4 Quantum Beam Science Research

Taking a Leading Role in Quantum Beam Technology

Quantum beams include electromagnetic waves (laser, X-ray, γ-ray, etc.), leptons (electron, positron, etc.) and hadrons (proton, neutron, ion, etc.), which possess the characteristics of both wave and particle. We are utilizing neutrons from research reactors, ions and electrons from accelerators, γ-rays, intense ultra-short pulsed lasers and synchrotron radiation, the sources of which are operated in the Kansai district, Tokai village and Takasaki city (Fig.4-1). We are promoting R&D activities as described below, making advances in science and technology and promoting industry through establishment and popularization of “quantum beam technology” as a core technology for innovation in science and technology.

What capabilities of quantum beams should we focus upon?

The fact that each quantum interacts with an atom or molecule enables fabrication with a precision of nm (the capability to “create”). The quantum beams can also observe atomic arrangement and electronic states, and identify elements in matter, through which material properties can be explored (the capability to “observe”). Moreover, as quantum beams can locally deposit huge amount of energy, they can attack cancer cells, causing little damage to other tissues (the capability to “cure”).

In which science and technology areas are we involved?

We promote R&D activities, mainly in the “Four Priority Fields to be Promoted” in the “Science and Technology Basic Plan”: development of a highly durable fuel cell membrane in the nanotechnology and materials area, structural analysis of proteins for drug discovery in the life sciences and biotechnology area, development of materials and technologies for environmental protection in environmental sciences and energy area, and development of radiation-resistant semiconductors in the information and communication technology area. In addition, in the advanced medical treatment area, technique for miniaturization of particle beam radiotherapy equipment by generating proton beams with high intensity lasers is envisioned.

What steps are we taking to promote R&D?

First, we are developing techniques to generate high quality quantum beams. We succeeded in developing the world’s highest performance supermirror for highly efficient transport and focusing of neutrons, and in generating protons up to 2.2 MeV through laser-driven acceleration.

Second, we seek to advance techniques of quantum beam application, to provide R&D results where they will lead to technological innovation and open up new possibilities. We succeeded in developing polarized neutron analysis and high magnetic field X-ray diffractometry, and applying them to determine the fine magnetic structure of magnetically frustrated compounds, and also discover a protein with new DNA repair mechanism. Moreover, as introduced in Topic 4-1, we demonstrated a new application of quantum beams to basic sciences, by proposing the existence of ferroelectric ice in the universe.

Third, for those techniques near the stage of practical use, we promote industrial application through technology transfer. For instance, we applied radiation-induced cross-linking and graft techniques utilizing electron beams and γ-rays to develop a mm-wave antenna substrate with low loss of electrical power, and to create a new flower variety by ion beam breeding. Moreover, we promote internal collaborations; for instance, applying neutrons and synchrotron radiation to residual stress measurement to solve issues in the Fast Breeder Reactor project.

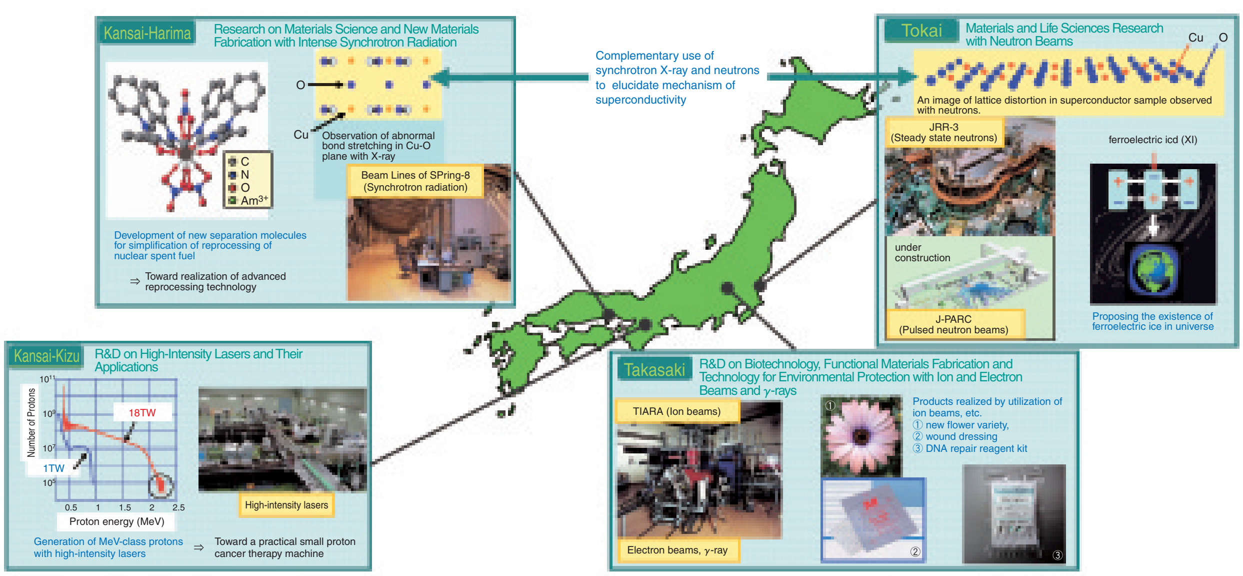

Fig.4-1 Quantum beam facilities in JAEA, with respective R&D topics