It follows from (1) and (2) that in the case of a weakly-bound neutron, for sufficiently heavy nuclei, the value of τ becomes of the same order as t when $E < E_B \sim z^2e^2/2R_0$.

The table lists the relative-motion energy most suitable for the measurements and also some of the other quantities used above, for a number of nuclei.

	C^{12}	O^{16}	Ne^{26}
t/τ	0.97	0.81	0.62
E_{cms}, MeV	6.0	10.0	15.0
η	6.1	9.3	12
$\Delta\theta$	30°	11°	9°

The experimental observation of the predicted oscillations and their further investigation are of considerable interest. First, this would make it possible to measure times $t \sim 10^{-21}$ sec in some nuclear reactions [3]. Second, it would be possible to estimate directly from the swing of the oscillations the the probability of existence of the target nucleus B in the form of the proposed nucleon cluster (B = A + a). Third, this would uncover a new method for investigating the rather complicated mechanism of nucleon (or cluster) transfer.

It must also be noted that a perfectly analogous situation can occur also in inelastic-scattering processes (for example, in the case of Coulomb excitation of single-particle states, a coherent contribution will be made by single-nucleon transfer at a given level), and also in scattering with nucleon redistribution, of the type**

$$A + B \rightarrow C + D.$$

The possibility of directly comparing, in one experiment, of the probabilities of different inelastic processes is in our opinion the most attractive feature of investigations of this kind.

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*Their number can in principle be also larger.

** This case was called to our attention by Ya. B. Zel'dovich.

GAS LASER USING MULTIPLY CHARGED IONS

B. M. Smirnov
Kurchatov Atomic Energy Institute
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Let us consider the operating conditions of a gas laser with multiply charged ions. Such a laser takes the form of a gas-filled tube with a current of multiply charged ions flowing along its axis. These ions have had time to cover a sufficiently long path from the source, so that they are in either the ground or a metastable state. The multiply-charged ions exchange charges with the atoms (molecules) of the gas, producing ions with smaller charge. The mechanism of partial charge exchange of a multiply charged ion, $x^{n+} + y \rightarrow x*^{(n-1)+} + y*^{+}$, is treated quite fully in the literature [1-8] and reduces to the following: When the distance between nuclei changes, the terms of the quasimolecule $(xy)^{n+}$, which correspond to the state $x^{n+} + y$, vary relatively little with the distance, owing to the weak polarization interaction, whereas the terms of the state $x^{*(n-1)+} + y^{*+}$ change strongly, owing to the strong Coulomb repulsion. Therefore, when the distance between the nuclei is finite, the terms of the states under consideration intersect if the binding energy of the last electron in the excited ion $x^{*(n-1)+}$ exceeds slightly the binding energy of the electron y. In fact, a pseudocrossing of the terms under consideration takes place, and the magnitude of the pseudocrossing, which is determined by the exchange interaction of the atomic particles, is the larger, the smaller the distance between nuclei to which they correspond. If this distance between the nuclei is attained in collisions between the atomic particles, then transitions between the states in question take place in the vicinity of the pseudo-crossing point. As a result we find that the charge exchange of the multiply-charged ion with the atom leads to the production of an excited ion, and there exists a limited number of excited-ion states in which the charge exchange has large cross sections. The binding energy of the electron in the produced excited ion exceeds in this case (by a factor not less than two) the ionization energy of the initial atom, and the weakly bound electron has a small angular momentum.

The proposed laser operates on transitions between the excited states of the ion or between the excited and ground states of the ion. Let us examine the operating conditions of the laser. Let N be the density of the initial beam of multiply-charged ions, N_i^* the density of the excited ions produced as a result of the charge exchange, N_i the density of the ions corresponding to the lower state of the transition at which the laser operates, N_a the density of the gas atoms, v the ion-beam velocity, σ the cross section for charge exchange with production of the given excited ion, and 1/τ the probability of radiation of the excited ion with transition to the other state under consideration. Confining ourselves to transitions between three ion states, we obtain the balance equation for the ion density:

$$\frac{dN}{dt} = -N N_a v\sigma, \quad \frac{dN_i^*}{dt} = N N_a v\sigma - \frac{N_i^*}{\tau}, \quad \frac{dN_i}{dt} = \frac{N_i^*}{\tau} . \tag{1}$$

In the stationary state, it is convenient to go over to the variable x = vt, which corresponds to the coordinate along the beam. Solving the system (1) under the initial conditions $N = N_0$ and $N_i^* = N_i = 0$ at $x = 0$, we obtain ($\lambda = 1/N_a\sigma$) for the density of the particles of any given kind along the beam:

$$\begin{gathered} N = N_0 e^{-x/\lambda}, \quad N_i^* = N_0 \frac{v\tau}{\lambda - v\tau} \left(e^{-x/\lambda} - e^{-x/v\tau}\right), \\ N_i = N_0 \left(1 - \frac{\lambda e^{-x/\lambda} - v\tau e^{-x/v\tau}}{\lambda - v\tau}\right) . \end{gathered} \tag{2}$$

As seen from (2), if the length of the path traversed by the ion beam does not greatly exceed the charge-exchange length of the ion in the gas, then $\int N_i^* dx > \int N_i dx$ even under the assumptions made. In fact, owing to the charge exchange of the ions in the lower state of the given transition, the operating conditions of the laser should be less stringent.

It is possible to create conditions such that the energy of the transition at which the laser operates exceeds the ionization energy of the gas. In this case it is necessary that the gain of the electromagnetic wave in the laser exceed the attenuation due to the photoionization of the atoms. This condition takes the form

$$\frac{w}{\Delta\omega} \cdot \frac{\pi^2 c^2}{\omega^2} N^* >> \sigma_{\text{phot}} N_a \,, \tag{3}$$

where N^* is the average density of the excited ions on the path of the beam, N_a the density of the atoms, ω the transition frequency, $\Delta\omega$ the width of the spectral line produced as a result of the spontaneous emission, and w the probability of spontaneous emission per unit time. Although the quantity N^*/N_a is very small,the quantity $\pi^2 c^2/\omega^2\sigma_{\text{phot}}$ is quite large. Therefore, by varying the laser parameters, it is possible to create conditions under which the foregoing inequality is satisfied. Then a laser constructed in according with the indicated scheme will generate photons with energies exceeding the ionization energy of the atoms. It must be noted that a beam of such photons has in air a path length of about 10^{-2} cm and is absorbed as a result of photoionization of the molecules.

The proposed laser makes it possible to obtain amplification in the region of photon energies on the order of ten electron volts. By varying the angle between the ion beam and the laser beam, and also the velocity of the ion beam, it is possible to vary continuously the frequency of the electromagnetic wave in a small frequency interval by using the Doppler frequency shift. For the same reason, it is possible to operate in such a design at one of two frequencies, $\omega = \omega_0 \pm v_x/c$, where ω_0 is the frequency of the transition between the ion levels, and v_x is the beam velocity along the resonator axis.

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SUBMILLIMETER CW GAS LASER

S. F. Dyubko, V. A. Svich, and R. A. Valitov
Kharkov State University

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The development of a cw laser using water vapor and chemical compounds containing cyan was reported in [1]. The laser generated at several wavelengths from 79 to 340 μ but, as reported in [1], the cw power did not exceed several microwatts.

To assess the possibility of increasing the power, we constructed an experimental laser 3 m long with inside tube diameter 70 mm. The mirrors of the non-confocal resonator were made of glass and had a diameter 70 mm. The glass surface was silvered by vacuum sputtering. The radiation was extracted from the resonator through an opening in the center of one of the mirrors. The output window of the laser was sealed with a sapphire plate 0.3 mm thick for the