Comments at
A discussion on
how to accelerate commercial deployment of fusion; technology, public private partnership

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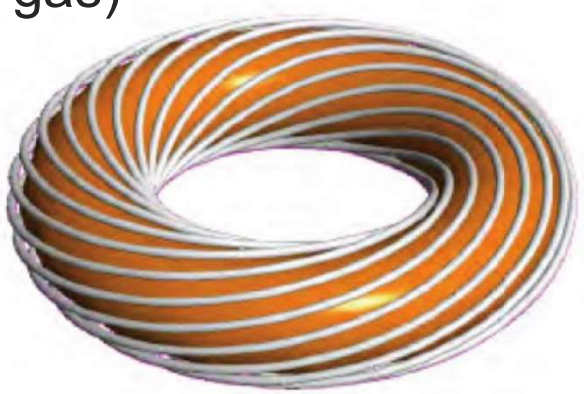
- Choice of ways to downsize a fusion reactor
- Technical challenges in SPARC towards ARC
- Vertical integration and horizontal collaboration

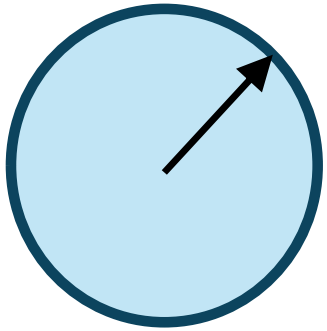
Acknowledgements to Prof.S.Imagawa at NIFS

The 126th GIST Seminar
20th Feb., 2024

Very rough sketching of confinement of fusion plasmas

- Fusion fuels are inevitably in a state of "**PLASMA**" (ionized gas) because of extremely high temperature beyond several hundreds of millions ℃
- "Confinement" is prerequisite for burning





1. Size of domain : L

2. Escaping velocity : $V \propto E / B$ (Electric field E / Magnetic field B)

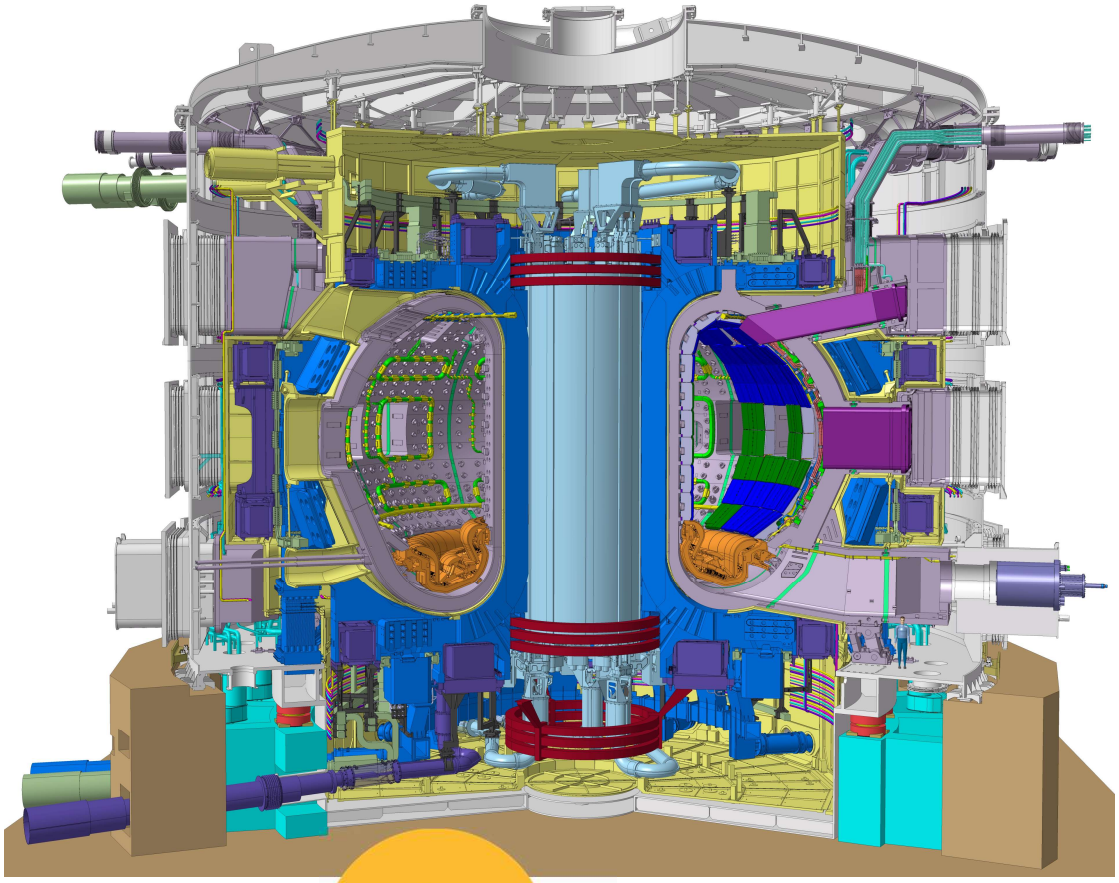
Then "confinement time" t is given by $t = L / V \propto L B / E$

- To secure sufficient t, the larger L and/or the higher B, the better

Large machine like ITER and/or high magnetic field machine like SPARC are convincing from fundamental physics

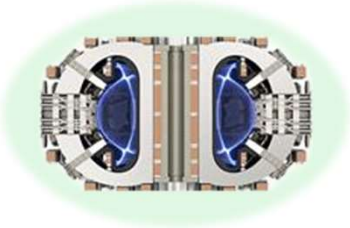
Two major issues before commercial deployment of fusion energy

1. Control of burning plasmas



2. Downsizing a machine

- Endless growth of machine is a dead end
- Economically feasible compactness



SPARC: Phys.Plasmas **30** (2023)

- Higher magnetic field would be a promising/straight attack choice
- Innovation of plasma confinement (obliged to skip this today)

Technical challenges in SPARC towards ARC

- Large scale HTS (High Temperature Superconductivity) magnet system has never been built before !! Really **first-of-a-kind**
  1. HTS is brittle material
     ➔ degradation by thermal stress and electro-magnetic force is concerned
  2. Difficulty of quench protection because of slow normal propagation velocity in HTS

  These two issues are not only of much importance for SPARC but also these resolutions have huge and wide impact on magnet technology/application

  ← **fundamental understanding** and **novel idea**

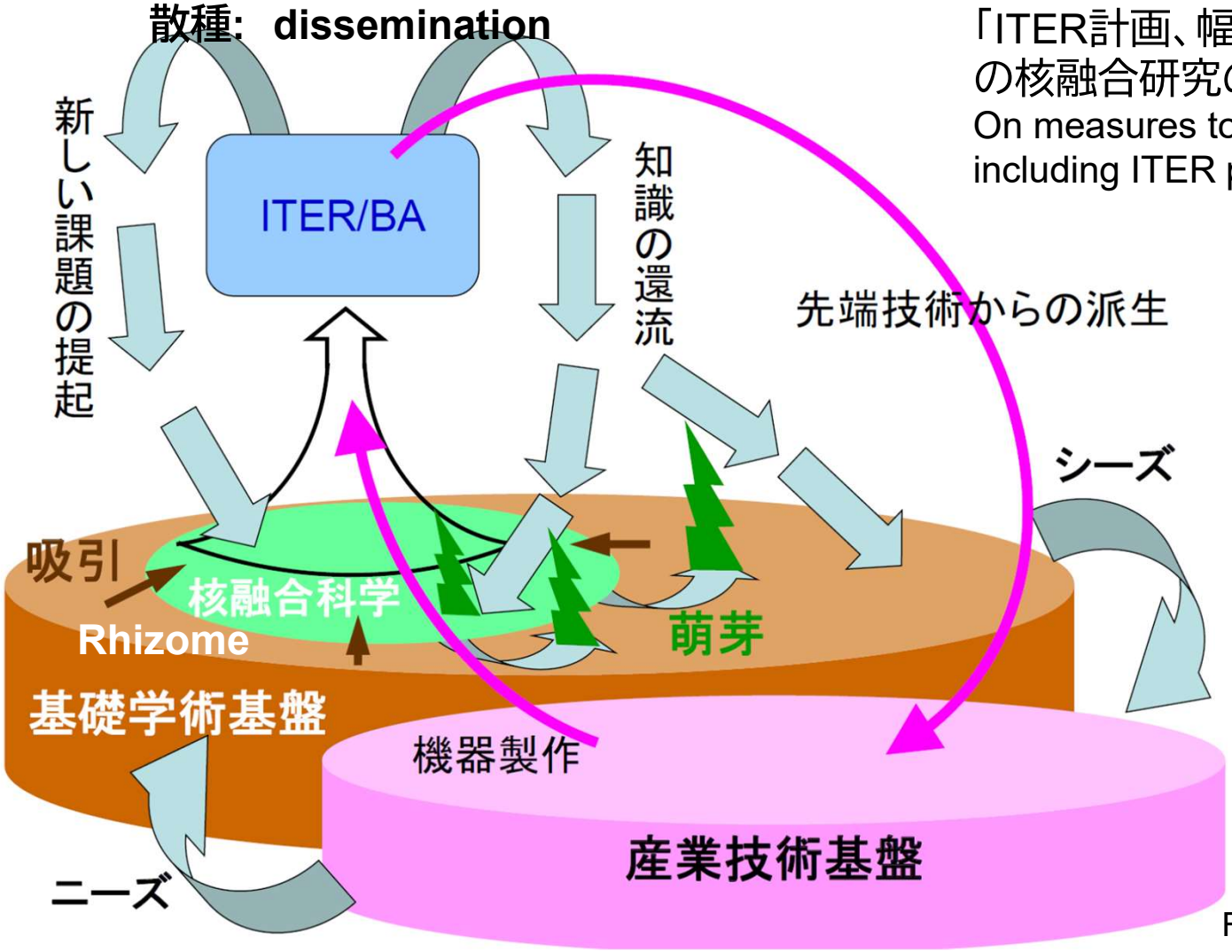
- Plasma heating by ion cyclotron frequency wave is relevant for a fusion reactor ?

  ← requirement of the antenna in the vicinity of plasma

Then prospect towards ARC

1. Helium-free cryogenic facility ?
   Helium is becoming a scarce resource
   Cooling capability against nuclear heat
2. HTS / high-magnetic-field coil system to accommodate the space for blanket

Needs both vertical integration and horizontal collaboration



「ITER計画、幅広いアプローチをはじめとする我が国の核融合研究の推進方策について」
On measures to promote fusion research in Japan, including ITER project and wide range of approaches
MEXT, June 27, 2007

"**Partnership**"
between actors
(cooperation and cooperation to solve common problems and use resources efficiently)

H.Yamada,
Fusion Research Working Group
at MEXT, 2007

Needs both vertical integration and horizontal collaboration

- Importance of **vertical integration** towards a fusion reactor

1. Define targets and motivate R&D program
2. To be a reliable reference for diversified options

- Getting to essential solution of critical technical issues via **horizontal collaboration**

1. Fundamental and basic research with exact science
2. Acceleration of R&D in a short turnaround by private funding

- ◆ Plan B is not an alternative option against Plan A
- ◆ Plan B is essentially how you bring Plan A to higher level of refinement through learning from partners (even competitors)