20150110-L6: Student questions during discussion, and answers

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1. **What's the difference between the practical experiment reactor and the DEMO?**

   Answer: "The DEMO in China is to demonstrate the safety, reliability and environment feasibility of the fusion power plants, meanwhile to demonstrate the prospective economic feasibility of the commercial fusion power plants." This statement was included in paper by KM Feng et al, presented at the 2nd IAEA Technical Meeting on First Generation Fusion Power Plants: Design and Technology, 2009. It defines the mission of a fusion DEMO in China. In contrast, a practical fusion experimental reactor would be to (see, lecture) demonstrate the technical practicality and safety of fusion power. These different missions would drive rather different technical objectives.

2. **What's the Achilles' heel of the fusion power plant?**

   Answer: "Achilles' heel", according to the legend, refers to a weakness in Achilles' invincible protection against bodily harm bestowed to him at birth by a mythological goddess. The story says that she dipped the baby Achilles in water while holding his feet and keeping her hand dry, thus allowing his heels to remain unprotected. By analogy, an Achilles' heel for a technology would refer to a weakness that is intrinsic to the physical properties on which the technology is based.

   Since fusion energy technology is being developed, it is too early to determine if there is an Achilles' heel. It is appropriate to say that the prospect for not having an Achilles' heel is good, as the R&D is directed away from potential Achilles' heels. This is the case, in view of the focus on low-activation materials in the R&D toward fusion power, thus minimizing or avoiding the long-lasting hazards of radioactive actinides.

3. **Considering the giant gap between the CFETR and the practical experiment reactor, do you still have confidence in fusion? And by what time do you think we can achieve the goal?**

   Answer: In terms of multiplying factors in the technical objectives when we advance from ITER to CFETR, the multiplying factors from CFETR to a practical fusion experimental reactor (PFER?) is much smaller. Also, the R&D challenges for PFER is more in technology than in fusion science when compared to CFETR. I would call this gap "substantial" rather than "giant".

   I am of the opinion that practical fusion power can be realized if and when adequate resources are applied to its R&D. Quoting *roughly* from Artsimovich (co-inventor of the tokamak configuration, 1956), fusion power will become available when society demands it.

4. **Can we deal with the Achilles' heel of fission reactors very well now?**

   Answer: I am of the opinion that fission power can be safe to the level of "as safe as humanly possible".

   Built into the mechanisms of nuclear fission is the long lasting radioactivity and health hazards of its by-products. If we diligently apply safety and accident protection measures "as safe as humanly possible," major fission nuclear accidents, even under the most unlikely situations, could in principle be avoided.

   However, this approach has a measure in risk analysis that is without an upper bound. Its implementation would quickly invoke complex societal issues that require far-sighted decisions and actions to resolve successfully.

5. **What's the relationship between the new generation fission plant and the fusion plant?**

   Answer: I am not conversant and knowledgeable in the latest R&D regarding the new generation fission power plants. Cursory reading suggests to me that fission energy R&D is diligently working on improving its intrinsic safety and robustness against accidents and their impact.

   A good example would be its new fuel elements for high temperature gas-cooled reactor designs based on the TRISO ceramic spheres containing UO_2 at the core. TRISO refers to a layer of C-C composite containing a layer of C-Si composite, which in turn containing another layer of C-C composite. This design has recently been tested to 1800^{o}C in operation without failure. This design also avoids H_2 production at such temperatures, as in the case of a loss-of-coolant accident involving the conventional Zr-based cladding of nuclear fuel elements.