Reactor Physics: Feedback

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Summary:
The concept of reactivity feedback is introduced and briefly discussed.

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Introduction

1.1 Overview

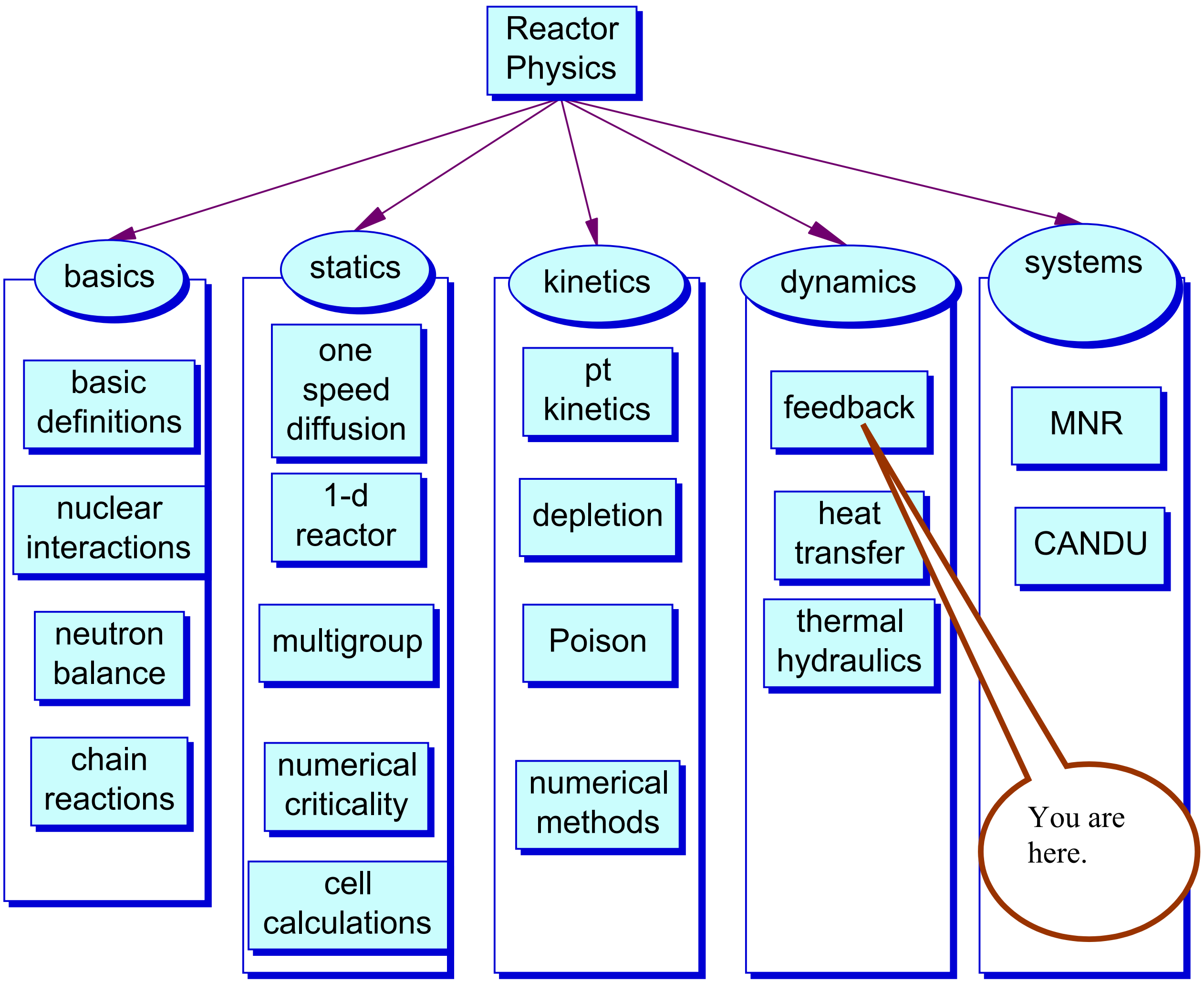

Figure 1 Course Map.

1.2 Learning Outcomes

The goal of this chapter is for the student to understand:

- What the feedback coefficient of reactivity is
- How the reactivity coefficients are part of the overall design.

2 Reactivity coefficients

In general, reactivity coefficients are simply the rate of change of reactivity with respect to a particular variable in question, ie:

$$\alpha_x \equiv \frac{\partial \rho}{\partial x} \tag{2.1}$$

A common variable of interest is temperature, so the *temperature coefficient of reactivity* is

$$\alpha_T \equiv \frac{\partial \rho}{\partial T} \tag{2.2}$$

If the core is heterogeneous then there is an α_T for each component since, obviously, changes in temperature in the coolant will affect reactivity differently than the same temperature change in the fuel. Reactivity change is really a system-wide response so a more useful coefficient is the power coefficient of reactivity:

$$\alpha_P \equiv \frac{\partial \rho}{\partial P} = \sum_j \frac{\partial \rho}{\partial T_j}\frac{\partial T_j}{\partial P},\ j = 1\ldots\#\text{ of components} \tag{2.3}$$

The coefficient would be a function of power, in general, as there is no reason to expect the overall reactor system to be a linear systems over the operating power range of zero to full power. Thus:

$$\rho = \int_0^P \alpha_P(P)dP \tag{2.4}$$

Figure 2 illustrates the feedback mechanism.

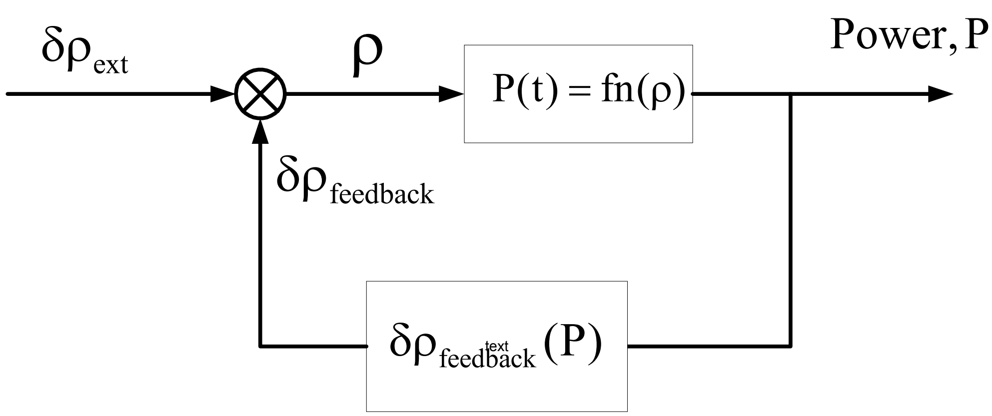

Figure 2 Feedback loop for the power coefficient of reactivity

If $\alpha_P < 0$ then the design is <u>inherently</u> stable against power fluctuations. Is this a good thing? A negative feedback coefficient for power means that if power should rise because of some input (perhaps due to come unwanted influence), the reactor will counter that input to some degree. That surely is a good thing, is it not? What could possibly be wrong with that?

If you wanted to lower the reactor power, how would the reactor respond? It would counteract your desire and try to keep the power up. That is not always a good thing but presumably that is a less dangerous situation than when the power is ramping up. In short, a large feedback coefficient is the cause of the problem more than its sign.

Another undesirable aspect of negative feedback coefficients is that they tend to mask underlying phenomena. If the mask is sufficiently good, it may hid a small problem long enough to allow it to become a big one.

In short, there is no right or wrong here in any absolute sense. The reactor needs to be properly designed with control systems appropriate to the design characteristics. But that is a topic for another course.

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