does not exceed about 0.5% and it is obviously impossible to observe the CW at the hole values $\omega\tau \sim 200 - 300$ possessed by the better of the samples at 0.6°K and 19 GHz.

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POSSIBLE METHOD OF OBTAINING ULTRACOLD NEUTRONS BY REFLECTION FROM MOVING MIRRORS

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When neutrons with velocity smaller than a certain limit $v_{lim} \simeq 5 - 6$ m/sec are normally incident from vacuum on a medium with appreciable positive coherent scattering length, they experience specular reflection [1 - 4]. We shall call such neutrons ultracold neutrons (UCN).

Research with UCN is of considerable interest [5, 9]. However, their fraction in neutron fluxes from moderators is extremely small. We discuss below the possibility of obtaining UCN by decelerating faster neutrons by a series of successive reflections from suitably moving mirrors. We shall show that in the case of a pulsed source it is possible to increase appreciably the yield of UCN from neutron fluxes by this method.

Neutrons are specularly reflected from a medium when the neutron-velocity component $v_{\perp}^{rel}$ normal to the surface, relative to the "mirror," does not exceed v_{lim}.

Let $\vec{v}$ and $\vec{u}$ be respectively the velocities of the neutron and the mirror, and let $\vec{n}$ be the unit vector of the outward normal to the reflecting surface of the medium. Then $v_{\perp}^{rel} = \vec{n}\cdot\vec{v} - \vec{n}\cdot\vec{u}$ and it can be readily verified that the neutron velocity after reflection is

$$\vec{v}' = \vec{v} + 2\vec{n}(\vec{n}\cdot\vec{u} - \vec{n}\cdot\vec{v}).$$

Inasmuch as $v_{\perp}^{rel} < v_{lim}$, the maximum decrease in velocity equals $2v_{lim}$. Thus, by causing the neutron to be reflected successively from a properly moving mirror (or system of mirrors), it is possible to reduce gradually its velocity to an arbitrarily low value. We note that the minimal number of reflections n_{min} necessary to decelerate completely a neutron having a velocity v is equal to $v/2v_{lim}$; in particular, if $v \simeq 2000$ m/sec, then $n_{min} \sim 10^2$.

Because the number of reflection may greatly exceed this value under real conditions, it is very important to determine the maximum number of possible specular neutron reflections from such mirrors without a noticeable loss of intensity. Unfortunately no reliable theoretical estimates of this number have been obtained as yet. In the experiment of Shapiro et al.

[8], the lifetime of UCN in a copper tube of ~10 cm diameter exceed 200 sec. During that time the neutrons should experience about 10^4 collisions with the walls. Of course, when the neutron velocity is increased, a decrease in the reflection coefficient is expected, owing to effects connected with the quality of the surface (diffuse scattering and inelastic interaction of the neutrons with the vibrations of the atoms localized near the surface). However, the already reported results [6, 7] give grounds for hoping that the development of mirrors having a sufficiently high neutron reflection coefficient is technically feasible (we note that the inelastic interaction effect can be greatly reduced by cooling the mirrors).

Let us consider two variants of moving-mirror systems.

Let a neutron of velocity v travel perpendicular to the surface of a flat mirror moving with deceleration in the same direction (see Fig. 1), and let the mirror velocity at the instant of collision be u. The neutron will be reflected if $v - u \equiv \Delta < v_{lim}$, and its velocity will decrease by an amount 2Δ. If the mirror is uniformly decelerated with deceleration $-a$, then after a time $t_1 = 2[(v - u)/a] = 2\Delta/a$ the neutron will again collide with the mirror. Its velocity will then exceed the mirror velocity by the same amount Δ as in the first collision, and therefore after the second collision the neutron velocity will again decrease by an amount 2Δ. The deceleration will terminate when the number of collisions between the mirror and the neutron, n_0, will satisfy the condition $u = 2(v - u)n_0 < \Delta < v_{lim}$; when $v >> v_{lim}$ we get $n_0 = u/2\Delta$ and the entire deceleration process lasts a time $t_n = 2\Delta n_0/a = u/a$.

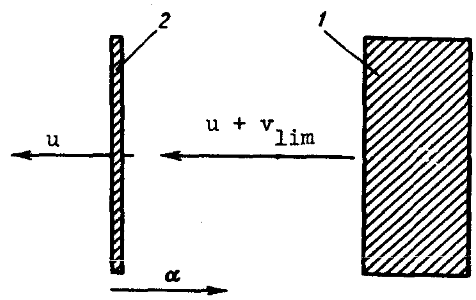

Fig. 1. Diagram of setup for producing UCN by successive reflection of neutrons normally incident on a flat decelerating mirror: 1 - pulsed source of cold neutrons; 2 - decelerating flat neutron mirror; u - mirror velocity, a - mirror acceleration.

A setup based on this method should include as the main units a flat neutron mirror executing reciprocating motion, and a pulsed source of cold neutrons, synchronized with the motion of this morror.

To obtain UCN (when $v >> v_{lim}$) it is possible to use neutrons that travel only in a narrow solid angle near the normal to the surface of the mirror, with an average value (when Δ changes from zero to v_{lim})

$$d\Omega_{eff} = \pi/3(v_{lim}/v)^2.$$

As the second variant, we consider successive reflection of a neutron from a curved uniformly moving mirror (see Fig. 2). Let the neutrons from the source be incident on the mirror in directions close to its axis, with velocities differing from its doubled velocity by not more than v_{lim}, i.e., $v_{lim} \geq |v - 2u|$. The condition $v^{rel} = v_{lim}$ is satisfied only for neutrons colliding with the peripheral part of the mirror, forming an effective surface in the form of a narrow ring of width $\delta = 2R_m v_{lim}^2/v^2$, where R_m is the radius of the mirror. If the first collision of the neutron with the mirror is elastic, then the succeeding collisions

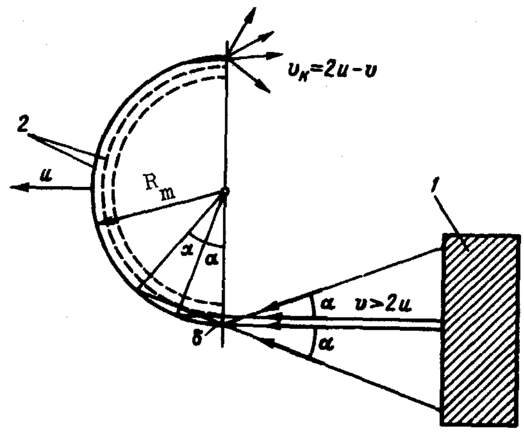

Fig. 2. Setup for obtaining UCN by successive reflection of neutrons from a spherical uniformly moving mirror: 1 - pused source of cold neutrons; 2 - system of concentric neutron mirrors moving uniformly with velocity u; R_m - radius of neutron mirror; v - velocity of neutron; $v_k = 2u - v$ is the neutron velocity on leaving the mirrors; α = arc tan $[v_{lim}/(v - u)]$ - limiting glancing angle of the neutrons reflected from the mirrors in the coordinate system attached to the mirror; δ - gap between neighboring mirrors.

will be elastic. As a result of each elastic collision with the mirror, the relative velocity of the neutron v^{rel} will turn through an angle 2α, where α is the angle between the neutron velocity before the first collision and the tangent to the mirror at the point of this collision. As a result of $k \approx \pi/2\alpha$ elastic collisions the neutron relative-velocity vector will turn through an angle close to π and the neutron will leave the mirror with a velocity $v_k = 2u - v$. To increase the "transmission" of a setup of this kind, it is necessary to use a system of mirrors in the form of a set of concentric hemispheres. The translational motion of the mirror can be replaced by rotation with a radius $\rho >> R_m$. Estimates show that the average effective angular width of the neutron beam, within which UCN are porduced by this method, is

$$\delta\Omega_{eff} = 4\pi/9(v_{lim}/v)^2.$$

The following setup is technically feasible: mirrors with $R_{m\ max}$ = 2 cm are placed on a wheel of radius ρ = 50 cm rotating at 4000 rpm (v ≈ 200 m/sec).

Let us consider by how much is it possible to increase the flux of UCN obtained by the method described above, compared with the fraction of UCN from neutron fluxes from moderators. we assume that the flux of the neutrons leaving the moderator is of the form

$$N(v)dv = 2(v^3/v_T^4)e^{-v^2/v_T^2}dv$$

($v_T = (2kT/m)^{1/2}$, T - temperature of medium, k - Boltzmann's constant). The normalization constant is chosen to satisfy the condition $\int_0^\infty N(v)dv = 1$. The fraction of UCN in such a spectrum is

$$N_0 \equiv \int_0^{v_{av}} N(v)dv = (1/2)(v_{lim}/v_T)^2.$$

In the case of room temperature, this quantity amounts to 3 x 10^{11}, and in the case of helium temperature to 2 x 10^{-7}.

It was shown earlier that when UCN are obtained by reflection from mirrors, a narrow part of the neutron spectrum is decelerated, in the interval from a certain velocity v to $v + v_{lim}$. It is possible to decelerate here neutrons that travel in the narrow solid angle $d\Omega_{eff} \sim (v_{lim}/v)^2$. The final gain in the flux of UCN compared with their fraction in the flux from the moderator is

$$q = \frac{d\Omega_{eff}}{2\pi} \frac{1}{N_o} \int_{v}^{v+v_{lim}} N(v)\, dv \sim \frac{v}{v_{lim}}.$$

When $v = 2 \times 10^3$ m/sec we have q = 300.

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CONCERNING THE NATURE OF THE COSMIC ISOTROPIC X-RADIATION

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The energy spectrum of the cosmic isotropic x-radiation shows a break at an energy $E_\gamma \sim 20 - 40$ keV. The soft part of the spectrum ($E_\gamma < 20$ keV) was interpreted many times as the radiation from the heated intergalactic plasma [1 - 4]. In the very latest papers, the very soft part of the spectrum ($E_\gamma \sim 0.3$ keV) is interpreted as the manifestation of discrete x-ray sources (cf., e.g., [5]). It seems to us that it is advantageous to explain the entire spectrum of the isotropic x-radiation by means of a single mechanism in the entire observed range (with the exception of the point $E_\gamma \sim 0.3$ keV [4]).

The proposed mechanism is the inverse Compton effect of the metagalactic electrons on the relict radiation (this process has been used many times to explain the short-wave part of the spectrum).

To verify this hypothesis, it is advantageous to compare three quantities: 1) the power exponent of the elctron and x-ray spectra before the kink; 2) the exponents of the electron and x-ray spectra after the kink, and 3) the energies of the electrons (E_{e0}) and of the x-rays ($E_{\gamma 0}$) at the "points" of the kinks of the spectra.

The exponents γ_e of the electron spectra can be determined from the averaged values of the spectral index α of the radio emission, assuming in first approximation that the energy spectra of the electrons are the same in the galxy and in the metagalaxy. Using the values of the spectral index α for a large number of radiogalaxies, given in [6], and the well known relation $\gamma_e = 2\alpha + 1$, we can obtain the values of γ_e listed in Table 1.