Some Physics Issues related to future Chinese Experimental Fusion Reactor

Qingquan Yu

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1. Introduction

*ITER is planed to begin operation in 2019/2020.

to obtain Q=10 in D-T experiments in 2027.

*The Chinese fusion reactor is expected to have a major radius ~5 meters, smaller than ITER, possibly starting construction in 2020.

*What is the key difference between our reactor and ITER?

*If one believes that ITER plasma will be well behaved, one can focus on the application of a fusion reactor.

e.g. follow ITER design but with different blanket module.

*However, ITER faces risks and uncertainties.

***In addition, some issues relevant for power plant have not been fully considered in ITER, e.g. steady operation.**

*** Only the possible physics-related issues are mentioned below.**

*** Purpose: to call for discussions;**

for optimizing reactor design based on ITER design and recent research development.

2. Possible physics-related risks on ITER

2.1 Disruption

* Due to low plasma rotation frequency and strong toroidal magnetic field, mode locking and disruptions in ITER are expected to be more frequent.
* The disruption prediction and Disruption Mitigation System (DMS) might not work well on ITER, resulting in frequent shutdowns to replace in-vessel components
* or they work well, but the use of DMS might be excessive.

***Possible solution**

***ECRH/ECCD for disruption avoidance?**

***to find a possible way to drive plasma rotation?**

2.2 ELM mitigation

* RMP coils could have no planned mitigation effect in ITER,
* or it works, but the required RMP amplitude is too large, causing locked mode.

* Pellet pace-making could be ineffective in ITER,
* or cause excessive fuelling and degrade confinement.

* Studies are still going on to understand this issue.
* It is already clear that ELM coil design based on vacuum assumption is not right.

2.3 Compatibility of Core and Radiative Divertor

- **Predicted narrow power deposition on divertor plate,**
  requires plasma detachment from the divertor.
- **In addition, there could be thermal transients.**
- **Excessive core impurities due to seeding for radiative divertor.**
  limiting H-factor, *Q* value and pulse length.

Possible measures:

- **Impurities may be limited by high power core electron heating.**
- **Change divertor design to prepare for narrow power deposition?**

2.4 Steady state operation

* Steady state operation is favorable for fusion power plant.
* requires high bootstrap current fraction and non-inductive current drive.
* The current drive efficiency is lower for a higher plasma density, but high plasma density is required for a reactor.
* For higher bootstrap current fraction, the (neoclassical) tearing mode is more unstable and could lead to disruptions.

* Possible measures?
  High RF power for both current drive and stability control?

2.5 Operational mode

*** Which operational mode should have the priority?**

Standard H-mode?

Hybrid (improved) H-mode?

Reversed magnetic shear?

*** If steady state operation is the major purpose, maybe the reversed magnetic shear configuration should have the priority.**

*** How to maintain the stability of reversed shear configuration?**

2.6 Other issues

- **Uncertainty in confinement in ITER.**
- **H-mode Power Threshold?**
- **density limit/peaking?**
- **Heating/Current drive system selection?**
- **In-vessel components?**
- **Fuel cycle**
- **...**

Summary

* Questions are there, but clear answers to them are not there yet.

* Conceptual design studies could let us know more clearly about the problems and possible solutions.

  - to lead to a reasonable reactor design

* In addition, the design studies would be helpful to

  - Guide experiment plan of our existing tokamaks.

  - Guide our investment in fusion research area.

Thank you for your attention