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Raman cooling of Yb^{3+}- doped nanocrystals

Tatiana A Vovk, Semyon S Rudyi, Andrei V Ivanov and **Yurii V Rozhdestvensky**
ITMO University, Russia

The possibility of deep cooling of nanocrystals draws special attention of researchers among the globe due to the implementation of the transition from the classical state of a nanoparticle to its quantum state. In this case the direct observation of such effects as wave function reduction or quantum states of viruses is feasible. Recently it was proposed to use the transition $^2F_{7/2} \rightarrow {}^2F_{5/2}$ of Yb^{3+} ions for the deep cooling of nanocrystal (down to $T \simeq 10^{-8}$ K). Due to its large mass, the time of optical cooling considerably increases in comparison with the case of single atoms, which leads to the necessity of utilizing of the radio-frequency (RF) Paul trap for spatial localization of the nanocrystal. In this work, we investigate the possibility of obtaining the translational temperature $T<10^{-8}$ K for Yb-doped nanocrystals when the states are excited through the upper D-state of the three-level system. In terms of the nanocrystal cooling only average recoil can be considered, and the peculiarity of Raman cooling is the dependence on the intensity of optical radiation. Thus, for low laser intensities a deeper cooling is obtained. The latter circumstance is important because the transitions that are used to in the cooling process are situated in the ultraviolet region of the spectrum. Accordingly, even with a weak excitation of Yb^{3+} ions, one can obtain a deep translational cooling of the entire nanocrystal. In this case, it is evident that the interaction time for obtaining of low temperatures increases, which is of negligible importance for the nanoclusters localized in the Paul trap. We will perform and present a numerical simulation of the trajectory of Yb-doped nanocrystal localized in RF trap during its Raman cooling and perform numerical estimates of the nanocrystal temperature for various optical radiation intensities.

avivanoff@mail.ru