4 Quantum Beam Science Research

The Future Explored by Quantum Beam Technology

What are quantum beams?

Quantum beams are high quality beams including electromagnetic waves (laser, X-ray, γ-ray, etc.), leptons (electron, positron, etc.) and hadrons (proton, neutron, ion, etc.), which possess both wave characteristics and particle characteristics. At JAEA we are utilizing these quantum beams (neutrons, ions, electrons, γ-rays, high intense ultra-short pulsed lasers and synchrotron radiation) in innovative R&D (Fig.4-1). We thereby aim to contribute to the progress in science and technology and promotion of industry. Specifically, we are dedicated to R&D in the "Four Priority Fields to be Promoted" contained in the "Science and Technology Basic Plan".

These fields are: development of highly durable fuel cell membrane (nanotechnology and materials area), fine structure analysis of proteins aiding drug discovery, analyzing DNA damage and restoration mechanism and the creating new species (life sciences and biotechnology area), development of materials and technologies for environmental protection (environmental sciences and energy area), and development of radiation-resistant semiconductors (information and communication technology area). Further, in the advanced medical treatment area, techniques for miniaturization of particle beam radiotherapy equipment by generating proton beams with high intensity lasers are being developed.

The characteristics of quantum beams

In this R&D, the characteristics of each quantum beam are utilized effectively and organically, leading to various unique achievements only possible for JAEA.

Quantum beams are excellent at revealing structure, allowing us "to see" better, and have new fabricating functions, allowing us "to create" more. High quality beams of atoms or ions enables us to observe and create with nm level precision. Through the observation and fabrication of atomic arrangement, electronic state, and various elements, we can explore the mystery why a substance becomes superconductive, or the various functions and reactions the human body has. We also are contributing to various important tasks such as developing new medicines, catalysts of exhaust gas from automobiles using less noble metal, and post-oil fuels made from plants, which are carbon-neutral.

Recent Accomplishment

As specific examples of our accomplishments, we have experimentally demonstrated the principle of the flying plasma mirror with a high intensity laser, and this result suggests the possibility of generating ato (10^{-18}) second quantum beams from tunable lasers. In Topic 4-1 and Topic 4-5 we show our steady progress in generating high energy particles with lasers, for medical applications. In Topic 4-3 and Topic 4-6, we show the possibility of using quantum beams in basic science by analyzing the mechanism by which a material has a huge negative coefficient of thermal expansion, or a heavy ion that has a special effect on living cells. In Topic 4-4 and Topic 4-9, we applied radiation-induced cross-linking and graft techniques utilizing electron beams and γ-rays to develop a post oil material made from carbon-neutral plants, and to develop an electrolyte film that operates at the high temperatures of a fuel cell. We promote collaboration inside JAEA so as to make basic science contributions to solving problems facing the Fast Breeder Reactor project, for instance residual stress measurement with neutrons and synchrotron radiation.

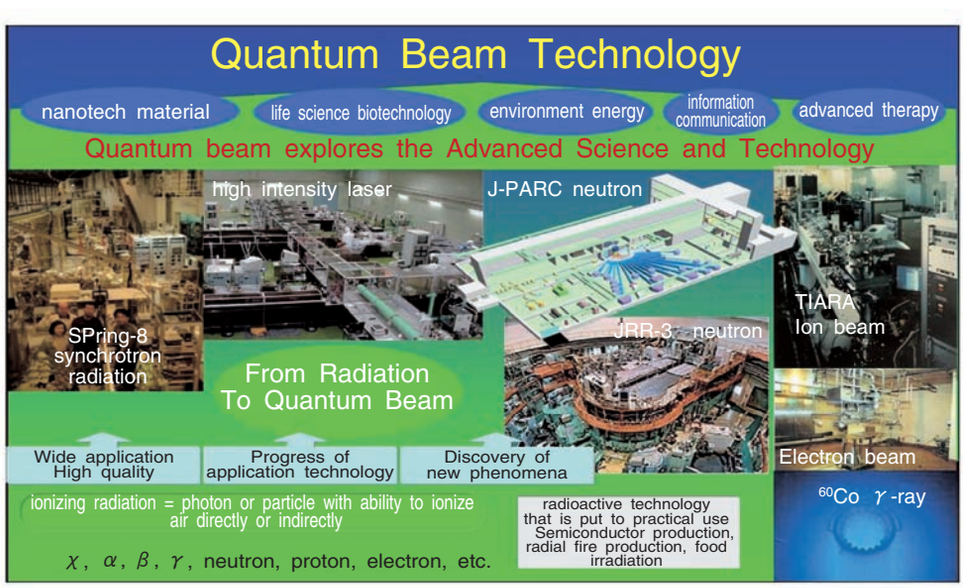

Fig.4-1 The Quantum Beam Facilities at JAEA