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Resolved Hyperfine Structure in the Spectra of Crystals for Optical Quantum Memory

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Abstract. A brief review is given on recent studies of the hyperfine structure and inhomogeneously broadened line profiles in the spectra of rare earth containing crystals considered as promising candidates for optical quantum memory.

Keywords: materials for optical quantum memory, rare earths, hyperfine levels

Much effort is given at present to implementation of optical quantum memory (OQM) which is supposed to be an essential part of different quantum informatics devices, in particular, of quantum repeaters intended for increasing the length of already functioning quantum cryptographic communication lines [1]. Any scheme of optical quantum memory is based on a so-called three-level Λ system. Among different systems investigated so far, the ground-state hyperfine levels of rare-earth (RE) ions in a crystal, combined with a third (metastable) level in optical frequency region are considered among the most promising candidates to realize an efficient three-level Λ system [2].

I'll briefly discuss what requirements should be met by materials for OQM and what characteristics of particular materials should be studied. Those are precise level positions, the optical density, coherence times of hyperfine levels, life times of metastable optical levels, hyperfine structure (HFS) of the energy levels, inhomogeneous broadening of spectral lines. A resent successful demonstration of the gradient echo type optical memory where the bandwidth limitations come from the HFS being unresolved [3] has put forward a task to search for crystals with resolved HFS in optical spectra.

My group, in collaboration with other institutions in Russia and abroad, studies spectroscopic properties of RE-doped crystals, relevant for applications in OQM. I'll review our recent results on the HFS studies in different crystals [4-6] and on specific peculiarities of an inhomogeneous broadening which have to be taken into account when considering applications in OQM [4,7-9].

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