Influence of intense coherent electromagnetic radiation on several types of radioactive decay

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Optical laser radiation

Many configurations have been proposed to use high-power laser radiation for acceleration of the charged particles [1]. Required power density for such experiments varied from 10^{18} W/cm^2 up to 10^{20} W/cm^2. For example, X-rays of MeV energy have been produced by accelerated plasma electrons when laser beam with intensity of $5*10^{18}$ W/cm^2 was focused on tantalum sheet. Energy of these X-rays was high enough to initiate a set of nuclear reactions, which have been registered experimentally [2].

We investigate an influence of coherent electromagnetic radiation on different types of radioactive decay. Our experiments indicate that some nuclear reactions can be initiated even at laser beam intensity about $1*10^{12}$ W/cm^2. The key feature is the presence of metallic (chemically inactive Au as a rule) nanoparticles. In plasmon resonance regime the wave field near nanoparticles can be concentrated up to the necessary level. Layout of the typical experiment is shown on fig. 1.

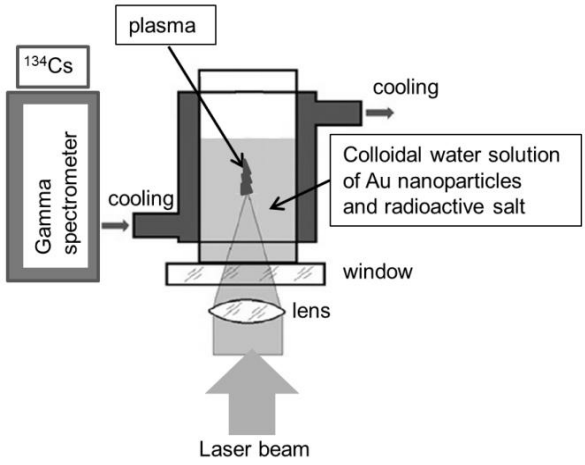

Fig. 1. Layout of the experiment on irradiation of water solution of the radioactive salt by the medium-power laser in presence of the metallic nanoparticles

We use several types of optical and near-infrared lasers – Cu vapor, femtosecond Ti:sapphire, 90-ps Nd:YAG, 350-ps Nd:YAG, 10-ns Nd:YAG, Their pulse energy varied from 0.1mJ up to 40 mJ, repetition rate varied from 10 Hz up to 20 kHz. Power density in focal region without influence of the nanoparticles varied from $1*10^{11}$ W/cm^2 up to $1*10^{12}$ W/cm^2. Nanoparticles being used in our experiments are produced by laser ablation by metal target in the water.

We have observed partial Hg transmutation into Au inside heavy water D_2O [3]. Laser irradiation in presence of Au nanoparticles initiates the decay of ^{232}Th [4]. Very exciting result was a significant (up to 50%) decrease of gamma-activity of ^{238}U and ^{235}U series after laser irradiation in presence of beryllium nanoparticles [5].

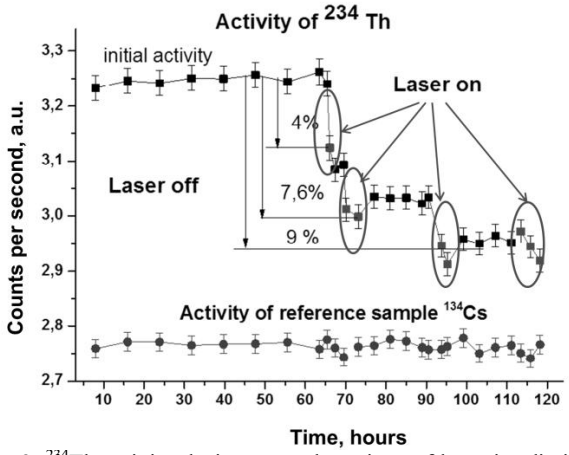

Fig. 2. ^{234}Th activity during several sessions of laser irradiation of UO_2Cl_2 water solution in presence of Au nanoparticles as the laser wave concentrators. ^{134}Cs is a reference sample

Figure 2 presents the results of long-time measurement of the ^{234}Th activity during several sessions of laser irradiation. Each session decrease the activity. Effect of each next irradiation is less than the previous one due to fragmentation of nanoparticles and their escape from the plasmon resonance.

Microwave radiation

There are some similar experiments in microwave and radiofrequency regions. 3 GHz radiation caused increasing the ^{51}Cr activity at 1% [6]. 0.07% of the ^{137}Cs activity growth was registered during irradiation of the sample by 4.1 MHz and 1.55 MHz radiation with a maximum power of 50 kW [7]. Our experiment using 30 GHz FEM shows about 1.5% variation of the ^{152}Eu activity [8]. In all these experiments there were no special measures to increase the power density.

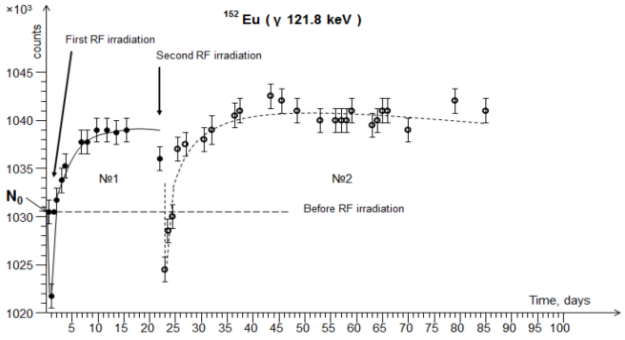

Fig. 3. Activity of the ^{152}Eu during two irradiations by 15 MW 30 GHz JINR-IAP FEM oscillator

Field concentrators in microwave experiment

We assume that all changes in the rate of the radioactive decay were caused by the charged particles accelerated in the plasma, produced in focal region in presence of field concentrators (metal nanoparticles). We have in mind that the power density about $1*10^{18}$ W/cm^2 is enough to produce some types of nuclear reaction without special field concentrators. Estimation of the maximal energy of the proton inside the electromagnetic wave with wavelength λ and intensity I can be done by [9]:

$$E_{\max} = 3.6 * \lambda \sqrt{I / 10^{18}}, \quad (1)$$

where E_{max} is in MeV, λ in microns, I in W/cm^2. Indeed, the wave with length of 1 micron and intensity of $1*10^{18}$ W/cm^2 can accelerate protons up to 3.6 MeV, which is more than the threshold of many nuclear reactions. In our experiments with power densities of $1*10^{12}$ W/cm^2 the presence of field concentrators (nanoparticles) can increase the field intensity up to 10^5 and (nanoparticles dimers) to 10^6 times.

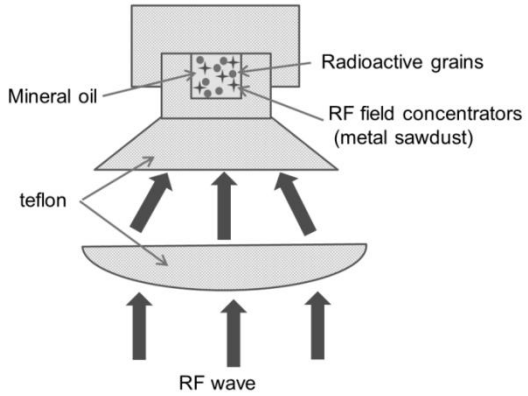

Fig. 4. Proposed layout of the experiment on the RF irradiation of the radioactive sample. Metal sawdust should be the RF field concentrators

Let us estimate the necessary rate of field concentration in microwave region. For wavelength of 1 cm (10^4 microns) the desired proton energy of 3.6 MeV requires the field intensity of $1*10^{10}$ W/cm^2. The diffraction limits the area of focal spot by 1 cm^2, so we need or 10 GW radiation source, or 10 MW radiation source and $1*10^3$ times field concentrators. For microwave region the role of the field concentrators can play metal sawdust. The layout of proposed experiment is shown on fig. 4.

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