HIGH-POWER MONOCHROMATIC GAMMA RADIATION SOURCES ON THE BASIS OF META-STABLE NUCLEI DISCHARGE INDUCED BY MUON CAPTURE AND NUCLEAR SENSORS

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The problem of creation of the high power monochromatic gamma radiation source and possible nuclear sensors is investigated. The possible approach is based on effect of discharge of meta-stable nuclei during μ^- capture. A nmuon captured by a meta-stable nucleus may accelerate the discharge of the latter by many orders of magnitude [1,2]. For a certain relation between the energy range of the nuclear and muonic levels the discharge may be followed by the ejection of a muon, which may then participate in the discharge of the other nuclei. We are modeling (within QED energy approach [2]) characteristics for discharge of a nucleus with emission of gamma quantum and further μ^- conversion. Three channels are taken into account: 1). radiative purely nuclear 2j-poled transition (probability *P1*); 2). Non-radiative decay, when a proton transits into the ground state and a meson leaves the nuclei with energy *E=E(p-N1J1)-E(i)*, where *E(p-N1J1)* is an energy of nuclear transition, *E(i)* is an energy of bond for meson in the *1s* state (*P2*); 3). A transition of proton into the ground state with excitation of muon and emission of the gamma quantum with energy *E(p-N1J1)-E(nl)* (*P3*). Numerical estimates are carried out for the Sc and Tm nuclei. The probabilities of the muonic atom decay for different transitions: $P2(p_{1/2}-p_{3/2})=3.9\cdot10^{15}$, $P3(p_{1/2}-f_{7/2})= 3.2\cdot10^{12}$, $P2(p_{3/2}-f_{7/2})=8.8\cdot10^{14}$. If a muonic atom is in the initial state p1/2, than the cascade discharge occur with ejection of meson on the first stage and the γ quantum emission on the second stage. To consider a case when the second channel is closed and the third one is opened, suppose: E(p1/2)-E(p3/2)=0.92 MeV. The dipole transition 2p-1s occurs with probability: P3=1.9·10(13) 1/s that is more than probabilities of the $p_{1/2}-p_{3/2}$ and $p_{1/2}-f_{7/2}$ transitions without radiation. The next transition $p_{3/2}-f_{7/2}$ occurs without radiation during 10(-15) s with ejection of the muon. The velocity of discharge for the target excited nuclei is defined by intensity of muon flux and coefficient of multi-time discharge. The necessary parameters are now reached for example on the meson factory in Los-Alamos. The requirement of high stability of the states [T-10(8)s] and sufficiently high transition energy [>Z(2)·2.8keV] transition limits a range of nuclei for observation of the effect. Our estimates show that the new high-energy transitions (with muon conversion) can occur in a sample radiated by muons and any long-lived isomer with high-energy transitions can be used for observation of effect and creating high-energy gamma radiation source.

References

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