Examination on 'Advanced Course in Fusion Plasma Physics' of the European PhD Network in Fusion Science and Engineering

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1.) Stability

1.1) Describe the β–limits due to global MHD instabilities in conventional tokamak scenarios. Give physics pictures of the instabilities. How can these limitations be overcome?

1.2) Describe the limits to plasma performance due to global MHD instabilities in RFPs. Give physics pictures of these instabilities. How can these limitations be overcome?

2.) Transport

a) What is the bootstrap current? Explain in a physics picture! Give an example where the bootstrap current is important in a tokamak plasma!

b) What is the H-mode? What physical mechanism is thought to be responsible for its formation?

c) What is meant by the term ‘profile stiffness’? How can it be understood in terms of the linear stability diagram of the micro-instabilities responsible for turbulent transport?

3.) Exhaust

Different wall materials are used in fusion devices. Nowadays, high-Z materials like Tungsten (W) receive special interest.

a) What are the main advantages of W versus carbon (C) as a wall material?

b) What are the main disadvantages of W versus C as a wall material?

c) To use W in a divertor, the divertor plasma should be cold and dense. How can the divertor heat flux be reduced for a given heating power supplied to the main plasma?

4.) Scenarios

Steady state tokamak scenarios would be very beneficial for the tokamak as reactor concept, but they require 100% noninductive CD.

a) How can the plasma current be driven noninductively? Compare the effectiveness of the different methods!

b) What would a self-consistent solution for a steady state tokamak scenario look like in terms of $p(r)$ and $j(r)$?

c) Describe the major challenges in achieving b) in an experiment!

d) The stellarator concept promises to allow much easier access to steady state scenarios than a tokamak or an RFP. Explain why this is the case!