Physics Requirements for Understanding the H-mode Pedestal*

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1

Overview

| We Want to Predict Pedestal Structure	Pedestal Physics is Rich and Complex

Several Tasks Must be Done to Obtain Predictive Capability

Pedestal People Should Develop a Strategy

- outline an approach to understanding the pedestal

- list and prioritize major tasks

Problem: How Do We Predict and Control Pedestal Height in Future Machines?

◆ **Studies presented at 2002 Snowmass, 2002 IAEA and elsewhere show that performance of burning plasma experiments is strongly dependent on value of pedestal temperature**

◆ *We do not know how to predict the pedestal temperature*
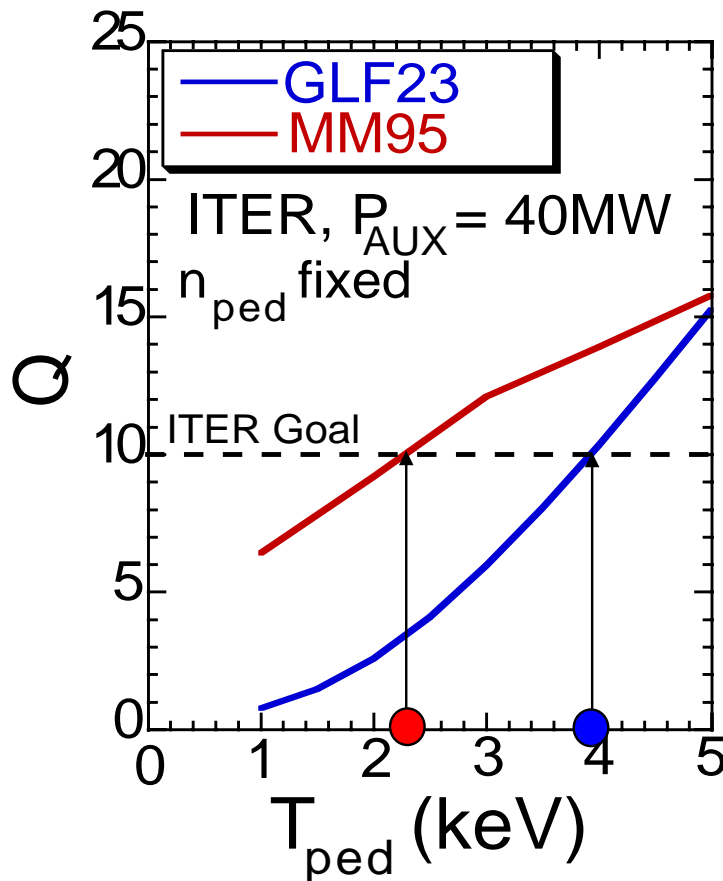
J. Kinsey 2002 IAEA

An Important Caveat

- **Much of the demand from pedestal physics is for predictions of pedestal height (ion temperature) in a burning plasma experiment.**

- **However, there are at least two other requirements of the pedestal in a burning plasma machine**
  - **Thermal impulses from any ELMs must be small enough so that plasma-facing components survive**
  - **Particle transport in pedestal must be sufficiently high to prevent build-up of impurities in core**

- **We concentrate on pedestal height here, but much of the physics for the height will also be relevant for ELM size and particle transport**

Pedestal Presents Rich and Complex Physics

- ◆ **Pedestal is a boundary layer which provides very good thermal insulation between open and closed field lines**
  - o Strong variation of parameters in a small distance
- ◆ **At the minimum, pedestal structure is determined by heat and particle sources, transport and MHD stability**
  - o Momentum sources? Ergodic magnetic fields? Other?
- ◆ **Pedestal is a self-consistent solution of these processes as they vary from top of pedestal to LCFS to limiting material surfaces**
- ◆ **Problem is inherently 2D (and maybe 3D) due to character of transport on open field lines, fuelling and perhaps other issues (orbit loss, ergodic B fields, ???)**
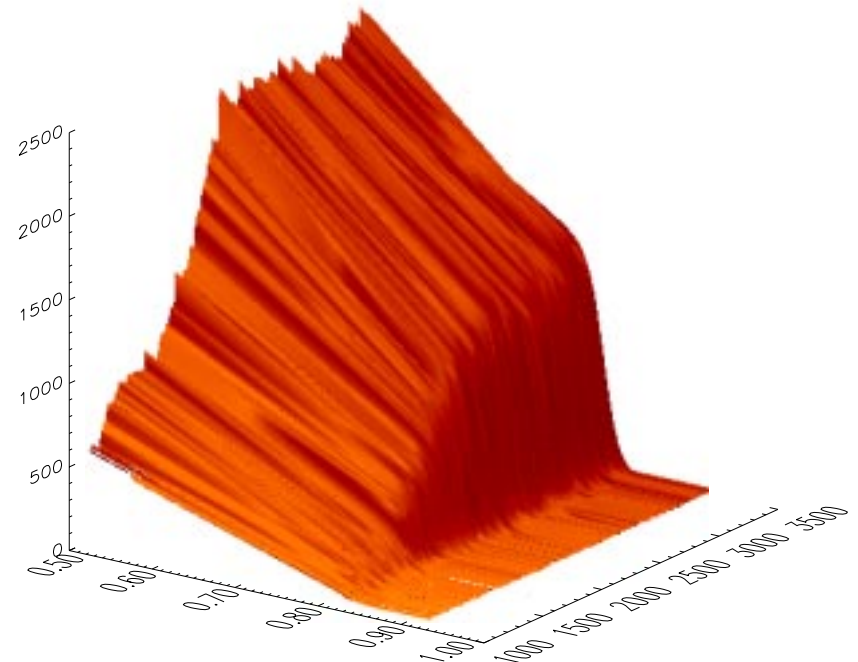- ◆ **Pedestal is not time-stationary**

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5

H-mode Transport Barrier (Pedestal) Provides Interface Between Core and SOL

Evolution of n_e Profile
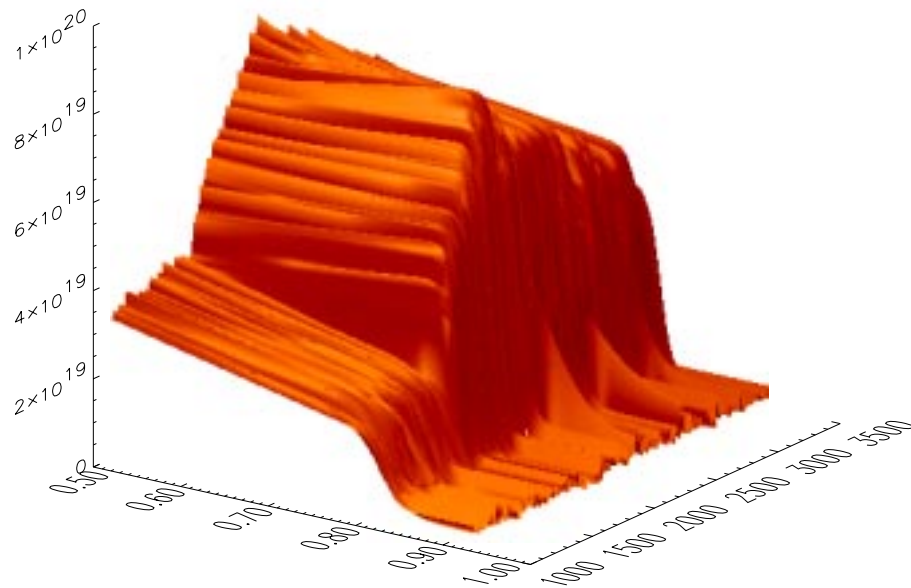
Evolution of T_e Profile

Pedestal Is a Self-Consistent Solution of at Least Four Physics Elements Inside LCFS

Heat source : Drives temperature gradients; provides energy required in fuelling process

Status: Heat deposition is reasonably well understood

Particle source : Provides plasma density; localization may affect density profile shape

Status: Atomic physics well understood, fuelling sources not well measured

Transport : Provides loss mechanism for energy and particles; may help to set pedestal "width"

Status: Transport mechanism(s) not known

MHD Stability : Provides hard upper limit for ∇P

Status: Very promising theory based on finite-n peeling/ballooning modes

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Basic Tasks Required to Advance Pedestal Understanding

Particle source

    - Measure fuelling source inside SOL in 2D, perhaps in 3D

    - Validate Monte Carlo and fluid neutrals models

Transport

    - Test fluid transport simulations with turbulence measurements

    - Develop kinetic transport simulations (ion orbit effects)

    - New turbulence measurements?

MHD Stability

    - Measure edge current density, validate bootstrap J models

    - Test peeling/ballooning theory under wide range of conditions

Integrated Modeling Codes Needed to Self-Consistently Include All Pedestal Physics

◆ **Perhaps we will find a simplifying principle which will allow us to predict pedestal height and shape**

◆ **More likely, we will need an integrated modeling code to accommodate the many interacting physics elements**

   o **Heat and particle sources, transport, MHD stability**

   o **Interaction of core, SOL and divertor plasmas and interaction of plasma with material surfaces**

   o **Rapid radial variations of parameters inside LCFS; 2D transport on open field lines**

◆ **Integrated modeling code must consist of physics modules which have been independently validated**

   o **Required so that we can trust results of the integrated code**

Some Conclusions and Opinions

◆ **The pedestal community needs to**

- o **Develop some ideas of where we need to go to solve the pedestal problem**

- o **Identify high leverage, high priority tasks for concentration of effort**

- o **Identify and publicize resources which will be required to solve the pedestal problem**

◆ **These ideas need to be projected to our colleagues, lab managers, program managers, etc**

- o **So that they understand the magnitude of the problem**

- o **So that they understand the magnitude of the solution**

- o **So that they provide required resources**

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