Scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the Academy of Sciences of the USSR (22–23 April 1987)

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A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on April 22 and 23, 1987 at the S. I. Vavilov Institute of Physics Problems of the USSR Academy of Sciences. The following reports were presented at the session:

April 22

1. V. I. Balykin and V. S. Letokhov. Laser optics of beams of neutral atoms.

2. Yu. E. Lozovik. Ion and electron clusters.

3. V. B. Braginskiĭ. Resolution in macroscopic measurements and the optical microcavity. [This report will be published in one of the next issues of Uspekhi Fizicheskikh Nauk (Editors).]

April 23

4. V. A. Noskin. Laser correlation spectroscopy of quasielastic scattering.

5. A. V. Lomakin. Study of the internal dynamics of macromolecules by the method of laser correlation spectroscopy.

6. E. B. Aleksandrov and V. S. Zapasskiĭ. Magnetic resonance in the noise in the intensity of scattered light.

Summaries of five of the reports are presented below.

V. I. Balykin and V. S. Letokhov. *Laser optics of beams of neutral atoms.* The report contains the results of experimental and theoretical investigations of the development of the optics of neutral atomic beams with the help of laser radiation. The problems of collimation, focusing, and specular reflection of an atomic beam, and also the possibility of deep Å-size focusing of an atomic beam are examined.

Collimation of a beam of atoms was realized[1] under conditions of interaction of laser radiation with atoms, when the force of light pressure depends on the velocity of the atoms. This interaction regime of an atomic beam with radiation was realized with transverse irradiation of the beam with an axially symmetric field, formed by reflection of the laser radiation from the conical mirror surface of an axicon. The axis of the axicon coincided with the axis of the atomic beam. The collimation regime was achieved with negative detuning of the frequency of the laser radiation from the frequency of the atomic transition by an amount equal to several homogeneous widths. For positive detuning by the same amount decollimation of the beam was observed. The density of the atoms on the axis at the transition from the collimation to the decollimation regime varied by a factor of 10^3. Collimation of the beam enables control of the phase density of the atoms.

Focusing of the atomic beam was achieved[2] by means of the force exerted by light pressure, which depends on the coordinate of the atom. Focusing was realized in the configuration of a field formed by four diverging laser Gaussian beams, propagating in the $\pm x$ and $\pm y$ directions of a Cartesian coordinate system. The caustics of the laser beams were located at the same distance from the origin of the coordinates, and the atomic beam propagated along the z axis. Expressions were obtained for the focal length and the formula of the "laser lens." Focusing of the atomic beam was realized experimentally and an "image" of the source of the atomic beam was produced.

Specular reflection of an atomic beam was realized[3] by means of the interaction of atoms with nonuniform optical radiation. In a nonuiform electromagnetic field a gradient force, proportional to the induced dipole moment and the

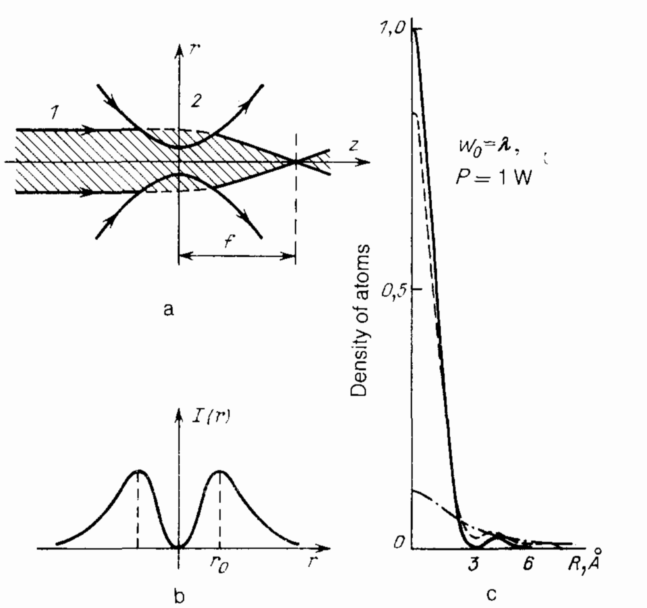

FIG. 1. Deep focusing of an atomic beam by a laser lens. a) Arrangement of the atomic (1) and laser (3) beams. b) Transverse distribution of the intensity profile of the TEM^{*}_{01} mode of the laser field 2. c) Intensity distribution of a monochromatic atomic beam in the focal plane.

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gradient of the field strength, acts on the atom. A nonuniform electromagnetic field with maximum nonuniformity of the intensity was created with the help of total internal reflection of laser radiation from the dielectric-vacuum interface. The field in the vacuum in this case decays over a characteristic distance $\approx\lambda$ and plays the role of a "mirror" for the atomic beam incident on it. Specular reflection of the atomic beam was observed in the experiment; the reflection coefficient in this case is close to 100%.

The possibility of deep Å-size focusing of an atomic beam[4] with the help of laser radiation is analyzed in the report. The atomic beam is regarded as a collection of de Broglie waves, and the potential field whose effect is analogous to the effect of an objective in light optics or electrooptics is found (Fig. 1a). Then the density distribution of the atoms in the focal plane of the objective is calculated and its basic characteristics are determined: the focal length, the aperture ratio, aberration, as well as the possibility of its realization using modern laser technology. Figure 1c shows the density distribution of an atomic beam in the focal plane for different parameters of the focusing field. The solid curve corresponds to the aberration-free case. The dashed curve corresponds to the distribution taking into account the chromatic aberration; the dot-dashed curve corresponds to the case taking into account spherical aberration; the distribution taking into account the effect of momentum diffusion is identical to the diffraction distribution.

In Fig. 1c the distribution was calculated with the following parameters: $P = 1$ W, $v_{at} = 2.2\cdot 10^5$ cm/s, $\Delta v_{at}/v_{at} = 10^{-3}$. The diameter of the atomic objective equals λ. The calculation shows that all distributions are close to the diffraction distribution.

[1]V. I. Balykin, V. S. Letokhov, and A. I. Sidorov, Pis'ma Zh. Eksp. Teor. Fiz. **40**, 251 (1984) [JETP Lett. **40**, 1026 (1984)].
[2]V. I. Balykin, V. S. Letokhov, and A. I. Sidorov, *ibid.* **43**, 172 (1986) [JETP Lett. **43**, 217 (1986)].
[3]V. I. Balykin, V. S. Letokhov, Yu. B. Ovchinnikov, and A. I. Sidorov, *ibid.* **45**, 282 (1987) [JETP Lett. **45**, 353 (1987)].
[4]V. I. Balykin and V. S. Letokhov, Opt. Commun. (1987).