DESCRIPTION OF THE PROJECT: PASSRA

Periodic Atomic Structures for Sources of coherent RAdiation

Coherent processes are studied very well for simple (mainly monoatomic) structures of the single crystals. It seems that investigations such complex single crystals as PWO, BGO and others is very interesting in present time. These single crystals will be used as electromagnetic calorimeters at high energies of particles and knowledge of coherent contribution in total energy losses is useful for understanding of processes in calorimeters. On the other hands the crystals as PWO are possessed high mean Z-value and due to this fact one can expect the very high electric planar and axial fields. Because of this investigations of channeling and channeling radiation are also interesting.

It is well-known that passage of electrons (positrons) through the crystalline medium is accompanied by their radiation. This radiation is strongly differ from the corresponding radiation in an amorphous medium. As samples of such processes in crystalline medium one can point out the coherent bremsstrahlung, channeling and transitition radiation. From this list one can choose the coherent bremstruglung as example of process which was successfully used in various applications in practice of accelerators (as electron such as proton ones) in the first place as the power source of the linear polarized quasimonochromatic high energy photons. However, in this case to utilize the process it is necessary to take into account the enough strong requirements for the angle characteristics of electron beams. These requirements grow when energy of electron beam is increased. Besides, at energies in some hundreds GeV the coherent bremsstruhlung transform in another type of radiation (magneto bremsstrahlung), which have less degree of linear polarization and quasimonochromasity. One of cause of the such behaviour of the bremsstrahlung process is the enough small size of the fundamental cell of the most single crystals (in some angstroms). Strictly speaking the effective angle area of the coherent bremsstruhlung process depend on the value of the least nonzero module of reciprocal vector (than this vector is smaller, then angle area is more large). For this reason new materials with large size of lattice period are very promissing like sources of coherent radiation. In our project coherent bremsstruhlung in nanostructures and new high -Z single crystals is considered.

Considerable advances have been made in recent years in the creation of the various nanostructures and particularly in the synthesis of so-called carbon nanotubes. In paper [1] the superlattice of single-wall nanotubes was described. According to this paper the single-wall nanotubes are uniform in diameter and they self-organize into ropes, which consist of 100 to 500 nanotubes in a two-dimensional triangular lattice with a lattice constant of 17 angstroms. For this structure in a number of papers the channeling, channeling radiation and coherent bremsstruhlung were considered. As expected these processes one can utilize for aims of the high energy physics, such as beam deflection, photon linear polarization sources, etc. The work for creation of necessary nanotube samples is in progress in LNF (Frascati) [2] .

Except the nanotube superlattice there are exist another lengthy periodic nanostructures. For instance, the alumina nanohole structure represent the close to periodic structure of holes starting with 150 angstrom in the diameter [3].

Our consideration of coherent bremsstrahlung in (10,10) armchair single-wall nanotube lattice [4] show that this process take place in the large angle range with high intensity. Figs.1,2 illustrate the calculated intensity of coherent bremstrahlung on above-mention nanostructure for the energy of electron (positron) beam equal to 0.5 GeV. One can see from here that the calculated values of coherent bremsstrahlung intensity is enough large and may be detected experimentally. From this figures we can obtain the necessary requirements for electron beam.

It is easy to see from figs.1,2 that the coherent effect will be observed at condition that the divergence of electron beam is equal to + - 1 mrad in one plane (in other plane this value may be in some times more). We excpect that the process of coherent electron-positron pair production must be also exist in nanotubes lattice and from observation one of them (coherent bremsstruhlung, for instance) follows existance another. The process of coherent pair production have the important meaning in creation of gamma-polarimeters (for example, for future gamma-gamma, e-gamma colliders) .

Note, that coherent processes are studied very well for simple (mainly monoatomic) structures of the single crystals. It seems that investigations such complex single crystals as PWO, BGO and others is very interesting in present time. These single crystals will be used as electromagnetic calorimeters at high energies of particles and knowledge of coherent contribution in total energy losses is useful for understanding of processes in calorimeters. On the other hands the crystals as PWO are possessed high mean Z-value and due to this fact one can excpect the very high electric planar and axial fields. Because of this investigations of channeling and channeling radiation are also interesting.

Experimental setup for observation of radiation spectra in oriented nanosamples and high-Z crystal samples is already exists in BTF area. Existing lead glass calorimeter can be used for gamma detection because of essentially high energy of particles .

So, for successful start of the project only small additional magnet with $Bl = 0.1$ Tl×m is needed.

Goals of the project

The goal of the experiment is observation and understanding of coherent effects in electron/positron radiation in periodic nanostructured materials and in high-Z crystal lattices like $PbWO_4$, BGO and zeolites.

Schedule of the work.

Only one visit to LNF is planned: one week for general approach, beam arrangement, support and alignment for the samples, electron, positron and photon diagnostics. Data taking (10-20 days).

Beam requirements.

The beam required for the experiment is electrons/positrons of high energy, about 100 - 700 MeV, low intensity.

Support neede.

For successful start of the project only small magnet with $Bl = 0.1$ Tl×m is needed in addition to existing experimental setup.

References

[1] A. Thess, R. Lee, P. Nikolaev et. al. Science, 273 p.484, 1996;

[2] S. Bellucci Talk on Wokshop "Relativistic Channeling and Related Coherent Phenomena", March 23-26, 2004, INFN, Frascati;
[3] S. Shingubara Talk on Wokshop "Relativistic Channeling and Related Coherent henomena", March 23-26, 2004, INFN, Frascati;
[4] S.Bellucci, V.M.Maisheev Talk on Wokshop "Relativistic Channeling and Related Coherent Phenomena" March 23-26, 2004, INFN, Frascati;

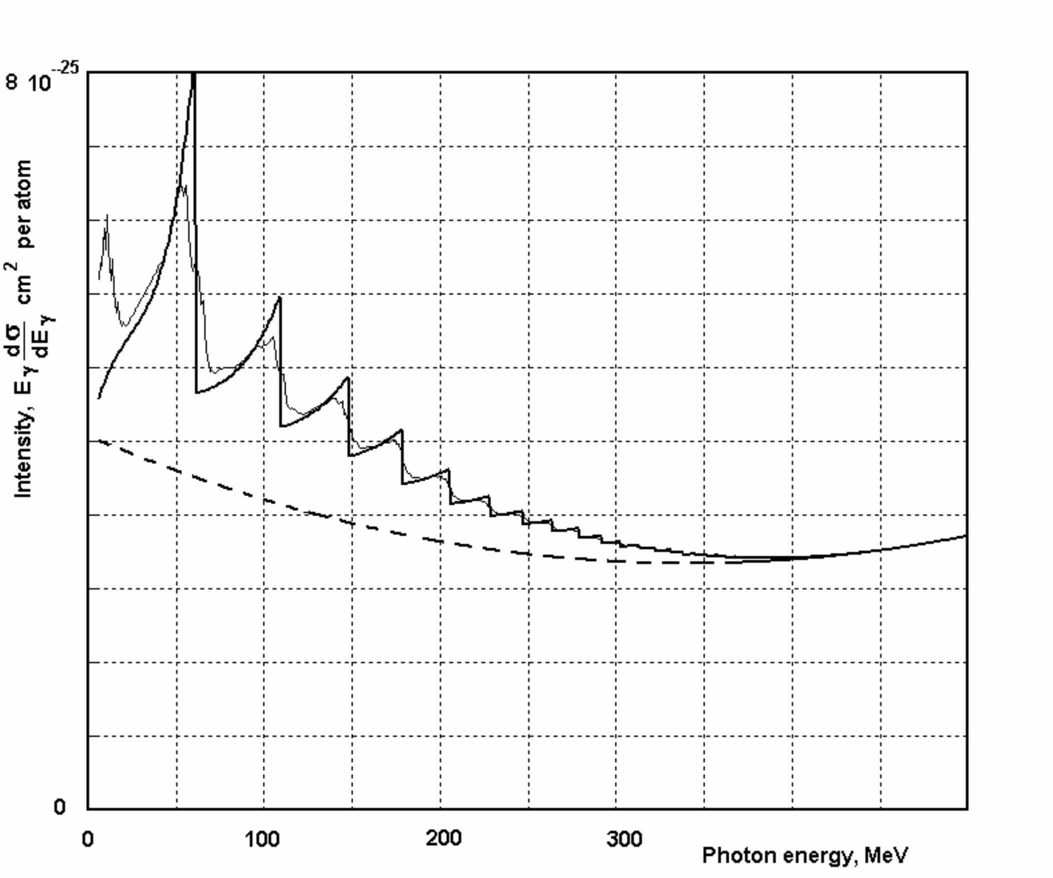

Fig1. The intensity of the coherent bremsstrahlung on the superlattice of (10, 10) single-wall nanotubes at energy electron (positron) beam 0.5 GeV. Thick line is for Theta_x = 0 mrad, thin line is for Theta_x= 1 mrad, Theta_y= 50 mrad for both curves, the dashed line is incoherent intensity.

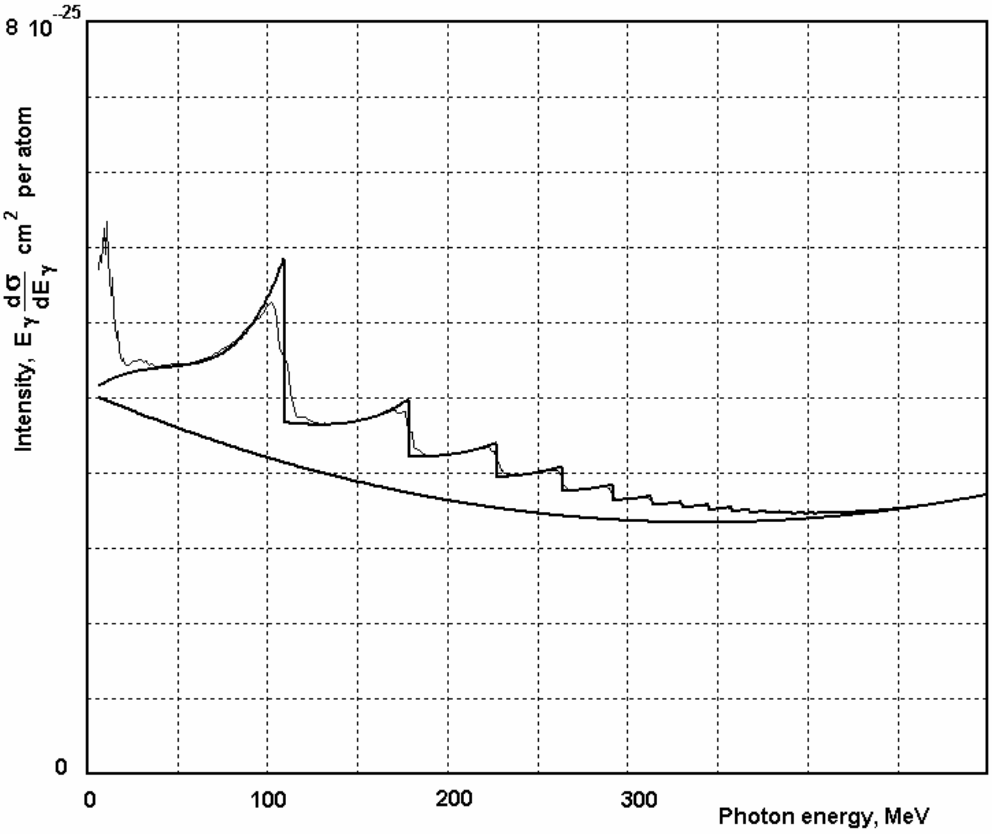

Fig2. The intensity of the coherent bremsstrahlung on the superlattice of (10, 10) single-wall nanotubes at energy electron (positron) beam 0.5 GeV. Thick line is for Theta_x = 0 mrad, thin line is for Theta_x= 1 mrad, Theta_y= 100 mrad for both curves, the dashed line is incoherent intensity.