USTC SNST 2014 Autumn Semester Lecture Series

Title: Introduction to Tokamak Fusion Energy Nuclear Science and Technology Research and Development (R&D)

L6: What R & D are needed in order to bridge to **practical** tokamak fusion power in the future (updated!)

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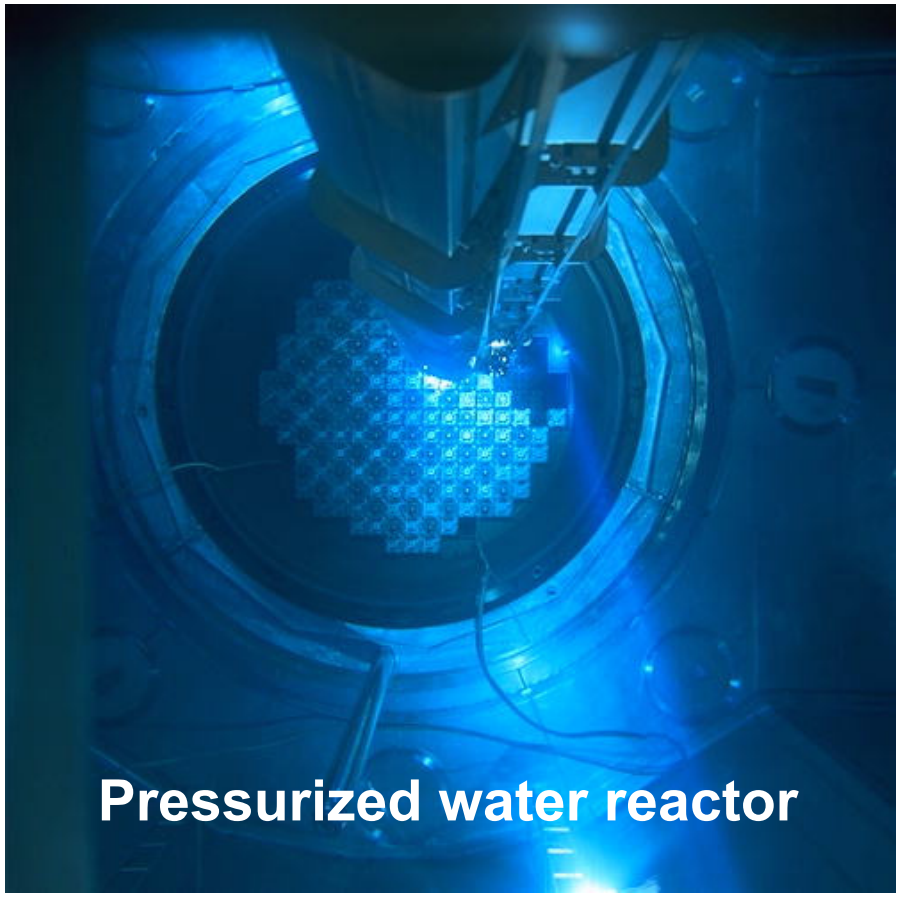
Room 1617, 930-1130, January 10, 2015

What to Carry with You?

- Practical energy source is efficient, reliable, economic, of large application, and **safe.**
- CFETR aims to advance far beyond ITER accomplishments.
- A presumed Practical Experimental Reactor would aim to advance far beyond CFETR in technical objectives
- Continue pursuit of new “道” (*via insight*) and developing new “德” (*via innovation*) toward practical fusion core components and supporting equipment.

Next session: discussion on joint evaluation of this lecture series on January 17, 2015

Nuclear power is a practical energy source



- **Efficient**: 1000 MW-yr uses
  - Fuel rod: ~500 tons
  - Oil: 1.4×10^7 barrels
  - Coal: 3.4×10^6 tons
  - Natural gas: 6.6×10^{10} ft^3
- **Reliable**: ~90% load factor
- **Economic**: ~2 c/kWh to generate
- **Of large application**: example, ~20% of electricity in U.S., rapidly growing in China

However, handicaps of fission in safety and environmental impact translate into high real total cost of generation $\Rightarrow$ poor economy.

Practical fusion reactor has potential to avoid this handicap while achieving the positive features of fission reactor

Complementarity of ITER and CFETR mission & objectives

	ITER Project (2009)	CFETR Proposal (2013)
Mission	• Demonstrate fusion power feasibility • Prove it can be done without impact	• Good complement to ITER (*in R&D toward DEMO)*
Fusion gain (Q)	• Q = 10 (short pulse); 5 (steady • Ignite and maintain burn for 480 s • Pf & duty cycle not specified	• Pf = 50 ~ 200 MW, Q not specified • Steady state operation • Duty cycle = 0.3 ~ 0.5
Burning plasma & techniques	• To be experimentally tested in ITER	• Rely on ITER plasma physics q>3,H~1) & techniques
Fusion core technology	• S/C magnets • Remote handling (RH)	• Rely on ITER • Easy RH change-out of blanket divertor
Tritium fuel	• Verify breeding concept	• Demonstrate full self-sustained with TBR ≥ 1.2
Neutron shield & heat conversion	• Refine techniques	• Explore DEMO blanket options

These complement ITER

Moving from CFETR mission & objectives toward a practical reactor

	CFETR Proposal (2013)	Practical Experimental Reactor
Mission	• Good complement to ITER (*in R&D toward DEMO)*	• Practical and safe
Fusion gain (Q)	• Pf = 50 ~ 200 MW, Q not specified • Steady state operation • Duty cycle = 0.3 ~ 0.5	• High Q (20-30?) • Continuous operation (~year?) • Duty cycle ~ 0.9?
Burning plasma & techniques	• Rely on ITER plasma physics q>3,H~1) & techniques	• Rely on CFETR physics &
Fusion core technology	• Rely on ITER • Easy RH change-out of blanket and divertor	• Rely on CFETR? • Routine RH change-out of blanket divertor?
Tritium fuel	• Demonstrate full self-sustained with TBR ≥ 1.2	• Full self-sustained cycle with TBR ≥
Neutron shield & heat conversion	• Explore DEMO blanket options	• Deploy most successful blanket
Safety & environment	• Add: measure safety & environment conditions?	• Make intrinsically safe

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Session II: discussion on joint evaluation of this lecture series on January 17, 2015

- Questionnaires to be prepared for student feedback?
- How best to conduct the feedback session?
- Other questions to discuss and prepare for January 17?