BASIC FEATURES OF COHERENT NUCLEAR FLUORESCENCE

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Coherence is one of the fundamental characteristics of oscillatory and wave processes. Amazing examples of coherence conservation in nature are radiative transitions in nuclear isomers. At a wavelength in a g-ray wave packet of about one angstrom, the strict phase correlation can extend for tens of meters! This possibility is primarily indicated by unusually long lifetimes of nuclear isomers and the corresponding small widths of energy levels in the isomeric states. A remarkable feature of the Mössbauer effect is that, thanks to it, the gamma radiation emitted by a nucleus can preserve and carry off the property of coherence of nuclear transitions into space and time.

Owing to the Mössbauer effect, it is possible to observe interference and diffraction upon elastic scattering of gamma quanta by an ensemble of nuclei in a crystal. In such processes, a delocalized excitation of nuclei by a single quantum is formed, which we call a nuclear exciton. The crystal acts as a kind of macroscopic quantum resonator. Since the multipolarity of excited nuclear transitions can differ from the multipolarity of transitions in atomic electron shells, it is possible to obtain in the certain crystals a purely nuclear coherent response without any admixture of electron scattering. The pure nuclear diffraction served as the cornerstone in the development of the Synchrotron Mössbauer Source of radiation of the ^{57}Fe isomer. In the source, the pumping of nuclei with synchrotron radiation pulses is accompanied by intense coherent nuclear fluorescence. We will consider the basic features and some unique applications of this phenomenon.