NONLINEAR INTERACTIONS, EXCITED NUCLEI AND NEUTRON FEW-BODY RESONANCES IN NEUTRON STAR ENVELOPES

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The physics of neutron stars is now at the new stage of its development, and this is true not only for descriptions of the processes in the quark-gluon or strange matter in the depths and core of the stars, but also of the reactions and states of matter in stellar envelopes. Thus, reactions, and properties of substance in crystalline envelopes of neutron star are considered in the models of band theory and nonlinear interactions of quasiparticles [1,2]. Nonlinear interactions lead to a number of new phenomena and effects that occur in the neutron star envelopes.

The overdense crystals, where distances between nuclei are very small, stimulate formation of excited states of nuclei in electron capture reactions. It has been shown that the increase in number density of such excited nuclei and their nonlinear interactions lead to high harmonic generation and to induced emissions in the crystal. In its turn, the high energy gammas, while scattering on nuclei and electrons of the media, can produce neutrino-antineutrino pairs, cause photonuclear reactions and knockout of neutrons from nuclei.

It is important to note that the excited nuclei in the outer crust generated in electron capture reactions with iron nuclides of even mass numbers such as ^{54}Fe, ^{56}Fe, ^{58}Fe or ^{58}Ni, ^{62}Ni, cannot emit gamma quanta within the overdense lattice in the usual way, and the number of excited nuclei should grow in the appropriate layer of the envelopes.

When the density of excited nuclei reaches some critical value, the nuclei in highly excited states will appear, like a high harmonic generation in nonlinear optics.

This means that the energy of a highly excited nucleus is already enough to trigger such reactions as emission of high harmonics gamma rays or free nucleon. Thus, in the envelopes of the neutron star, gas of free neutrons can occur even in the lower layers of outer crust at $\rho \geq 7.155 \cdot 10^9 g \cdot cm^{-3}$; or even in the layers above if we take into account the chains of reactions with ^{54}Fe and ^{58}Ni. Presence of free neutrons in the outer crust can cause a range of other reactions and effects [3,4].

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