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Study of the characteristics of high-energy proton-induced gamma ray and neutron emissions from materials that imitate surfaces of planets

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A proposed ISTC Project is discussed in the present paper. The proposal is aimed at experiments to determine the space-energy characteristics of the neutron and gamma ray emission fields generated by 0.2-0.8 GeV proton irradiation of thick targets composed of various elements.

At present, reliable data on physical properties of secondary radiation from materials irradiated by intermediate- and high-energy protons for some fundamental and applied researches in astrophysics, space physics, atomic and nuclear physics, as well as for designing and operating the latest accelerators are lacking.

The said researches include:

- determination of the elemental composition of planetary surfaces monitored by satellites capable of recording neutrons and γ-rays (orbital spectrometry);
- designing radiation shielding for charged particle accelerators;
- verification and validation of models and codes for high-energy hadron-nucleus interactions.

Orbital spectrometry determines the chemical abundances of planetary surfaces with little or no atmosphere and provides valuable clues to the origin and evolution of planets.

The γ-ray and neutron production in nuclear interaction of high-energy protons with matter may be simulated using proton accelerators.

Geochemical interpretation of the measurement data on γ-radiation from planetary surfaces need to be additionally verified because none of planetary rock samples have ever been recovered on the Earth. Therefore, it is very important to simulate the processes of γ-ray and neutron production in nuclear interactions of high-energy galactic and solar cosmic ray protons using proton accelerators with a view of interpreting spacecraft observation data.

The following basic results are expected be obtained under the proposed Project:

- experimental and calculated data on spatial-energy distributions of secondary γ-rays emitted backward from 0.2 GeV and 0.8 GeV proton-irradiated blocks of bulk (1.5x1.5x1.5 m^3) materials (iron, aluminum, basalt, granite, concrete);
- experimental and calculated data on spatial-energy distributions of secondary neutrons inside and outside the said blocks obtained with threshold activation detectors (Bi, Au, Co, Al).
- neutron spectral indices near the front surface space of bulk targets with and without water-filled tanks;

The data expected to be obtained under the proposed Project can be used

(1) in fundamental researches

- to monitor the elemental composition of planetary surfaces from satellites that carry monitors of ionizing radiation (for example, the MARS Odyssey Gamma-Ray Spectrometer);
- to improve models for planetary core formation and, hence, solar system history;
- to specify property concepts of astronomical bodies, that is of importance when preparing and realizing manned interplanetary missions (water occurrences, for example);
- to verify and update high-energy transport codes that simulate hadron-nucleus interactions;

(2) in applied researches

- to obtain the data required when designing radiation shielding for high-current accelerators of charged particles.