Development of Quantum Beam Technology

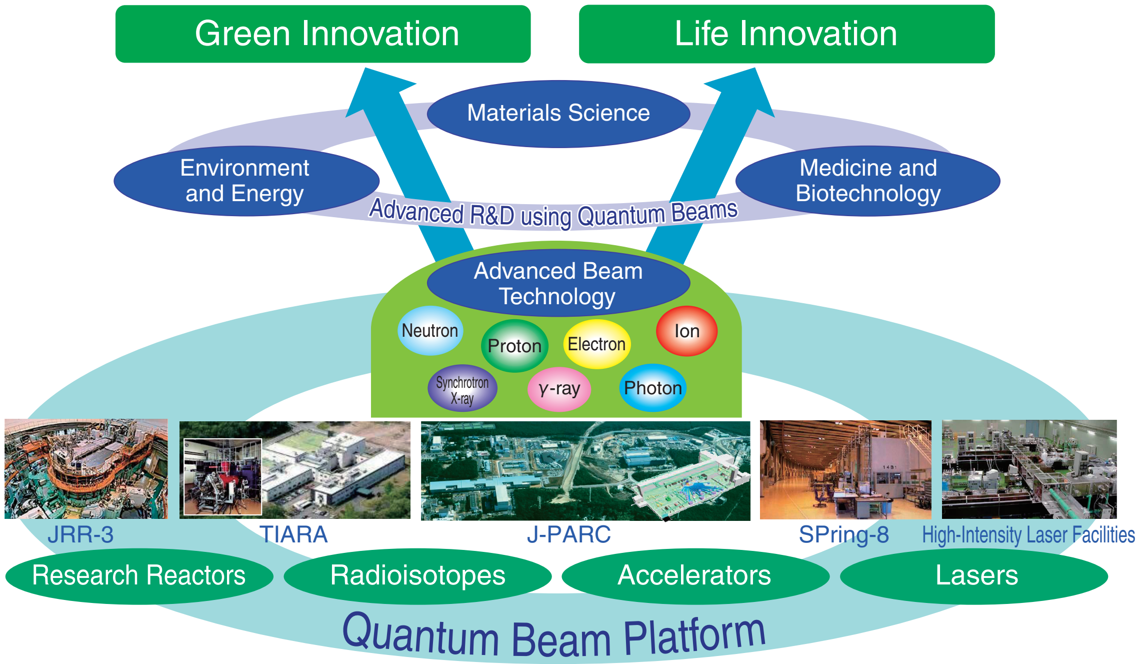

Fig.4-1 JAEA quantum beam facilities and the R&D done there

Characteristics of quantum beams

Quantum beams such as neutron beams, ion beams, electron beams, high-intensity lasers, and synchrotron X-rays have a create function, that is, they allow us to process materials on a nanometer level (atomic or molecular level) by interacting with the constituent atoms of a material to change their configuration, composition, and electronic state. Such quantum-beam interactions cause changes in the beams too, such as those in the beam direction and energy, and sometimes generate different types of quantum beams. Thus, quantum beams have a probe function as well, whereby we can obtain atomic- or molecular-level information by observing the alterations in the beam parameters.

Application of quantum beams

At JAEA, we are carrying out R&D on advanced beam technology at our beam facility complex, which includes research reactors, accelerators, and so on (Quantum Beam Platform), as shown in Fig.4-1. By utilizing the create and probe functions of quantum beams, we are promoting fundamental and applied research in a wide range of fields, such as (1) materials science, (2) environment and energy, and (3) medicine and biotechnology. We are intensively performing these R&D activities to obtain results that would lead to green innovation and life innovation, and to contribute to the progress of science and technology as well as the promotion of industry.

Recent achievements

In the field of advanced beam technology, we developed a 500-kV photocathode DC electron gun for realizing a next-generation light source, improved the reflectivity of relativistic flying mirrors for use in a high-brightness X-ray source, and developed a technology for analyzing the polarization of soft X-rays (Topics 4-1 to 4-3).

In the materials science field, we developed a new spin contrast variation technique for small angle neutron scattering, a polarization-analyzed resonant inelastic X-ray scattering method, and a multiple-length-scale observation apparatus using coherent X-rays, and used them for investigating advanced functional materials (Topics 4-4 to 4-6).

In the field of environment and energy, we succeeded in elucidating hydrogen storage mechanisms by using X-ray absorption spectroscopy, developed a novel compound efficiently separating lanthanides, and fabricated polymer adsorbents extracting rare-earth metals. Moreover, we developed a practical system to purify waste gases by using electron beams and catalysts. These results are presented in Topics 4-7 to 4-10.

In the field of medicine and biotechnology, we clarified the existence of low-barrier hydrogen bonds in photoactive yellow protein on the basis of neutron crystallography. We found that the electric field produced by heavy ions influences the generation of clustered DNA damage, and that the genetic information in plants is altered late as well as immediately after γ-ray irradiation. These findings are described in Topics 4-11 to 4-13.