to determine the cross sections for the resonance excitation-energy transfer in heavy-metal vapors.

Vibrational levels of polyatomic molecules are used in the multistep selective photodissociation of molecules by infrared laser radiation. The elementary dissociation event is produced by the absorption by the molecule of a large number of infrared laser photons which are in resonance with vibrational transitions in the molecule. The presence in sufficiently symmetric polyatomic molecules of a quasicontinuum of the higher vibrational states exhibiting a band structure plays an important role in this process.

The presence of the quasicontinuum has been demonstrated experimentally, and the importance of its band structure leading to the red shift effect has been established. This effect consists of a sharp reduction in the dissociation threshold and an increase in the dissociation rate when the frequency of the laser radiation passing through the quasicontinuum is detuned from resonance toward lower frequencies.

The selective ionization of atoms and selective dissociation of molecules are fundamentally new methods for isotope separation. Laser radiation can also be used to accelerate molecular-kinetic processes used in isotope separation and occurring under heterophase conditions. The separation of boron isotopes has been achieved in a laser chromatographic column, a laser filtration cell, and under laser resonance evaporation.

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Modern quantum electronics is now ready (from the power point of view) for the solution of problems in the laser separation of isotopes. At the same time these problems impose some quite stringent conditions on the laser systems. The most important are the requirements of high efficiency, tunability, monochromaticity, stability, high mean power, long life, and high reliability.

N. G. Basov, É. M. Belenov, V. A. Isakov, E. P. Markin, and A. N. Oraevskii, Usp. Fiz. Nauk **121**, 427 (1977) [Sov. Phys. Usp. **20**, 209 (1977)].

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V. S. Letokhov and S. B. Mur, Kvantovaya Elektron. (Moscow) **3**, 248, 485 (1976) [Sov. J. Quantum Electron. **6**, 129, 259 (1976)].