Contribution ID: **4** Type: **Poster**

Physics of laser-assisted nuclear processes

Monday, 2 May 2022 19:00 (1h 30m)

A considerable progress during the past decades was achieved in investigation of the interrelation of the atomic structure with the nuclear processes. Nuclear isomers can be effectively triggered by making use of a resonance with the electronic transitions, which can be further tuned either through changing the electron shell, or irradiating with resonance field of a laser [1,2]. Thus, it was predicted that the decay of the 229Th isomer would be by ~700 times faster in the hydrogen-like ions. The lifetime of the nucleus in the crystal matrix also may vary.
New mode of nuclear decay: resonance conversion (RC) was predicted, suitable for the purposes of triggering. RC was discovered in fragments of prompt fission in muonic atoms [3] and 35-keV transition in 125Te [4]. The effect has to be especially strong in heavy ions, where RC can be observed in its undamped mode.
Moreover, experiments show influence of the electronic shells on the processes, mastered by other fundamental interactions, e.g. beta decay of isomers. Thus, effect of the electronic shake on the double e-capture diminishes the lifetimes of the parent nuclei by several times. There is a comparative study of α decay in H-, He-like ions on the urgent agenda, with respect to that in neutral atoms.
The resonance properties of the electron shell are of extreme importance for creation of the nuclear clock. From the other side, it is generally accepted that the nuclear properties, specifically the radioactive decay constant, are essentially independent of the physical environment. Such stability against the environmental medium underlies the idea of the nuclear clock. This is in contrast with what is said above. In fact, in the case of the nuclear deexcitation through the resonance conversion (or electronic bridge), the decay probability turns out to be directly proportional to the atomic width. Therefore, it may be mastered by simple factors, such as ambient temperature and atmospheric pressure. This dependence may be directly related to the thorium puzzle of the short lifetime in the single ions [3]. Especial features of the electronic-nuclear resonance are discussed.

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Session Classification: Poster Session On Site