Summary of Chapter 15

It is well recognized that the presence of a conducting shell close to a plasma improves the MHD stability. Liquid metal wall concepts being considered by APEX place a liquid metal quite close to the plasma. Investigations are being performed to determine the potential physics benefits of using the liquid wall as the conducting shell, and the engineering feasibility of this approach. Analysis to date indicates that the potential physics benefits are quite large. For example, reactor designs such as ARIES have placed the stabilizing shell for the vertical instabilities behind the blanket and shield, limiting the stable elongation to approximately 2, with a beta limit of about 5-6%. However, the stable elongation could be increased to above 3 by using ~2 cm of lithium at the first wall of the plasma, increasing the beta limit for reactor relevant cases to ~ 20% (for the same aspect ratio as ARIES). Though a full systems analysis has not been performed, this could potentially allow a large reduction in the size of a reactor (e.g., from 5.5 meter major radius to ~ 3 meter). In addition, the confinement appears to be significantly improved allowing ignition in such small systems.

These calculations indicate large potential benefits, but are incomplete in several respects. This will be addressed in the next phase of APEX. Published results are indicative that a shell close to the plasma can stabilize ideal kink modes for highly elongated geometries, but this will be verified. The vertical stability calculations and feedback control requirements will also be refined. Several potential strategies to stabilize the resistive wall kink mode appear conceptually compatible with liquid metal walls, but these require quantitative assessment. The liquid nature of the stabilizing shell must be included in the calculations (adding greatly to the complexity of the analysis, but preliminary indications do not reveal any show stopping difficulties to the concept itself). The simultaneous use of a liquid first wall as a stabilizing shell as well as a heat removal system presents considerable engineering challenges. However there are multiple potential solutions, and each must be assessed. In addition, it may turn out that design possibilities need to be considered which separate these functions, e.g., use of a liquid metal slightly behind the first wall solely as a stabilizing element.